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Identification and Prioritization of Human Error Factors Related to Maritime Accidents

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ABSTRACT

Maritime accidents associated with its consequences, such as loss of people, huge financial compensations, pollution disasters, and environmental damage, are real threats to maritime transport industry. Many factors have a direct or an indirect effect on marine accidents; however, the Human Error Factors (HEFs) are the main contributor to those accidents, as confirmed by many investigations and databases concerning this issue.

Purpose: *This paper aims to study, identify, and prioritize the most important human error factors related to maritime accidents, in an attempt to control and reduce their potentiality in future, and to consequently increase the maritime safety level.*

Approach/Design/Methodology: *The paper presents a systematic literature review on the human error factors that affect maritime safety. Additionally, the study depends on collecting quantitative data using a specially designed questionnaire, which is based on the Analytic Hierarchy Process (AHP) of Multi-Criteria Decision Making (MCDM). The questionnaire targeted around 80 maritime experts working in the maritime industry and academia. The final sample size ended up with 51 respondents.*

Findings: *The participants gave the Competency Factors (CFs) group first rank and priority over the other factor groups. Then, the Psychological Factors (PSFs) group, the Team Factors (TFs) group, the Application Factors (AFs) group, the Voyage Management Factors (VMFs) group, and the Physical Factors (PHFs) group followed in descending order. Moreover, the factors included in each group, totaling 32 factors, were similarly ranked and prioritized.*

Recommendations: *The findings of this paper could serve as a milestone for further studies to trace and identify more factors that contribute to the occurrence of maritime accidents. Thus, to consider the best alternatives to reduce their potentiality and, consequently, to increase the overall maritime safety level.*

Key-words:
Maritime accidents, Human Error Factors (HEFs), Maritime safety, Analytic Hierarchy Process (AHP).

INTRODUCTION

The maritime industry is crucial for global trade and economic growth, but it faces significant safety challenges due to complex operations and an unpredictable marine environment (Arslan et al., 2016). Understanding Human Error Factors (HEFs) is essential for enhancing maritime safety through reducing maritime accidents' rate. Human error factors are broadly categorized into competency factors, physical factors, team factors, psychological factors, voyage management factors, and application factors.

Competency factors relate to personnel skills that encompass knowledge and experience of maritime personnel, influencing their ability to navigate and respond effectively to dynamic and challenging situations at sea (Skorupski and Wiktorowski, 2015). Psychological factors explore the cognitive and emotional aspects that may affect decision-making processes, reaction times, and overall performance during maritime operations (He et al., 2021; Fan et al., 2023). Team factors delve into the collaborative dynamics within maritime crews, examine how effective communication, coordination, and teamwork contribute to or mitigate human errors (Tavakoli and Nafar, 2021). Application factors consider the role of technological equipment in influencing the occurrence and severity of human errors in maritime settings (Morais et al., 2022). Voyage management factors extend the focus to the planning, execution, and monitoring of maritime journeys, exploring how these aspects impact safety outcomes (Graziano et al., 2016). Lastly, the physical factors investigate the environmental and ergonomic elements that may act as contributing or mitigating factors to human errors in the maritime context (Morais et al., 2022).

Maritime accidents result from various factors, including human errors, engine failures, and environmental conditions (Galić et al., 2014). Human error is responsible for more than 85% of maritime accidents and 30-50% of oil spills. Despite this, there is a startling lack of research in the management literature on human errors in the maritime domain and how they affect the maritime safety (Dominguez-Péry et al., 2021). The current endeavor, therefore, is concerned with human-error-related accidents only.

According to the European Maritime Safety Agency report, human factors were the main reason behind most of the maritime accidents which were traced from 2014 until 2020 (EMSA, 2021). Furthermore, the navigation accidents assessment conducted by EMSA in 2022 revealed that nearly 78% of the navigation incidents that have been investigated had some sort of "human factor" component. By focusing on the intricacy of human mistakes, it was demonstrated that marine casualty is not explained by the variability of the major actors' performance. On the other hand, human activity results from complex, non-linear, and dynamic socio-technical interactions between individuals onboard, organizations onshore, policies, procedures, and machinery (EMSA, 2022).

Due to complexity and lack of standardization in maritime accident reporting, determining particular causation factors can be difficult and time-consuming. Despite this, human error has been identified as a primary cause in more than 75% of maritime accidents. A review of 177 marine accident reports revealed that one component of human error, namely a lack of situation awareness, is a serious concern in the maritime realm. In particular, there are failings in the cognitive psychology paradigm of perception, cognition, and future event prediction since human error resulted from a failure to anticipate future actions, a failure to correctly perceive information, and a failure to correctly integrate or comprehend information and/or the system. These human failures are deemed hinderances in the context of advancing onboard digital systems because they suggest that if the crew becomes overly reliant on new technologies, the problems of situational awareness may worsen and may have a greater detrimental influence on safety (Dominguez-Péry et al., 2021).

Several individual factors contribute to navigation accidents as shown in Table 1.

Table 1: Factors contributing to navigation accidents

Ser. No.	Factor	Description
1	Fatigue	Both physical and cognitive functions are impaired by lack of sleep, long hours, and circadian rhythm disorders, leading to poor performance
2	Mispercep-tion/Misin-terpretation/ Distraction	Refer to inadequate operator performance resulting from misreading or misinterpreting information supplied by tools or instruments or other input from the environment, also due to operator's distractions and interruptions
3	Situational Awareness	Failures in processing available information, often due to interruptions, and improper attention-redirections that lead to errors
4	Physical and Mental In-competence	The operator's physical stamina and coordination were not sufficient to meet the demands of the duties. The majority of incidents listed in EMCIP have been connected to operator performance being hampered by alcohol use

5	Cognitive Workload	This is a result of cognitive processing being negatively influenced by the rapid operational pace of the developing scenario, which results in dangerous operator performance
6	Lack of Awareness of Actual Risks	A false sense of security causes operators to dismiss or underestimate dangers
7	Overconfi-dence	Poor operator assessment of one's own, others', or equipment's capabilities results in incorrect performance at work, such as approaching the port without a pilot's help

Source: EMSA (2022)

Through a systematic examination of these human error factor groups, this research endeavors to clarify the complicated interplay between human actions and maritime safety levels. By identifying patterns, correlations, and dependencies, this study aims to provide valuable insights for industry stakeholders, regulatory bodies, and maritime professionals.

While significant strides have been made in understanding the intricate relationship between human error and maritime safety, there exists a noticeable research gap regarding the comprehensive examination of specific human error factor groups and their collective impact on maritime safety levels. The existing body of literature often addresses isolated aspects of human error in maritime contexts, but a holistic investigation into competency factors, psychological factors, team factors, application factors, voyage management factors, and physical factors is notably lacking. This gap presents an opportunity for further exploration and in-depth analysis to contribute to a more comprehensive understanding of the dynamics at play.

The complexity and the interactions of the human behaviors, responses, and perceptions, make it so difficult and important at the same time to trace and identify the most important HEFs that have a significant impact upon maritime accidents. Thus, the urgency of this paper lies in its potential to identify and prioritize more accurately the most important human error factors that have an impact on marine accidents in order to study the suitable preventive actions to reduce them in future. The paper aims to provide a perspective that can guide the development of effective strategies to enhance the seafarers' performance and skills, thus enhancing the maritime safety level. The findings of this study have the potential to significantly contribute to the overall safety and elasticity of maritime operations, ensuring the well-being of maritime personnel, the protection of valuable cargo, and the sustainability of global trade.

METHODOLOGY

The current study depends on adopting a deductive approach, which explains the causal relationships between the variables of the study, depending on collecting quantitative data. A specially designed questionnaire has been distributed to maritime experts from the industry, with at least 15 years of experience, academic experts, with at least 10 years of experience, and maritime officers working onboard ships, with at least 10 years of experience. The questionnaire was designed to be clear, unbiased, easy to understand, and interesting to maintain the participant's interest, and motivation. It is based on the Analytic Hierarchy Process (AHP) of Multi-Criteria Decision Making (MCDM) (Saaty, 1980), which is based on pairwise comparisons of parameters and subsequent calculation of their weights.

Returned questionnaires were subsequently used to prioritize the different human error factors. The questionnaire provides perfectly consistent pairwise comparison matrices by asking the participants to complete the first row only, that is (a_{1j} , j = 1, 2,...n), where n is the number of factors. Then the remaining elements of the matrix are obtained as follows: (i) the diagonal elements a_{ij} , i = j are all equal to 1, (ii) the upper off-diagonal elements, except for those of the first row, are obtained applying the property $a_{ij} = a_{1j} / a_{1i}$, where i , j = 1, 2, ..., n, and (iii) the lower off-diagonal elements are obtained from the property $a_{ij} = 1/ a_{ji}$, where i , j = 1, 2, ..., n.

The questionnaire targeted around 80 maritime experts, while the final sample size ended up with 51 respondents. Statistical analysis of the data provided by the respondents and completed by the authors was done by using the SPSS to check their frequencies; also, quantitative analysis of the data was attempted using the AHP method. A specially designed computer program was constructed to accommodate the chosen parameters, based essentially on the use of Excel spreadsheets (Microsoft, Excel 2016).

Selection of Factor Groups

Six main HEFs groups were considered as follows: (a) Competency Factors (CFs) group, (b) Physical Factors (PHFs) group, (c) Team Factors (TFs) group, (d) Psychological Factors (PSFs) group, (e) Voyage Management Factors (VMFs) group, and (f) Application Factors (AFs) group.

These groups totaled a number of 32 human error factors as listed in Table 2. The relative significance or preference of each factor is then calculated using the priority or relative importance of each factor. The factor with the highest weight value was taken as the most important factor, followed by the lower-weight factors in descending order.

Table 2: Human error groups and pertinent factors included in the analysis

Group	Code	Factor
Competency Factors (CFs)	CF1	Technical Knowledge
	CF2	Training
	CF3	Skills
	CF4	Attitude
	CF5	Response
	CF6	Experience
	CF7	Perception
Physical Factors (PHFs)	PHF1	Fatigue
	PHF2	Fitness
	PHF3	Sensitivity to Temperature
	PHF4	Sensitivity to Noise
	PHF5	Sensitivity to Ship's Motion/Vibration
Team Factors (TFs)	TF1	Communication
	TF2	Team Management
	TF3	Multi-Cultural Team
	TF4	Watchkeeping
	TF5	Safety Awareness
Psychological Factors (PSFs)	PSF1	Risk Tolerance
	PSF2	Stress Resistance
	PSF3	Panic Resistance
	PSF4	Motivation
	PSF5	Complacency
Voyage Management Factors (VMFs)	VMF1	Passage Plan/Voyage Planning
	VMF2	Decision Making
	VMF3	Procedures and Checklists
	VMF4	Look Out
	VMF5	Situation Awareness
Application Factors (AFs)	AF1	Position Fixing
	AF2	Usage of Bridge Equipment
	AF3	Maneuvering
	AF4	Interpretation Adequacy
	AF5	Ship Speed

DATA ANALYSIS

As stated in the previous section, a questionnaire has been specifically designed to collect data for the current study. More than 80 experts were contacted in order to complete the questionnaire and participate in the analysis. After excluding the biased and incomplete ones, the final sample size ended up with 51 respondents, approximately representing 64% of the targeted sample, and were grouped as follows: (a) 31 experts from AASTMT (~ 61%), and (b) 20 experts from different organizations and companies in the maritime field (~ 39%).

The experts' age ranged from less than 40 years to more than 70 years, and their years of experience ranged from 10 years to more than 40 years. Table 3 shows the descriptive analysis of the respondents. It is clear that the group with the age range from 41 to 55 are 21 respondents (41.2%), while the group with 15 to 20 years of experience are 19 respondents (37.3%).

Table 3: Descriptive analysis of the respondents' profile

Age			Experience		
Range	Frequency	Percent	Range	Frequency	Percent
Less than 40	16	31.4	From 10 to 14	16	31.4
From 41 to 55	21	41.2	From 15 to 20	19	37.3
From 56 to 70	9	17.6	From 21 to 34	10	19.6
More than 70	5	9.8	From 35 to 40	4	7.8
Total	51	100.0	Above 40	2	3.9
			Total	51	100.0

RESULTS

Table 4 displays a typical pairwise comparison matrix of factor groups provided by the experts involved in the analysis. The weight of the individual groups is also shown in the same table. According to the experts, group CFs has the highest weight, followed by groups PSFs, TFs, AFs, VMFs and finally PHFs.

Table 4: Pairwise comparison matrix of the factor groups

Group	CFs	PHFs	TFs	PSFs	VMFs	AFs	GM	W	Rank
CFs	1.000	3.157	1.943	1.618	2.723	2.118	1.963	0.304	**1**
PHFs	0.317	1.000	0.616	0.513	0.863	0.671	0.622	0.096	**6**
TFs	0.515	1.625	1.000	0.833	1.401	1.090	1.010	0.156	**3**
PSFs	0.618	1.951	1.201	1.000	1.683	1.309	1.213	0.188	**2**
VMFs	0.367	1.159	0.714	0.594	1.000	0.778	0.721	0.112	**5**
Afs	0.472	1.491	0.917	0.764	1.286	1.000	0.927	0.144	**4**
Sum	3.289	10.383	6.390	5.322	8.956	6.966	6.456	1.000	

The weight of the individual groups is depicted in Figure 1. It could be observed that the CFs group is ranked first, while the PSFs group comes in the second rank; the third one is the TFs group; the fourth rank goes to AFs group, while VMFs group comes in the fifth rank, and finally the PHFs group is ranked sixth.

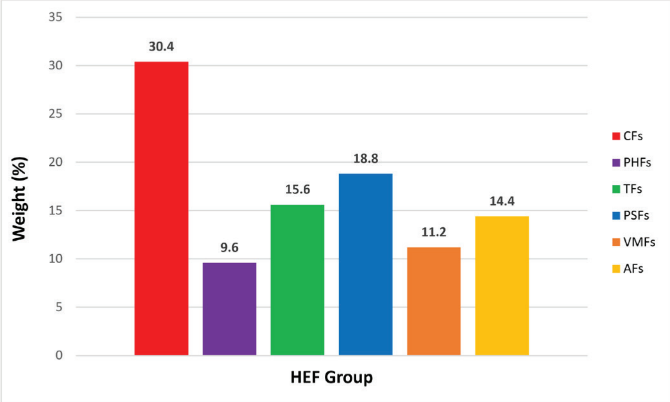

Fig. 1. Weight of the HEF Groups

Table 5 displays another typical pairwise comparison matrix of the seven factors of the CFs group. The weight of each individual factor is calculated in Table 4. According to the experts, Technical Knowledge CF1 is given the highest weight, followed by Experience CF6, Training CF2, Skills CF3, Response CF5, Perception CF7, and finally Attitude CF4.

Table 5: Pairwise comparison matrix of CFs

HEFs	CF1	CF2	CF3	CF4	CF5	CF6	CF7	GM	W	Rank
CF1	1.000	1.575	1.648	2.429	1.712	1.180	1.824	1.567	0.216	1
CF2	0.635	1.000	1.046	1.542	1.087	0.749	1.158	0.995	0.137	3
CF3	0.607	0.956	1.000	1.474	1.039	0.716	1.107	0.951	0.131	4
CF4	0.412	0.648	0.678	1.000	0.705	0.486	0.751	0.645	0.089	7
CF5	0.584	0.920	0.963	1.419	1.000	0.689	1.065	0.915	0.126	5
CF6	0.847	1.335	1.397	2.058	1.451	1.000	1.546	1.328	0.183	2
CF7	0.548	0.863	0.904	1.332	0.939	0.647	1.000	0.859	0.118	6
Sum	4.633	7.297	7.636	11.254	7.933	5.467	8.451	7.262	1.000	

Similarly, Tables 6 to 10 were constructed to calculate the weight of the factors of each of the remaining groups and to subsequently prioritize them. It is worthy to mention that in Table 6, PHF4 (Sensitivity to noise) and PHF5 (Sensitivity to ship motion) come in the same level as they have the same weight of the third rank. Also in Table 8, PSF3 (Panic Resistance) and PSF5 (Complacency) share the second rank as they have equal weights.

Table 6: Pairwise comparison matrix of PHFs

HEFs	PHF1	PHF2	PHF3	PHF4	PHF5	GM	W	Rank
PHF1	1.000	2.303	3.227	2.844	2.848	2.269	0.409	1
PHF2	0.434	1.000	1.401	1.235	1.237	0.985	0.177	2
PHF3	0.310	0.714	1.000	0.881	0.883	0.703	0.127	4
PHF4	0.352	0.810	1.135	1.000	1.001	0.798	0.144	3
PHF5	0.351	0.809	1.133	0.999	1.000	0.797	0.144	3
Sum	2.447	5.636	7.896	6.959	6.969	5.553	1.000	

Table 7: Pairwise comparison matrix of TFs

HEFs	TF1	TF2	TF3	TF4	TF5	GM	W	Rank
TF1	1.000	2.687	1.841	2.377	1.531	1.783	0.335	1
TF2	0.372	1.000	0.685	0.885	0.57	0.663	0.125	5
TF3	0.543	1.46	1.000	1.291	0.832	0.968	0.182	3
TF4	0.421	1.13	0.775	1.000	0.644	0.75	0.141	4
TF5	0.653	1.755	1.202	1.553	1.000	1.164	0.219	2
Sum	2.989	8.032	5.503	7.106	4.577	5.329	1.000	

Table 8: Pairwise comparison matrix of PSFs

HEFs	PSF1	PSF2	PSF3	PSF4	PSF5	GM	W	Rank
PSF1	1.000	2.318	1.891	2.062	1.887	1.763	0.336	1
PSF2	0.431	1.000	0.816	0.890	0.814	0.761	0.145	4
PSF3	0.529	1.226	1.000	1.090	0.998	0.933	0.178	2
PSF4	0.485	1.124	0.917	1.000	0.915	0.855	0.163	3
PSF5	0.530	1.228	1.002	1.093	1.000	0.935	0.178	2
Sum	2.975	6.896	5.626	6.135	5.614	5.247	1.000	

Table 9: Pairwise comparison matrix of VMFs

HEFs	VMF1	VMF2	VMF3	VMF4	VMF5	GM	W	Rank
VMF1	1.000	1.769	1.791	1.82	1.447	1.529	0.297	1
VMF2	0.565	1.000	1.012	1.029	0.818	0.864	0.168	3
VMF3	0.558	0.988	1.000	1.016	0.808	0.853	0.166	4
VMF4	0.549	0.972	0.984	1.000	0.795	0.84	0.163	5
VMF5	0.691	1.223	1.238	1.258	1.000	1.056	0.205	2
Sum	3.363	5.952	6.025	6.123	4.868	5.142	1.000	

Table 10: Pairwise comparison matrix of AFs

HEFs	AF1	AF2	AF3	AF4	AF5	GM	W	Rank
AF1	1.000	1.916	1.772	1.644	1.612	1.552	0.302	1
AF2	0.522	1.000	0.925	0.858	0.841	0.810	0.157	5
AF3	0.564	1.081	1.000	0.928	0.910	0.876	0.170	4
AF4	0.608	1.165	1.078	1.000	0.981	0.944	0.183	3
AF5	0.620	1.189	1.099	1.020	1.000	0.963	0.187	2
Sum	3.314	6.351	5.874	5.450	5.344	5.144	1.000	

DISCUSSION

Based on the previous pairwise comparison matrices, the participants gave the Competency Factors (CFs) group first rank and priority over the other factor groups. Then, the Psychological Factors (PSFs) group, the Team Factors (TFs) group, the Application Factors

(AFs) group, the Voyage Management Factors (VMFs) group, and the Physical Factors (PHFs) group followed in a descending order, as has been shown in Figure 1.

In the same manner, the factors included in each one of these groups, were also weighed and prioritized according to their importance based on the participants' judgements, as has been shown in Tables 5 – 10. The results in the previous section, from Table 5 to Table 10, are concerned with the ranking of the factors of each group. However, to reveal the overall significant importance of each factor regarding all factors (32 factors), weight of each factor has been multiplied by its related group weight, so the overall weight of all 32 factors amounts to 100%. Thus, all of the 32 factors have been ranked and prioritized, as shown in Figure 2.

The figure reveals that the technical knowledge ranks first, with a relative importance of 6.57%, followed by risk tolerance, experience, communication, position fixing, training, skills, fatigue, response, perception, safety awareness, complacency, panic resistance, passage plan, motivation, multi-cultural team, stress resistance, attitude, ship speed, interpretation adequacy, maneuvering, situation awareness, usage of bridge equipment, watch keeping, team management, decision making, procedures and checklists, look out, fitness, sensitivity to ship motion, sensitivity to noise, and finally comes sensitivity to temperature, ranking last with a relative importance of 1.22%.

Moreover, it could be observed that six factors from the Competency Factors (CFs) group are within the first ten factors; these are the technical knowledge, experience, training, skills, response, and perception. On the contrary, four factors from the Physical Factors (PHFs) group take the lowest four ranks; these are the fitness, sensitivity to ship motion, sensitivity to noise, and finally sensitivity to temperature. Nonetheless, fatigue, which is related to the same group, comes in the eighth rank.

To make the picture clearer, the previous results are reproduced in Figure 3, where the groups are prioritized, together with their pertinent factors. It could be observed in this figure, that two groups acquire low weights in groups' prioritization; these are the Application Factors (AFs) group and Physical Factors (PHFs) group, but on the contrary, they compromise two factors having high weights among the overall factors; these are position fixing with a relative importance of 4.35%, acquiring the fifth rank, and fatigue with a relative importance of 3.93%, occupying the eighth place.

The figure also reveals that the top-ranked group, i.e. Competency Factors (CFs), comprises a factor with a significant low weight, which is attitude, with a relative importance of 2.71%, occupying the eighteenth place. Similarly, the Psychological Factors (PSFs) group occupies the second place though it comprises the stress resistance factor with a relative importance of 2.73%. Likewise, Team Factors (TFs) group has the third rank, while it includes the team management factor, with a significantly low relative importance of 1.95%, thus occupying the twenty fifth place.

The results of the current study were compared with similar results of other investigators as follows: Uğurlu et al. (2015) prioritized HEFs behind grounding accidents and confirmed that application errors were the most common type. This study, however, confirmed that the competency factors are the most important type of factors behind maritime accidents. They classified HEFs and groups to Voyage Management Errors: Faulty or inadequate passage plan, Inappropriate route selection, Use of improper chart; Team Management Errors: Lack of communication and coordination in bridge resource management, Lack of external communication, Improper look-out, Deficiency in safety management system, Failure of watch arrangements; Application Errors: Position Fixing Application Errors, Inefficient usage of bridge navigation equipment, Faulty maneuvering, Interpretation Errors, Unsafe speed; and Individual Errors: Fatigue, Alcohol, Stress, Lack of training and education, Watch-keeping officer who is unfamiliar with bridge.

Uğurlu et al. (2015) stressed the importance of enhancing education and training to prevent grounding accidents in maritime operations, focusing on competency, shore-based, and onboard training. They also emphasized the need for competency training in team management, communication, and navigation equipment use, alongside promoting Electronic Chart Display and Information Systems (ECDIS) usage. Additionally, they addressed the impact of increased workload due to reduced crew numbers, advocating for increased seafarer numbers and proper rest hours, and recommended improvements in Safety Management Systems (SMS) concerning passage planning, chart applications, and team management.

Figure 4 represents a comparison of results between the current study and Uğurlu et al. (2015) study concerning prioritization of factors according to its relative importance. For comparison reasons, the common HEFs in both studies were selected and their relative weights adjusted (normalized) such that the sum in each case is 100%. In doing so, six factors suffered from some kind of deviation in terminology between the two studies. To get around this difficulty and to conduct the comparison more accurately Uğurlu et al. names of factors have been adjusted to match the same terminology of the current study, as shown in Table 11. It is important to state here that one of the problems that encountered this study in its early stages was concerned with the variation and diversity in terminology regarding the human error factors among the different studies found in the literature, which makes the process of identifying such factors more difficult.

Table 11: Adjusted names of Uğurlu et al. (2015) factors to match current study

Uğurlu et al. (2015) factors	Current study factors
Communication and coordination in bridge resource management	Team management
Use of improper chart	Technical knowledge
Safety management system	Safety awareness
Route selection	Decision making
Alcohol	Fitness
Unfamiliarity with bridge	Experience

Figure 4 reveals that team management and position fixing factors in Uğurlu et al. (2015) study have significant high weights, with a relative importance of 18.7% and 17.2%, respectively. On the contrary, in the current study, team management has low weight with a relative importance of 3.3%, while position fixing has a higher weight with a relative importance of 7.4%. Technical knowledge has the highest weight with a relative importance of 11.2%, then comes experience with a relative importance of 9.4%.

Özdemir et al. (2018) used fuzzy AHP technique to identify important elements that contribute to occupational accidents involving sailors onboard and provided alternative remedies. The research ranked the following variables as the primary causes of these mishaps: environmental factors, shipborne problems, cargo problems, human issues, and poor management. The main reasons were found to be human issues, such as exhaustion, ignorance, and a lack of training. Results of Özdemir et al. (2018) and those of the current study are generally in good agreement, as they both emphasize that the main reasons that contribute to accidents are related to human error. However, the former study stresses on exhaustion, ignorance, and lack of training. In the current study, these factors are called fatigue, lack of technical knowledge, and also lack of training, and have the weights of 3.93%, 6.57%, and 4.16%, respectively, in good agreement with their counterparts in Özdemir et al. (2018).

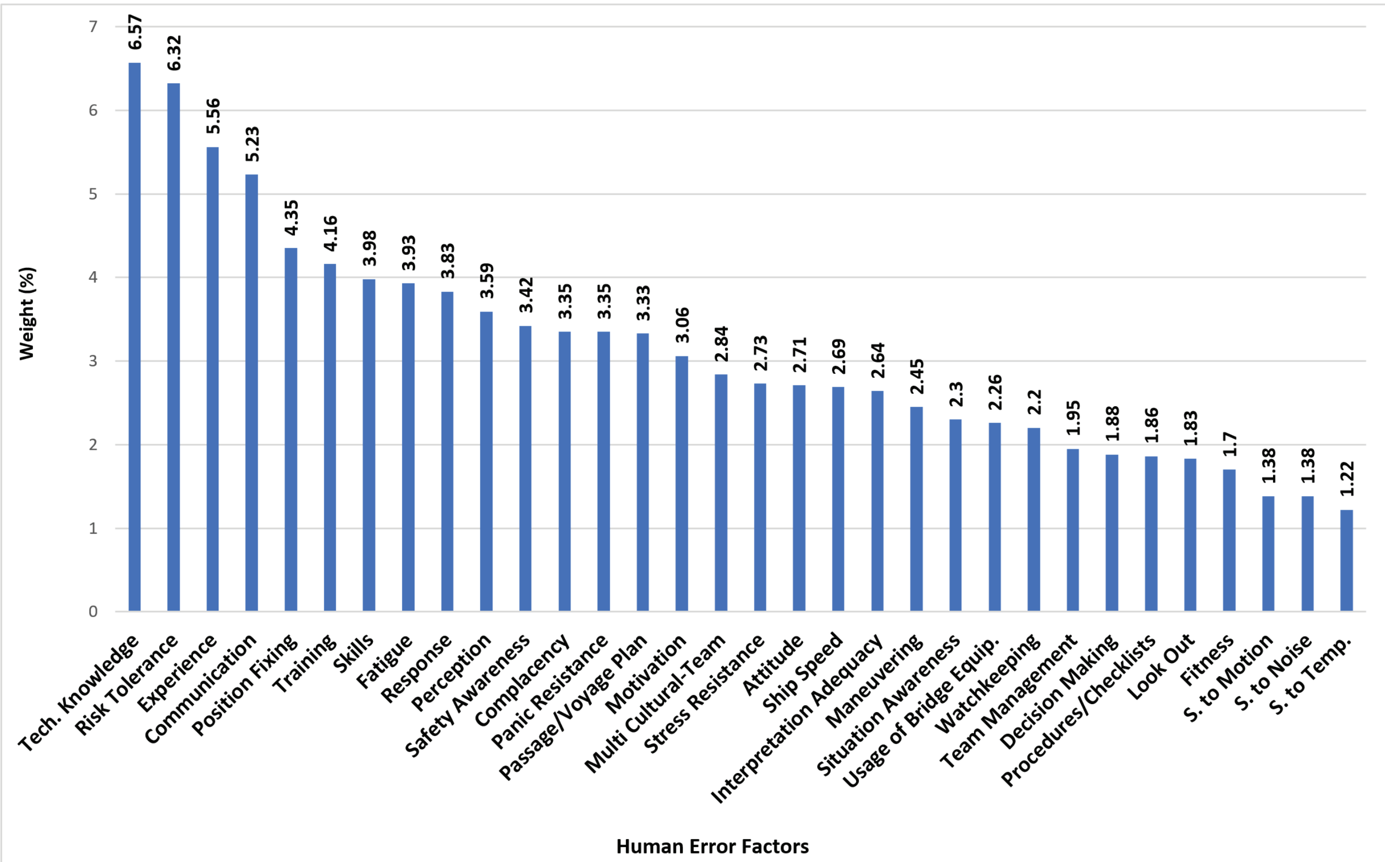

Fig. 2. Weights of human error factors

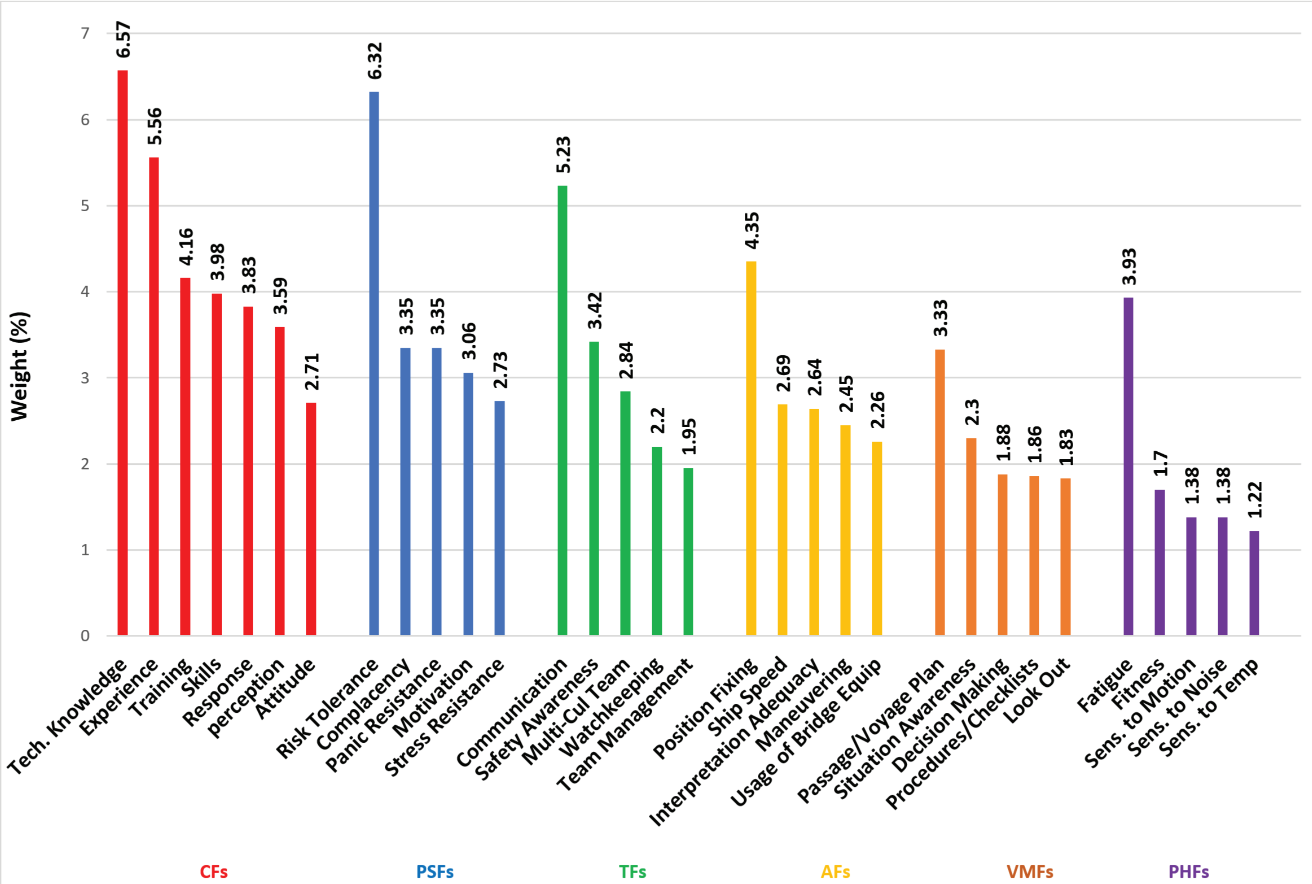

Fig. 3. Prioritization of groups and factors

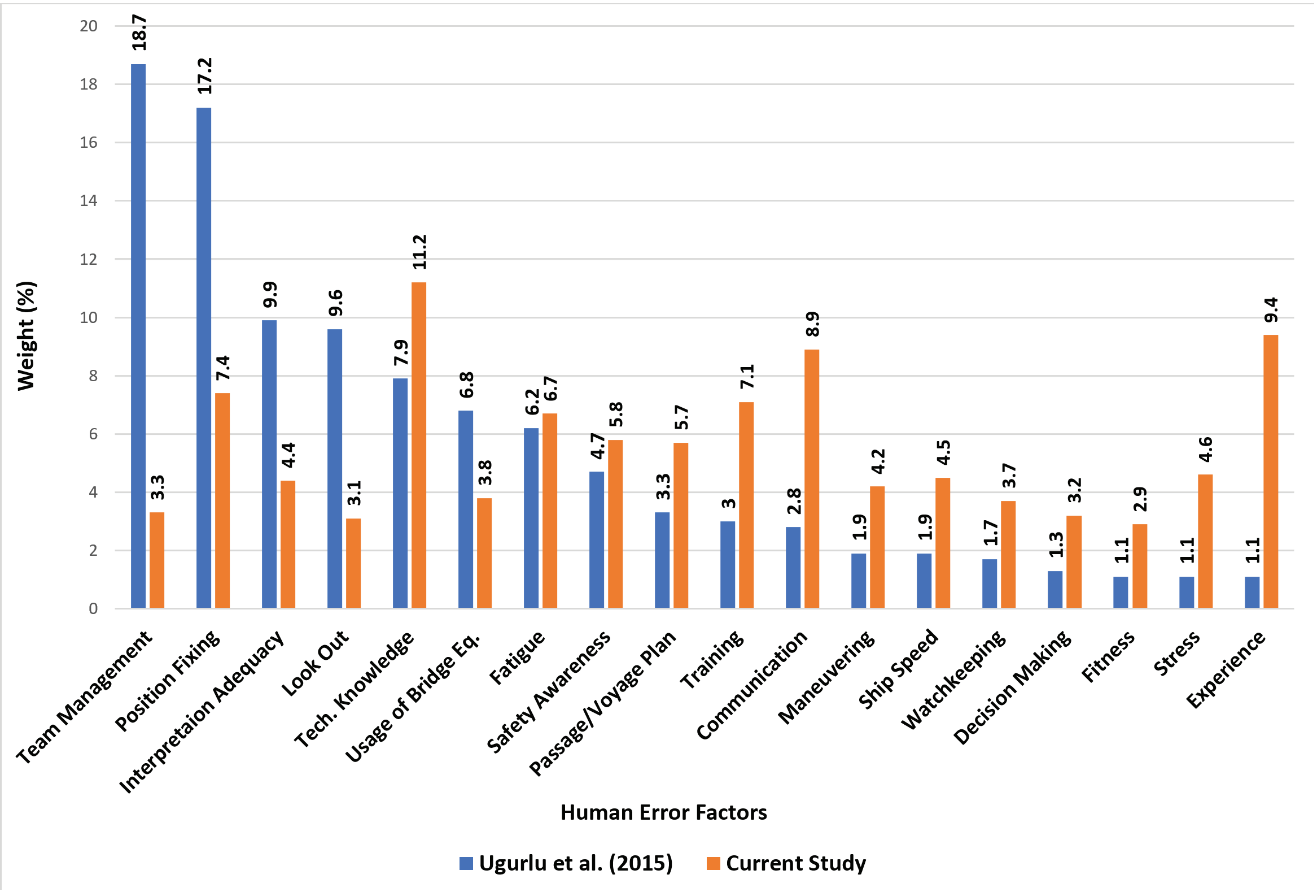

Fig. 4. Comparison between Uğurlu et al. (2015) and the current study corresponding factors' weight

CONCLUSION

The aim of this paper was to study, identify, and prioritize the most important human error factors related to maritime accidents in an attempt to control and reduce their potentiality in the future by considering the suitable preventive measures and to consequently increase the maritime safety level. Motivated by this aim, the study presented a specially designed questionnaire, completed by 51 experts from the maritime field to identify the most important HEFs related to maritime accidents. Based on their judgements, this questionnaire was analyzed using AHP technique. The results showed the most influential factors on maritime accidents based on the participants' perspective; which are technical knowledge, risk tolerance, experience, communication, position fixing, training, skills, and fatigue factors that have scored significantly high weights, agreeing with several studies and researches that investigate human error factors related maritime accidents, e.g. Özdemir et al. (2018), EMSA – EMCIP (2020), and EMSA – EMCIP (2022). This could help the decision makers to adopt the most suitable solutions to neutralize those factors and to subsequently enhance the skills and performance of seafarers towards achieving higher safety levels. However, the results reported herein cannot be generalized without taking the limitations encountered during conducting this research into consideration. Two such limitations were dictated by the time available to finish the research and the availability of a large number of experts to participate in the data collection process via the questionnaire.

RECOMMENDATIONS

Based on the present findings, it is verified that the lack of technical knowledge, inefficient communication skills, inappropriate risk tolerance and inaccurate risk assessment are the most important human error factors that have a significant impact on maritime accidents, in addition to the need for more technical training to enhance the seafarer's skills and experience. Therefore, Maritime Education and Training (MET) should focus more effectively upon the improvement of seafarers' technical and non-technical skills. In this regard, the following recommendations can be singled out:

- Providing periodical effective learning and training sessions to seafarers, in order to continuously enhance their technical and non-technical skills.
- Training programs should encompass maneuvering under emergency situations, whether critical environmental conditions or maneuvering in restricted areas; this improves the seafarer's risk tolerance, response, and perception. Also, the practical training should include working under stress and pressure; so, it could reduce seafarers' panic when facing critical situations.
- Regularly evaluating the emergency response protocols in high-risk regions to guarantee that all affected crew members are aware of them.
- Sticking to the following rules to reduce the risks of collision and grounding in high-risk locations: (i) keeping a close eye on the situation of a vessel and to conduct bridge watch constantly, and (ii) minimizing the chance of making poor or late decisions.

The findings of this paper could serve as a milestone for further studies to trace and identify more factors such as mechanical failure, environmental and weather conditions, that have an influential impact on maritime accidents and to adopt the best alternatives to reduce their potentiality, thus increasing the overall maritime safety level. Moreover, the impact of new technologies, such as artificial intelligence and virtual reality, on maritime safety deserves a separate investigation to augment the current endeavor.

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The Impact of Automation of Operational Processes and Its Role in Raising the Competitiveness of the Aden Container Terminal

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ABSTRACT

Purpose: *Ports are an essential pillar of economic development globally, as they contribute significantly to enhancing local and international trade exchange. Ports seek to improve their efficiency and provide high-quality services to meet customer needs. Consequently, many countries have developed their maritime capabilities using ICT, which has increased trade volume, reduced overall costs, and reduced port arrival time for ships. Since its emergence, container transportation has become vital in the field of logistics and global trade, as it contributes significantly to improving the efficiency of supply chains by simplifying shipping and tracking processes using modern technology, and effectively enhances local and international trade exchange.*

The study aims to investigate the impact of automation of operational processes on the competitiveness of the Aden Container Terminal, and to provide future directions and suggestions for enhancing competitiveness through the application of technology and automation.

Approach/Design/Methodology: *The researcher used the descriptive analytical approach, where a questionnaire was created to measure the impact of automation of operational processes at the Aden Container Terminal, and this data was analyzed using the SPSS program.*

Key-words:
Automation, Operational Processes, Competitiveness, Aden Container Terminal, Yemen.

INTRODUCTION

The globalization of the world economy has increased the role and importance of the maritime transport industry, particularly container transport. Maritime transport is the backbone of international trade and the global economy, with over 80 percent of global trade volume transported by sea worldwide. The United Nations Conference on Trade and Development (UNCTAD) estimated the total volume of maritime trade in 2019 at 11.08 billion tons (UNCTAD 2023).

Ports are a fundamental pillar and a vital supporter of economic development worldwide. They play a prominent role in enhancing trade exchange on both national and international levels. Ports have focused on improving efficiency and enhancing the quality of services provided to meet the needs of current and future customers. Many countries have made serious efforts to improve their maritime performance using Information and Communication Technology (ICT), leading to increased overall trade volume, reduced total costs, and reduced ship stay times at ports. Since its inception, container transportation has become a fundamental pillar in logistics and global trade, playing an undeniable role in improving the effectiveness and efficiency of supply chains. Container transportation enhances logistics operations by simplifying shipping and tracking processes using modern technology and effectively facilitates trade exchange on both national and international levels.

In modern shipping, port automation has become essential. It enhances efficiency and accuracy in loading and unloading operations, helps reduce delays and congestion at ports, and improves time and resource management by enabling continuous and efficient operations. Additionally, port automation improves cargo tracking and inventory management, reducing cargo losses and increasing transparency in transportation operations. Automation also contributes to providing better logistics services to customers and increasing their overall satisfaction.

Significance of the Study

The importance of studying automation lies in its significant contribution to enhancing the effectiveness and efficiency of logistics operations at ports, improving their performance, and transforming them into effective and safe work environments. Automation speeds up loading and unloading operations using smart equipment and robots, reducing waiting times and increasing port productivity.

This, in turn, improves customer experience and enhances port competitiveness. Thus, automation enhances efficiency and reduces costs at the port. This study analyzes the opportunities and challenges of applying automation at the Aden Container Terminal, a topic that has not been previously addressed, to derive conclusions about the expected impacts on the terminal's competitiveness.

Statement of the Problem

Regional and neighboring container terminals to the Aden Container Terminal have seen significant development in their use of port technology, increasing their competitiveness. Despite the unique location of the Aden Container Terminal, the lack of necessary actions to develop it has negatively impacted its performance and reduced its operational efficiency and competitiveness. This has prevented the terminal from keeping pace with surrounding developments, while neighboring ports have increased their competitiveness. Additionally, lack of automation in various sections of the port poses a significant issue for the shipping industry and cargo management at the terminal. Hence, the question of the study arises: How can automation contribute to increasing the competitiveness of the Aden Container Terminal?

Objectives of the Study

The study aims to investigate the impact of automation of operational processes on the competitiveness of the Aden Container Terminal. Research objectives are:

- To identify the deficiencies and weaknesses that have affected the competitiveness of the Aden Container Terminal.
- To propose future visions and suggestions for applying automation and its role in enhancing the terminal's competitiveness.

Study variables

Study variables refer to the factors or elements that are being measured, manipulated, or observed in a research study or experiment. These variables can be classified into two main types:

- Independent Variables: These are the variables that the researcher intentionally manipulates or controls to observe their effect on other variables. Independent variables are also known as predictor variables or causal variables.
- Dependent Variables: These are the variables that are observed, measured, or recorded as outcomes in response to changes in the independent variables. Dependent variables

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are also known as outcome variables or response variables.

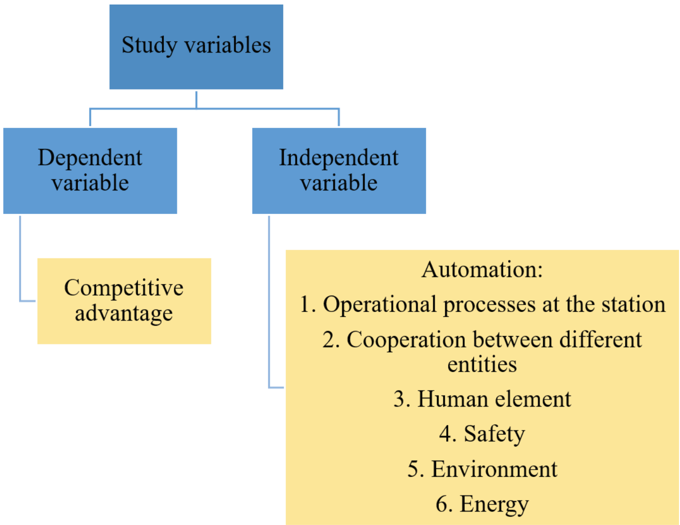

Fig. 1. Study variables (Source: The researcher)

Hypotheses of the Study

H1: There is a positive relationship between automation and the competitiveness of the Aden Container Terminal, branching into the following sub-hypotheses:

H 1-1: There is a positive relationship between operational processes and the competitiveness of the Aden Container Terminal.
H 1-2: There is a positive relationship between automation (cooperation between different entities) and the competitiveness of the Aden Container Terminal.
H 1-3: There is a positive relationship between human element and the competitiveness of the Aden Container Terminal.
H 1-4: There is a positive relationship between security and the competitiveness of the Aden Container Terminal.
H 1-5: There is a positive relationship between environment and the competitiveness of the Aden Container Terminal.
H 1-6: There is a positive relationship between energy and the competitiveness of the Aden Container Terminal.

METHODOLGY OF THE STUDY

The researcher used the descriptive analytical approach, combining both quantitative and qualitative methods. As the researcher works at the Aden Container Terminal, he is directly involved with the reasons for not adopting modern systems (automation) implemented in most modern seaports. A questionnaire was created to measure the impact of automation of operational processes at the Aden Container Terminal, and these data were analyzed using the SPSS program. Additionally, an analysis of the internal and external environment of the Aden Container Terminal (SWOT analysis) is conducted to identify strengths, weaknesses, opportunities, and threats.

Study Limits

- The research aims to study the Aden Container Terminal, which is part of the Port of Aden, the main port of Yemen and one of the largest natural ports in the world and the primary ports in the Gulf of Aden and the Red Sea (Qurdash, 2021).
- The study focuses on data and comparisons over five years, from 2019 to 2023.

LITERATURE REVIEW

Siyouh et al. (2017) highlighted the importance of maritime transport for the economy and Syrian ports. It aimed to understand the impact of electronic applications on the operation of Syrian ports by sending data electronically without human intervention, applied to the Port of Latakia. The researchers concluded that there is a good environment for using technological applications, the possibility of applying electronic data transmission, and the possibility of implementing VTS systems in the Port of Latakia. They recommended that the government reviews and amends legal systems to align with electronic business practices and international standards.

Gerlitz and Meyer (2021) aimed to address the limited administrative capacity of small and medium-sized ports in the European Union in terms of environmental responsibility and digital efficiency. It sought to bridge the gap between research and practice by improving decision-making capacity for small and medium-sized port service providers in pursuing sustainable and digital port services. The study recommended improving the limited administrative capacity of small and medium service providers regarding environmental responsibility and digital efficiency using proposed decision-making tools.

Heilig et al. (2017) analyzed digital transformations in seaports and their impact on port operations. It aimed to provide a comprehensive overview of seaport development, focusing on digital transformation, and to identify and explain the significant impacts of digital transformation, particularly in relation to smart ports. The study mentioned that digital transformation has a significant impact on port operations in terms of costs, efficiency, security, and sustainability, with terminal equipment integration enabling automation, leading to improved productivity and competitiveness.

Yang et al. (2018): This study compared traditional container terminals with automated container terminals using modern technology. It provided the following comparison as shown in Table 1:

Table 1: Comparison between Traditional Container Terminals and Automated Container Terminals.

Characteristics	Traditional Container Terminal	Automated Container Terminal
Operation	Workers and machines	Automated systems and equipment
Operations on the quay	Quay cranes	Semi-automatic/automatic quay cranes
Horizontal transport	Container trucks and extended carriers	Container trucks, extended carriers, AGVs
Container yard operations	Rubber-tyred gantry cranes	Automated rail-mounted gantry cranes
Operational efficiency	Labor-dependent, limited efficiency	Information-based, high efficiency
Economic efficiency	Low construction and maintenance costs, high labor and transport costs	High construction and maintenance costs, low labor and transport costs
Supervision and security control	Low reliability, slow response	High intelligence, high reliability, quick response, more secure
Environmental protection	High energy consumption, heavy pollution	Low energy usage, minimal pollution
Sustainability	No	Yes

Source: Yang et al. (2018)

Douaioui et al. (2018): This research aimed to define the concept of logistics intelligence and identify the main challenges that led researchers to consider the smart port. The study proposed a model for the smart port concept by identifying its core pillars and the essential components for the success of each pillar. Technology and innovation, the environmental dimension, operational excellence, security, and governance were among the core pillars identified by the study.

Schröder et al. (2017): This study explored the development of Industry 4.0 in logistics and its impact on port operations. It aimed to provide a comprehensive overview of Industry 4.0 development and to explain significant impacts on port operations. The study concluded that Industry 4.0 has a significant impact on port operations, particularly in terms of costs, efficiency, security, and sustainability. It recommended the integration of terminal equipment to enable automation and improve productivity and competitiveness.

The study of Meyer et al. (2021) aimed to investigate the impact of digital and environmental twinning perspective on assessing the readiness of small and medium-sized ports for sustainable development in the Baltic Sea region. The research relied on audit processes conducted in small and medium-sized ports in the Baltic Sea region. In total, 38 ports participated in the audit processes during the period from 2014 to 2020, which were conducted as organized interviews or through online surveys using a measurement model. The results revealed significant challenges facing small and medium-sized ports in this region, particularly lack of financial support from European financing programs. The results also highlighted the importance of these ports in promoting economic development at the regional level, acting as gateways to individual areas, and contributing to social, economic, and environmental transformation. Additionally, the results indicated that ports play a vital role in tracking innovation paths in port management and adapting to environmental goals set by the European Commission for the maritime sector for the periods 2030 and 2050. This responds to the challenges of innovation and development, enabling successful digital and environmental transformation in small and medium-sized ports. Therefore, it emphasizes the importance of assessing sustainable readiness to implement customized solutions based on individual needs and ensuring the effective use of available resources and capacities.

Digitization impacts all areas of maritime transport and logistics. The ability of ports to function as part of digital networks and information chains is crucial for their competitiveness. Hence, a study by Brunila et al. (2021) aimed to identify the challenges facing the adoption of digital technologies in the port sector, focusing on analyzing the problems and possible solutions. The study showed that the impact of digital technologies extends to all aspects of maritime transport and logistics services. The results emphasized the importance of the ability of ports to integrate into digital networks and information chains, which is essential for enhancing their competitiveness. To achieve this, the necessary requirements and infrastructure must be available for integration with modern technology platforms in various port operations. The results confirmed that the success of digital upgrade operations depends on advanced technological management, ensuring smooth interaction between systems and data transfer.

The study highlights the importance of evaluating the readiness of port operations to face these technological challenges and achieve sustainability and efficiency in adopting digital technologies.

The study of Elbayoumi (2022) aimed to measure the operational efficiency of the most important container terminals in the Middle East, which had the highest productivity in 2020. The study also aimed to measure the impact of operational efficiency on the competitiveness of container terminals in the Middle East region. The study recommended that Egyptian container terminals increase their productivity: Sokhna by 13%, Damietta by 30%, and Alexandria by 50%.

Qureshi (2021) discussed the current capacity of the Aden Container Terminal in light of the accelerating stages of service and technological progress of container terminals in the region, especially given the conflicting geopolitical interests in the Red Sea region. The research was classified as descriptive and quantitative analysis through comparisons, data collection, and analysis. The research was conducted by addressing previous studies that focused on the competitiveness of container terminals. The second stage involved analyzing the market structure by presenting and analyzing the competitive capacities of competing terminals in the region and evaluating the capacity of the Aden Container Terminal and competing terminals using HHI and CRN indices to determine competitive levels and monopolistic ratios among container terminals located in the specified geographic area in the research. In the third stage, the competitiveness of the Aden Container Terminal was analyzed using a SWOT analysis matrix.

Abdo et al. (2022) aimed to develop a proposal using the hierarchical analysis model to increase the competitiveness of the Aden Container Terminal during 2021. The hierarchical analysis model determines the relative importance of the variables used to determine the competitiveness of container terminals. The study found deficiencies and weaknesses in all selected variables to measure competitiveness, including waterway depth, storage area, quay length, and handling equipment. According to the hierarchical analysis model, it was found that the Aden Container Terminal suffers from a very poor performance level in all variables used. To enhance the competitiveness of the terminal, investments must be made in all variables under study, transforming them from very poor to good or very good performance levels. The study also showed that the Salalah Container Terminal ranked first in competitiveness among the studied container terminals, while the Djibouti Container Terminal ranked second.

Statistical Analysis

The study population consists of employees from various specialties at the Aden Container Terminal, totaling 1500 individuals. The study employed a stratified random sampling method. Therefore, a stratified random sample was selected from the employees at the Aden Container Terminal. The sample size was determined from the study population using the following equation:

$$n = \frac{N \times p(1-p)}{N - 1 \times (d^2 \div z^2) + p(1-p)}$$

Where:
- \(N \) = Population size
- \(n \) = Sample size
- \(z \) = Standard score corresponding to a 95% confidence level, which is 1.96
- \(d \) = Margin of error, which is 0.05
- \(p \) = Maximum proportion of the desired characteristics available in the study population, which is 0.50

The calculation of the required study sample size can be distributed across the study population compensatory in the preceding equation as follows:

$$n = \frac{1500 \times 0.5(1-0.5)}{1500 - 1 \times (0.05)^2 \div (1.96)^2 + 0.5(1-0.5)}$$

$$n = \frac{1500 \times 0.25}{1499 \times (0.0025) \div (3.8416) + 0.25}$$

$$n = \frac{375}{1499 \times (0.000650771) + 0.25}$$

$$n = \frac{375}{1.225504998}$$

$$n = 305.9963$$

Through substituting the values into the preceding equation, it becomes evident that the required sample size for the study distributed across the study population amounted to 306 individuals. Table 2 illustrates the distribution of the study sample across different categories of the study population, according to the representation of the proportion of each category in the study population.

The researcher relied on the stratified random sampling method from the study population at Aden Container Terminal, the study site, as the study population is heterogeneous, comprising a diverse group of workers with varying specialties, qualifications, and job titles, along with differences in their numbers at different administrative levels.

The researcher distributed the survey questionnaires to the different categories within the study site, and they were responded to by individuals in the sample with varying response rates. Table 2 illustrates the study population, sample, distributed questionnaires, retrieved questionnaires, and excluded questionnaires for all individuals in the study sample.

Table 2: The Distributed, Retrieved, and Excluded Questionnaires along with the Response Rate

Study Community	Sample Size	Distributed Surveys	Returned Surveys	Excluded Surveys	Response Rate
1500	306	306	282	24	92.16%

Source: The author

DESCRIPTIVE STATISTICS RESULTS

Analysis of Operational Process Automation Dimensions

Analysis of items after operational processes:

Table 3: Average, Standard Deviation, and Relative Importance of Items after Operational Processes

N.	Statement	Aver-age	S. D.	Relative Importance	Ranking
1	Automating operations at the Aden Container Terminal will contribute to improving operational efficiency.	3.12	0.628	62.48%	3
2	Automating operations at the terminal will lead to a reduction in the time required to process containers.	3.47	0.827	69.36%	1
3	The presence of a robust automation system at the terminal enhances the attractiveness of the port to logistics companies and shipping firms.	2.84	0.809	56.81%	5
4	Automating operations at the Aden Container Terminal will enhance the competitiveness of the station in the maritime shipping market.	3.24	0.588	64.75%	2
5	The presence of a strong automation system will lead to accuracy or error reduction.	3.03	0.581	60.64%	4
	Average	3.14	0.451	62.81%	

Source: The author

Data from table 3 indicate that the overall score of the sample individuals' responses to the items related to operational automation was moderate, with an arithmetic mean of 3.14 and a standard deviation of 0.451. The highest responses from the sample individuals were for the item stating, "Automation of operations at the terminal will reduce the time required to process containers," while the lowest responses from the sample individuals were for the item stating, "The presence of a strong automation system at the terminal enhances the attractiveness of the port to logistics companies and shipping companies."

Analysis of items of collaboration between different entities:

Table 4: Average, Standard Deviation, and Relative Importance of Items after Collaboration between Different Entities

N.	Statement	Aver-age	S. D.	Relative Importance	Ranking
1	Automating operations at the Aden Container Terminal will contribute to improving collaboration among different entities.	3.41	0.751	68.30%	2
2	There will be an improvement in communication between different departments at the terminal due to the automation of operations.	3.72	0.816	74.33%	1
3	Automating operations will facilitate operations and interaction between different entities.	3.14	0.717	62.84%	4
4	Automating operations will contribute to increasing the transparency of operations among different entities.	2.79	0.818	55.89%	5
5	Automating operations at the terminal will lead to improving the quality of service provided to customers.	3.29	0.674	65.74%	3
	Average	3.27	0.491	65.42%	

Source: The author

Data from table 4 indicate that the overall score of the sample individuals' responses to the items related to collaboration among different entities was moderate, with an arithmetic mean of 3.27 and a standard deviation of 0.491. The highest responses from the sample individuals were for the item stating, "There will be an improvement in communication between different departments at the terminal due to operational automation," while the lowest responses from the sample individuals were for the item stating, "Operational automation will contribute to increasing transparency of operations among different entities."

Analysis of items of human element:

Table 5: Average, Standard Deviation, and Relative Importance of Items after the Human Element

N.	Statement	Average	S. D.	Relative Importance	Ranking
1	Automating operations at the terminal will contribute to improving the working environment for employees.	3.35	0.676	67.09%	2
2	Automating operations will lead to reducing operational pressure on employees at the terminal.	3.06	0.662	61.13%	4
3	Automating operations at the terminal will contribute to reducing the risk of accidents resulting from human errors.	3.58	0.784	71.56%	1
4	Automating operations will lead to improving interaction between employees and management.	3.18	0.707	63.69%	3
5	Adopting modern technology in automating operations will contribute to enhancing employees' skills and capabilities.	2.88	0.843	57.59%	5
	Average	3.31	0.609	66.21%	

Source: The author

Data from table 5 indicate that the overall score of the sample individuals' responses to the items related to the human element dimension was moderate, with an arithmetic mean of 3.31 and a standard deviation of 0.609. The highest responses from the sample individuals were for the item stating, "Operational automation at the terminal will contribute to reducing the risk of accidents resulting from human errors," while the lowest responses from the sample individuals were for the item stating, "Adopting modern technology in operational automation will contribute to improving the skills and capabilities of employees."

Analysis of items of safety:

Table 6: Average, Standard Deviation, and Relative Importance of Items after Safety

N.	Statement	Average	S. D.	Relative Importance	Ranking
1	Employees at the terminal believe that there is a need to increase security awareness regarding technology and process automation.	3.33	0.769	66.60%	3
2	Workplace accidents or collisions are expected to decrease due to the automation of operations at the terminal.	3.17	0.746	63.48%	4
3	Automating operations may improve understanding and implementation of safety procedures at the terminal.	2.93	0.836	58.58%	5
4	Automating operations at the Aden Container Terminal will contribute to improving overall safety levels at the terminal.	3.45	0.786	69.01%	2
5	There are challenges in improving safety levels during the implementation of operation automation at the terminal.	3.67	0.849	73.40%	1
	Average	3.21	0.419	64.21%	

Source: The author

Data from table 6 indicate that the overall score of the sample individuals' responses to the items related to the safety dimension was moderate, with an arithmetic mean of 3.21 and a standard deviation of 0.726. The highest responses from the sample individuals were for the item stating, "There are challenges in improving safety levels during the implementation of operational automation at the terminal," while the lowest responses from the sample individuals were for the item stating, "Operational automation may improve the understanding and implementation of safety procedures at the terminal."

Analysis of items of environment:

Table 7: Mean, Standard Deviation, and Relative Importance of Items after Environment

N.	Statement	Aver-age	S. D.	Relative Importance	Ranking
1	There is a need for additional investments to improve the environmental impact of station operations.	3.51	0.801	70.28%	1
2	Automating operations at the Aden Container Terminal will contribute to enhancing the environmental efficiency of operations.	3.23	0.705	64.54%	3
3	Improvements in waste management and environmental impact reduction will occur due to the automation of operations.	2.96	0.744	59.29%	5
4	Automating operations will contribute to reducing environmental emissions and improving air quality in the vicinity of the terminal.	3.18	0.714	63.55%	4
5	There are challenges in improving the environmental impact during the implementation process of operation automation at the terminal.	3.37	0.725	67.38%	2
	Average	3.25	0.489	65.01%	

Source: the author

Data from table 7 indicate that the overall score of the sample individuals' responses to the items related to the environmental dimension was moderate, with an arithmetic mean of 3.25 and a standard deviation of 0.489. The highest responses from the sample individuals were for the item stating, "There is a need for additional investments to improve the environmental impact of the terminal's operations," while the lowest responses from the sample individuals were for the item stating, "There will be an improvement in waste management and a reduction in environmental impact due to operational automation."

Analysis of items of energy:

Table 8: Mean, Standard Deviation, and Relative Importance of Items after Energy

Ranking	Relative Importance	S. D.	Aver-age	Statement	N.
4	61.28%	0.775	3.06	Operational automation at the Aden Container Terminal will contribute to reducing energy consumption for operational processes.	1
3	62.77%	0.772	3.14	Operational automation will enhance the sustainability of energy use at the container terminal.	2
5	58.44%	0.857	2.92	Automation will increase the use of more efficient energy sources at the terminal.	3
2	64.96%	0.765	3.25	There is a need to improve integration between operational automation systems and energy management.	4
1	68.58%	0.863	3.43	There are challenges in improving the sustainability of energy use during the implementation of operational automation at the terminal.	5
	63.21%	0.661	3.16	**Average**	

Source: The author

Data from table 8 indicate that the overall score of the sample individuals' responses to the items related to the energy dimension was moderate, with an arithmetic mean of 3.16 and a standard deviation of 0.661. The highest responses from the sample individuals were for the item stating, "There are challenges in improving the sustainability of energy use during the implementation of operational automation at the terminal," while the lowest responses from the sample individuals were for the item stating, "Automation will increase the use of more efficient energy sources at the terminal."

Analysis of items of competitiveness:

Table 9: Mean, Standard Deviation, and Relative Importance of Items after Competitiveness

N.	Statement	Average	S. D.	Relative Importance	Ranking
1	Operational automation contributes to reducing waiting times for ships at the Aden Container Terminal.	3.43	0.683	68.65%	3
2	Automation improves the accuracy and quality of operations at the Aden Container Terminal.	3.36	0.698	67.16%	4
3	Operational automation increases the efficiency of resource utilization at the Aden Container Terminal.	2.86	0.808	57.23%	10
4	Automation helps in reducing operational errors at the terminal.	2.96	0.784	59.22%	9
5	Automation provides accurate and real-time information to aid in managerial decision-making.	3.07	0.777	61.35%	8
6	Improving automation makes the Aden Container Terminal more competitive compared to other terminals in the region.	3.57	0.816	71.35%	2
7	Investing in automation technology is economically viable for the Aden Container Terminal.	3.15	0.756	63.05%	7
8	Automation helps in enhancing safety and security at the terminal.	3.29	0.717	65.89%	5
9	Automation contributes to improving customer satisfaction.	3.85	0.875	77.09%	1
10	Automation enhances the capacity of the Aden Container Terminal to handle the increasing volume of containers.	3.23	0.664	64.61%	6
	Average	3.28	0.429	65.56%	

Source: The author

Data from table 9 indicate that the overall score of the sample individuals' responses to the items related to the competitiveness dimension was moderate, with an arithmetic mean of 3.28 and a standard deviation of 0.429. The highest responses from the sample individuals were for the item stating, "Automation contributes to improving customer satisfaction," while the lowest responses from the sample individuals were for the item stating, "Operational automation increases the efficiency of resource utilization at the Port of Aden Container Terminal."

Hypotheses Testing

The main hypothesis of the study states that: There is a positive relationship between the automation of operational processes and the competitiveness of the Aden Container Terminal. This hypothesis has been divided into the following sub-hypotheses:

First sub-hypothesis: There is a positive relationship between operational processes and the competitiveness of the Aden Container Terminal.
To test this hypothesis, the researcher conducted several tests as follows:

Correlation coefficient

Table 10 illustrates the correlation coefficient between operational processes as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 10: Correlation Coefficient for Sub-Hypothesis One

Variable	Test	The competitive capability of the Aden Container Terminal
Operational processes	Correlation coefficient	0.724
	Significance	0.000

Source: The author

Table 10 indicates a statistically significant correlation of 72.4% at a significance level of 0.05 between operational processes and the competitive capability of the Aden Container Terminal.

Coefficient of determination

Table 11: Coefficient of Determination for Sub-Hypothesis One

Independent variable	Coefficient of determination	Adjusted coefficient of determination	Standard error
Operational processes	0.525	0.523	0.2967

Source: The author

Table 11 indicates that the coefficient of determination (R^2 = 0.525), which means that operational processes explain 52.5% of the variation in the competitive capability of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression model, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

Analysis of variance (ANOVA) test

Table 12: Analysis of Variance for Sub-Hypothesis One

Title	Sum of squares	Degrees of freedom	Mean square	F	Significance
Regression	27.232	1	27.232	309.32	0.000
Residuals	24.651	280	0.088		
Total	51.884	281			

Source: The author

Table 12 indicates a significant positive correlation between operational processes and the competitive capability of the Aden Container Terminal. This is evident from the \(F \) value, which is statistically significant at the 0.05 level. This signifies the validity and importance of the relationship between the variables and underscores the reliability of relying on the results without errors.

Regression analysis

Table 13: Regression Results Analysis for Sub-Hypothesis One

Model	Non-standardized Coefficients		Standardized Coefficients	t-Test	Significance
	Beta	Standard Error	Beta		
Constant	1.106	0.125	0.724	8.863	0.000
Operational processes	0.692	0.039		17.587	0.000

Source: The author

Table 13 shows that the values of the "t-test" for the variable of the operational processes are statistically significant at a significance level of 0.05. This indicates the strength of the regression relationship between operational processes and the competitiveness of the Aden Container Terminal.

From the preceding tables, one can infer the following:

- The significance level of both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between operational processes and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient suggests a positive linear relationship between operational processes and the competitiveness of the Aden Container Terminal.
- The significance level of the overall regression equation (F-test) was less than 0.05, indicating the reliability of the estimated regression model and the possibility of generalizing the sample results to the study population.
- The beta coefficients indicate that operational processes influence the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation is unlikely to be due to chance.
- Based on the above, the researcher can accept the hypothesis that there is a positive relationship between operational processes and the competitiveness of the Aden Container Terminal.

The second sub-hypothesis states: There is a positive relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

Correlation coefficient:

Table 14 illustrates the correlation coefficient between collaboration among different entities as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 14: Correlation Coefficients for Sub-Hypothesis Two

Variable	Test	The competitive capability of the Aden Container Terminal
Collaboration among different entities	Correlation coefficient	0.809
	Significance	0.000

Source: The author

From table 14, it is evident that there is a statistically significant correlation of 80.9% at a significance level of 0.05 between collaboration among different entities and the competitiveness of the Aden Container Terminal.

Coefficient of determination

Table 15: Coefficient of Determination for Sub-Hypothesis Two

Independent variable	Coefficient of determination	Adjusted coefficient of determination	Standard error
Collaboration among different entities	0.654	0.653	0.2531

Source: The author

Table 15 shows that the coefficient of determination (R^2 = 0.654), indicating that collaboration among different entities explains 65.4% of the variability in the competitiveness of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression relationship, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

The analysis of variance (ANOVA) test

Table 16: Analysis of Variance for Sub-Hypothesis Two

Title	Sum of squares	Degrees of freedom	Mean square	F	Significance
Regression	33.953	1	33.953	530.22	0.000
Residuals	17.93	280	0.064		
Total	51.884	281			

Source: The author

From table 16, it is evident that there is a statistically significant positive correlation between collaboration among different entities and the competitiveness of the Aden Container Terminal. This is demonstrated by the F-value, which is statistically significant at a significance level of 0.05. This indicates the validity and substance of the relationship between the variables, ensuring the quality of the framework and the reliability of the results without errors.

Regression analysis:

Table 17:Regression Results Analysis for Sub-Hypothesis Tw.

Model		Non-standardized Coefficients		Standardized Coefficients	t-Test	Significance
		Beta	Standard Error	Beta		
1	Constant	0.958	0.102	0.809	9.397	0.000
	Collaboration among different entities	0.709	0.031		23.026	0.000

Source: The author

From table 17, it is evident that the t-test values for the variable of collaboration among different entities are statistically significant at a significance level of 0.05. This indicates the strength of the regression relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal.

From the preceding tables, one can conclude the following:

- The significance level of both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient suggests a positive linear relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal.
- The significance level of the overall regression equation (F-test) was less than 0.05, indicating the reliability of the estimated regression model and the possibility of generalizing the sample results to the study population.
- The beta coefficients indicate that collaboration among different entities influences the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation is unlikely to be due to chance.
- Based on the above, the researcher can accept the hypothesis that there is a positive relationship between collaboration among different entities and the competitiveness of the Aden Container Terminal.

The third sub-hypothesis states: There is a positive relationship between the human element and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

Correlation coefficient:

Table 18 illustrates the correlation coefficient between the human element as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 18: Correlation Coefficients for Sub-Hypothesis Three

Variable	Test	The competitive capability of the Aden Container Terminal
Human element	Correlation coefficient	0.821
	Significance	0.000

Source: the author

From table 18, it is evident that there is a statistically significant correlation of 82.1% at a significance level of 0.05 between the environment and the competitiveness of the Aden Container Terminal.

Coefficient of determination

Table 19: Coefficient of Determination for Sub-Hypothesis Three

Independent variable	Coefficient of determination	Adjusted coefficient of determination	Standard error
Human element	0.674	0.673	0.2458

Source: The author

Table 19 indicates that the coefficient of determination (R^2 = 0.783), which means that the human element explains 78.3% of the variation in the competitive capacity of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression equation, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

The analysis of variance (ANOVA) test

Table 20: Analysis of Variance for Sub-Hypothesis Three

Title	Sum of squares	Degrees of freedom	Mean square	F	Signifi-cance
Regression	34.963	1	34.963	578.57	0.000
Residuals	16.92	280	0.06		
Total	51.884	281			

Source: The author

Table 20 indicates a statistically significant negative correlation between the human element and the competitive capacity of the Aden Container Terminal, as shown by the F-value. This statistical significance at the 0.05 level confirms the validity and substantiality of the relationship between the variables, ensuring the reliability of relying on the results without errors.

Regression analysis:

Table 21: Regression Analysis Results for Sub-Hypothesis Three

Model		Non-standardized Coefficients		Standardized Coefficients	t-Test	Signifi-cance
		Beta	Standard Error	Beta		
1	Constant	0.576	0.113	0.821	5.086	0.000
	Human element	0.842	0.035		24.054	0.000

Source: the author

Table 21 shows that the t-test values for the human element variable are statistically significant at the 0.05 significance level, indicating the strength of the regression relationship between the human element and the competitive capacity of the Aden Container Terminal.

From the preceding tables, one can conclude the following:

- The significance level of both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between the human element and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient indicates a positive linear relationship between the human element and the competitiveness of the Aden Container Terminal.
- The significance level of the overall regression equation (F-test) was less than 0.05, suggesting the reliability of the estimated regression model and the possibility of generalizing the sample results to the study population.
- The beta coefficients suggest that the human element influences the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation is unlikely to be due to chance.
- Based on the above, the researcher can accept the hypothesis that there is a positive relationship between the human element and the competitiveness of the Aden Container Terminal.

The fourth sub-hypothesis states: There is a positive relationship between safety and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

Correlation coefficient:

Table 22 illustrates the correlation coefficient between safety as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 22: Correlation Coefficient for the Fourth Sub-Hypothesis

Variable	Test	The competitive capability of the Aden Container Terminal
Security	Correlation coefficient	0.747
	Significance	0.000

Source: The author

From table 22, it is evident that there is a statistically significant correlation of 74.7% at a significance level of 0.05 between safety and the competitiveness of the Aden Container Terminal.

Coefficient of determination

Table 23: Coefficient of Determination for the Fourth Sub-Hypothesis

Independent variable	Coefficient of determination	Adjusted coefficient of determination	Standard error
Security	0.557	0.556	0.2864

Source: The author

Table 23 indicates that the coefficient of determination (R^2 = 0.557), meaning that safety explains 55.7% of the variability in the competitiveness of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression relationship, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

The analysis of variance (ANOVA) test

Table 24: Analysis of Variance for the Fourth Sub-Hypothesis

Title	Sum of squares	Degrees of freedom	Mean square	F	Significance
Regression	28.925	1	28.925	352.76	0.000
Residuals	22.959	280	0.082		
Total	51.884	281			

Source: The author

From table 24, it is evident that there is a statistically significant positive correlation between safety and the competitiveness of the Aden Container Terminal. This is demonstrated by the F-value, which is statistically significant at a significance level of 0.05. This indicates the validity and substance of the relationship between the variables, ensuring the quality of the framework and the reliability of the results without errors.

Regression analysis:

Table 25: Regression Analysis Results for the Fourth Sub-Hypothesis

Model		Non-standardized Coefficients		Standardized Coefficients	t-Test	Significance
		Beta	Standard Error	Beta		
1	Constant	1.533	0.094	0.747	16.235	0.000
	Safety	0.527	0.028		18.782	0.000

Source: The author

From table 25, it is evident that the t-test values for the safety variable are statistically significant at a significance level of 0.05. This indicates the strength of the regression relationship between safety and the competitiveness of the Aden Container Terminal.

From the preceding tables, one can infer the following:

- The significance level of both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between safety and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient suggests a positive linear relationship between safety and the competitiveness of the Aden Container Terminal.
- The significance level of the overall regression equation (F-test) was less than 0.05, indicating the reliability of the estimated regression model and the possibility of generalizing the sample results to the study population.
- The beta coefficients indicate that safety influences the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation is unlikely to be due to chance.
- Based on the above, the researcher can accept the hypothesis that there is a positive relationship between safety and the competitiveness of the Aden Container Terminal.

The fifth sub-hypothesis states: There is a positive relationship between the environment and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

Correlation coefficient:

Table 26 illustrates the correlation coefficient between the environment as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 26: Correlation Coefficient for the Fifth Sub-Hypothesis

Variable	Test	The competitive capability of the Aden Container Terminal
Environment	Correlation coefficient	0.811
	Significance	0.000

Source: The author

Table 26 shows a statistically significant correlation of 81.1% at a 0.05 significance level between the environment and the competitiveness of the Aden Container Terminal.

Coefficient of determination

Table 27: Coefficient of Determination for the Fifth Sub-Hypothesis

Independent variable	Coefficient of determination	Adjusted coefficient of determination	Standard error
Environment	0.658	0.657	0.2516

Source: The author

Table 27 indicates that the coefficient of determination (R^2 = 0.658), meaning that the environment explains 65.8% of the variability in the competitiveness of the Aden Container Terminal. The remaining percentage is explained by other variables not included in the regression relationship, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

The analysis of variance (ANOVA) test

Table 28: Analysis of Variance for the Fifth Sub-Hypothesis

Title	Sum of squares	Degrees of freedom	Mean square	F	Significance
Regression	34.162	1	34.162	539.75	0.000
Residuals	17.722	280	0.063		
Total	51.884	281			

Source: The author

Table 28 clearly shows a significant positive correlation between the environment and the competitiveness of the Aden Container Terminal. This is evident from the F-value, which is statistically significant at a 0.05 significance level, indicating the validity and substance of the relationship between the two variables, the quality of the framework, and the reliability of the results without errors.

Regression analysis:

Table 29: Regression Analysis Results for the Fifth Sub-Hypothesis

Model		Non-standardized Coefficients		Standardized Coefficients	t-Test	Significance
		Beta	Standard Error	Beta		
1	Constant	0.959	0.101	0.811	9.495	0.000
	Environment	0.714	0.031		23.232	0.000

Source: The author

Table 29 shows that the t-test values for the environment variable are statistically significant at a 0.05 significance level. This indicates the strength of the regression relationship between the environment and the competitiveness of the Aden Container Terminal.

One can conclude from the preceding tables the following:

- The significance level for both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between the environment and the competitive capacity of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient implies a statistically significant positive correlation between the environment and the competitive capacity of the Aden Container Terminal.
- The significance level for the overall regression equation (F-test) was less than 0.05, suggesting that we can rely on the estimated regression model and therefore generalize the sample results to the study population.
- The Beta coefficient values indicate that the environment affects the competitive capacity of the Aden Container Terminal to varying degrees, and this interpretation cannot be attributed to chance.
- Therefore, the researcher can accept the hypothesis that there is a positive relationship between the environment and the competitive capacity of the Aden Container Terminal.

The sixth sub-hypothesis states: There is a positive relationship between energy and the competitiveness of the Aden Container Terminal. To test this hypothesis, the researcher conducted several tests as follows:

Correlation coefficient:

Table illustrates the correlation coefficient between energy as an independent variable and the competitiveness of the Aden Container Terminal as a dependent variable.

Table 30: Correlation Coefficient for the Sixth Sub-Hypothesis

Variable	Test	The competitive capability of the Aden Container Terminal
Energy	Correlation coefficient	0.736
	Significance	0.000

Source: The author

The preceding table indicates a statistically significant correlation of 73.6% at a significance level of 0.05 between energy and the competitiveness of the Aden Container Terminal.

Coefficient of determination

Table 31: Coefficient of Determination for the Sixth Sub-Hypothesis

Independent variable	Coefficient of determination	Adjusted coefficient of determination	Standard error
Energy	0.541	0.541	0.2916

Source: The author

The preceding table indicates that the coefficient of determination ($R^2 = 0.541$), which means that energy explains 54.1% of the variation in the competitive capacity of the Aden Container Terminal. The remaining percentage is explained by other variables that were not included in the regression relationship, in addition to random errors resulting from sampling methods, measurement accuracy, and other factors.

The analysis of variance (ANOVA) test

Table 32: Analysis of Variance for the Sixth Sub-Hypothesis

Title	Sum of squares	Degrees of freedom	Mean square	F	Significance
Regression	28.084	1	28.084	330.39	0.000
Residuals	23.8	280	0.085		
Total	51.884	281			

Source: The author

The preceding table indicates a statistically significant positive correlation between energy and the competitiveness of the Aden Container Terminal. This is evident from the F-value, which is statistically significant at a significance level of 0.05. This signifies the validity and substance of the relationship between the variables, ensuring the quality of the framework and the reliability of the results without errors.

Regression analysis:

Table 33: Regression Analysis Results for the Sixth Sub-Hypothesis

Model		Non-standardized Coefficients		Standardized Coefficients	t-Test	Significance
		Beta	Standard Error	Beta		
1	Constant	1.767	0.085	0.736	20.805	0.000
	Energy	0.478	0.026		18.177	0.000

Source: The author

Table 33 indicates that the "t" test values for the energy variable are statistically significant at a significance level of 0.05. This demonstrates the strength of the regression relationship between energy and the competitive capacity of the Aden Container Terminal.

From the preceding tables, the following conclusions can be drawn:

- The significance level for both the Pearson correlation coefficient and the regression coefficient was less than 0.05, indicating a statistically significant relationship between energy and the competitiveness of the Aden Container Terminal.
- The positive sign of the Pearson correlation coefficient indicates a positive relationship between energy and the competitiveness of the terminal.
- The significance level for the overall regression equation (F-test) was less than 0.05, suggesting that the estimated regression model can be relied upon and that the sample results can be generalized to the study population.
- The Beta coefficients indicate that energy affects the competitiveness of the Aden Container Terminal to varying degrees, and this interpretation cannot be attributed to chance.
- Therefore, the researcher can accept the hypothesis that there is a positive relationship between energy and the competitiveness of the Aden Container Terminal.
- From these results, the validity of the study's main hypothesis is evident, namely the presence of a positive relationship between the automation of operational processes and the competitiveness of the Aden Container Terminal.

RESULTS

The study revealed several key findings:

- A significant relationship exists between automating operational processes and boosting competitiveness at Aden Container Terminal.
- The absence of a robust automation system for operational processes diminishes the appeal of the terminal to logistics companies and shipping firms, thereby negatively affecting its ability to fulfill commitments to predetermined customers.
- Implementing automation in operational processes at the terminal and providing suitable equipment in terms of size, modernity, and quantity lead to a reduction in the time required for container handling and ensure the attainment of desired quality in task completion.

- Developing comprehensive plans for integrating process automation enhances communication, cooperation, and coordination among different departments at the terminal, thereby facilitating development, improvement, and enhanced coordination of activities.
- Insufficient investment in modern technology and resources for automation negatively impacts the development of employees' skills, capabilities, and experiences.
- Automation of processes at the terminal helps mitigate the risk of accidents resulting from human errors and ensures the effective implementation of plans, work programs, evaluation of results, and alignment with set standards.
- Challenges exist in improving safety levels during process automation at the terminal due to inadequate attention to defining objectives, strategies, mechanisms, and developing various scenarios for implementing an effective safety and security system.
- Increased investment in enhancing environmental impact and operational processes at the terminal is crucial for adapting to changing variables and ensuring sustainability.
- Developing a more effective strategy for utilizing energy sources at the terminal is essential to improve performance, achieve strategic objectives, develop service delivery methods, and introduce new services relying on process automation.

RECOMMENDATION

Based on these findings, the following recommendations are suggested:

- Emphasizing the strong correlation between automating operational processes and enhancing competitiveness at Aden Container Terminal and leverage the positive effects of automation to boost competitiveness.
- Implementing a robust automation system for operational processes at the terminal to enhance its attractiveness to logistics companies and shipping firms, thereby meeting commitments to predetermined customers effectively.
- Focusing on achieving automation of operational processes and providing appropriate equipment to reduce container handling time and ensure high-quality task completion.
- Developing comprehensive plans for integrating process automation to enhance communication, cooperation, and coordination among different departments at the terminal.
- Investing in modern technology and resources to support automation, thereby enhancing employees' skills, capabilities, and experiences.
- Prioritizing automation of processes to mitigate the risk of accidents resulting from human errors and ensure compliance with set standards.
- Addressing challenges in improving safety levels during process automation by defining objectives, strategies, mechanisms, and implementing effective safety and security measures.
- Increasing investment in improving environmental impact and operational processes at the terminal to adapt to changing variables effectively.
- Developing a comprehensive strategy for utilizing energy sources at the terminal to enhance performance, achieve strategic goals, and introduce innovative services relying on process automation.

Future studies could explore the long-term effects of advanced automation technologies and artificial intelligence on the sustainability and strategic growth of the Aden Container Terminal, including the potential for integrating emerging technologies such as blockchain for enhanced security and transparency, the impact on workforce dynamics and training needs, and the environmental implications of automation. Additionally, comparative studies with other leading global container terminals could provide further insights into best practices and innovative solutions for maintaining and enhancing competitiveness.

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Teaching Strategies, Pedagogical Competence, And Challenges Among Maritime Professional Instructors Of Maritime Higher Education Institutions (MHEIs): Bases For An Enhancement Program

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ABSTRACT

Purpose: *This study aims to investigate the teaching strategies, pedagogical competence, and challenges encountered by maritime professional instructors in Maritime Higher Education Institutions (MHEIs) to inform the development of an enhancement program.*

Approach/Design/Methodology: *A descriptive-comparative design was employed, utilizing a quantitative approach to examine the teaching strategies, pedagogical competence, and challenges faced by 75 maritime professional instructors selected through stratified random sampling. Data were gathered using a researcher-made instrument consisting of four parts, with its validity established through expert validation and reliability ensured via pilot testing using Cronbach's Alpha method.*

Findings: *The results indicated that the most prevalent teaching strategies among maritime professional instructors included quizzes, tests, discussions, demonstrations, hands-on activities, practical exercises, and lectures enhanced by interactive techniques. The instructors exhibited a very high level of pedagogical competence overall and across various categories, including rank, teaching experience, educational attainment, and classification. Nonetheless, they encountered significant challenges such as financial concerns, limited resources and skills, and fatigue stemming from inadequate sleep.*

Research Implications: *The study underscores the importance of a balanced approach that integrates traditional and interactive teaching methods to foster comprehensive learning in maritime education. The high level of pedagogical competence among instructors highlights their effectiveness in facilitating meaningful learning experiences. Furthermore, the findings suggest that factors such as training in instructional methods and industry expertise may be more critical in developing effective teaching skills than conventional indicators like rank, experience, or educational background.*

Practical Implications: *Educational institutions should consider addressing the challenges faced by maritime professional instructors by providing support systems and resources that enhance teaching efficacy and well-being. Additionally, promoting ongoing professional development focused on instructional methods and practical skills can further strengthen the pedagogical competence of instructors, ultimately benefiting student learning outcomes in maritime education.*

Key-words:
Demonstrations, Fatigue, Financial concerns, Hands-on activities, Lectures, Limited sources and skills, Practical exercises, Quizzes, Tests, Marine Education & Training - Marine Higher Education Institution- Maritime Professional Instructor.

INTRODUCTION

Maritime education has undergone significant evolution in response to the dynamic demands of the maritime industry. Initially rooted in vocational training, it has expanded to include interdisciplinary academic fields that align with stakeholder requirements (Martínez De Osés & Ventura Jariod, 2021). The global quality of maritime education is critical, as it plays an essential role in training individuals for safe and proficient navigation of the oceans. This quality is heavily dependent on the competencies of instructors who impart vital knowledge and skills to future seafarers (Vujičić et al., 2020; Wulandari et al., 2020).

To maintain high standards, the International Convention on Standards of Training, Certification and Watchkeeping (STCW Convention) establishes requirements for instructor qualifications in Maritime Education and Training (MET) institutions (Kuzmenko & Kutsenko, 2018). In the Philippines, the Maritime Industry Authority (MARINA) has implemented the Continuing Development Training program for instructors and assessors to ensure they remain current with industry standards (MARINA Circular No. SC-2024-01, 2024). The Commission on Higher Education (CHED) further reinforces these standards by mandating specific requirements for maritime education, collaborating with MARINA and the Technical Education and Skills Development Authority (TESDA) to enhance educational quality and outcomes.

In the 21st century, educational practices are undergoing substantial transformations to meet societal needs. The pedagogical competence of teachers is vital for effective education delivery, requiring transversal skills like critical thinking, interpersonal skills, and media literacy (Tkachenko et al., 2023). Continuous enhancement of pedagogical competence is essential for educators to keep pace with innovation and evolving student needs (Halder, 2023).

For maritime professional instructors, pedagogical competence is crucial, as it directly influences teaching effectiveness and the development of seafarers' knowledge and safety standards (Victoriano et al., 2022). While seafarers-turned-instructors bring valuable experience, they must continuously update their skills to provide relevant instruction (Vujičić et al., 2020). Instructors should not only possess subject matter expertise and shipboard experience but also a genuine passion for teaching, which fosters an engaging learning environment.

Despite holding the required bachelor's degrees, many maritime instructors lack formal training in teaching methodologies. Pursuing advanced degrees or specialized training can help bridge this gap, equipping them with vital teaching strategies, classroom management techniques, and assessment methods. This ongoing professional development benefits both instructors and students, ensuring the delivery of quality education.

The inconsistency in teaching strategies and competencies due to a lack of formal training poses a significant gap in MET. This gap can lead to inadequately trained seafarers, making the educational process challenging for students. Effective monitoring of learning outcomes is essential for improving education quality and addressing these challenges (Estimo, 2020).

This study aims to assess the pedagogical competence of maritime instructors in higher education institutions by identifying the teaching strategies utilized and the challenges faced. The findings will inform an enhancement program to improve the overall quality and effectiveness of maritime education and training.

This study is grounded in Constructivism Theory, as proposed by Jean Piaget (1977), which emphasizes that individuals learn from their experiences and reflections. Constructivism promotes a learner-centered approach, where teachers facilitate learning through engaging activities such as project work and inquiry-based learning. This methodology encourages outdoor lessons and interactions with the environment, fostering a deeper connection between students and the maritime context.

Incorporating Constructivism into the pedagogical practices of maritime instructors supports inquiry-based learning and reflective practices, which are essential for developing critical thinking and adaptability. By tailoring teaching methods to meet diverse student needs, maritime instructors can prepare future professionals for the dynamic challenges of the maritime industry while ensuring a comprehensive educational experience.

Thus, the main purpose of this study is to determine the teaching strategies, pedagogical competence of maritime professional instructors in MHEIs, and the challenges encountered in the delivery of instruction as bases for an enhancement program.

Specifically, it seeks answers to the following questions: a) What are the teaching strategies used by the maritime professional instructors of

Maritime Higher Education Institutions? b) What is the level of pedagogical competence of maritime professional instructors when taken as a whole group and when classified according to rank, length of teaching experience, highest educational attainment, and classification of instructors? c) What are the challenges encountered by Maritime Professional Instructors in the delivery of instructions? d) Is there a significant difference in the pedagogical competence of maritime professional instructors when grouped according to rank, length of teaching experience, highest educational attainment, and classification of instructors? e) What enhancement program can be designed to enhance the teaching strategies of the maritime professional instructors?

METHODOLOGY

This study employed a descriptive-comparative design with a quantitative approach to investigate the pedagogical competence of maritime professional instructors in maritime higher education institutions (MHEIs) and the challenges they face in delivering instruction. The descriptive-comparative design was deemed appropriate for this research as it allows for the exploration of prevailing opinions and beliefs, processes, and emerging trends without manipulating independent variables. By utilizing this design, the study aimed to describe and analyze the conditions that exist among the instructors, uncovering relationships between various non-manipulative factors.

The respondents for this study were 75 maritime professional instructors, including those from deck, engine, and technical allied disciplines, drawn from a total of 92 instructors through stratified random sampling. A researcher-made questionnaire was developed, consisting of four parts: demographic information (Part I), a checklist of teaching strategies used (Part II), a questionnaire assessing pedagogical competence (Part III), and a list of challenges encountered in instruction (Part IV). The pedagogical competence section included 20 items validated by experts, achieving a high reliability index using a 5-point Likert scale to gauge responses, where higher scores indicated greater competence.

To ensure the validity and reliability of the questionnaire, it underwent a rigorous validation process involving five experts who provided feedback based on established criteria. The instrument received a mean score of 4.64, indicating excellent validity. Reliability was assessed through a pilot test conducted with 30 educators, utilizing the Cronbach Alpha Method, yielding a reliability coefficient of .946, which reflects high consistency in the data collection instrument. Following validation and reliability testing, the questionnaire was administered face-to-face to respondents, ensuring they were informed about the study purpose and scope and that consent was obtained.

Data collected from the questionnaires were tallied and analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including frequency counts, percentage distributions, means, and standard deviations, were used to summarize demographic data and assess teaching strategies and encountered challenges. Inferential statistics, specifically the t-test for Independent Samples and One-Way ANOVA, were employed to evaluate significant differences in pedagogical competence based on rank, teaching experience, educational attainment, and instructor classification. The findings from this research will inform the development of an enhancement program aimed at improving the teaching strategies of maritime professional instructors.

RESULTS

Teaching Strategies Used by Maritime Professional Instructors of Maritime Higher Education Institutions

Results suggest that while these strategies can effectively motivate students and encourage critical thinking, problem-solving, collaboration, and creativity, they may only sometimes be the most effective for achieving desired learning outcomes in maritime education.

According to Frias et al. (2022), role-playing, case studies, project-based learning, reflections, and journal writing are beneficial for motivation and critical thinking in maritime education but may not be always effective in achieving desired learning outcomes.

Integrating traditional and interactive approaches enhances the effectiveness of teaching strategies. The findings align with research emphasizing the importance of using various methods to encourage critical thinking, active participation, and deeper understanding (Bean & Melzer, 2021).

Table 1: Frequency and Rank for Teaching Strategies Used by Maritime Professional Instructors

Teaching Strategies	Frequency	Rank
• Quizzes and Tests	155	1
• Discussions	153	2
• Demonstrations	150	3
• Hands-on/Practical Activities/ Exercises	146	4
• Lecture	145	5

• Questioning	139	6
• Interactive Lecture	134	7
• Laboratory Exercises	132	8
• Assignments	131	9
• Assessments and Feedback	123	10
• Student Reporting	111	11
• Simulation-based Training	97	12
• Scenario-based Learning	92	13
• Collaborative Learning	90	14
• Observations	83	15
• Rubrics	77	16
• Modeling	53	17
• Role Playing	44	18
• Case Studies	43	19
• Project-based Learning	36	20
• Reflections	36	20
• Journal Writing	26	22

Level of Pedagogical Competence of Maritime Professional Instructors When Grouped According to Profile

The results show that the pedagogical competence of maritime professional instructors is consistently rated "Very High," with an overall mean of 4.50 and a standard deviation of 0.438. Instructors with longer teaching experience demonstrate the highest competence, with a mean of 4.80 and a standard deviation of 0.122. It reflects their extensive knowledge, effective teaching methods, and significant influence on student learning, highlighting the importance of experience, ongoing professional development, and institutional support in promoting high-quality education and lifelong learning.

These findings are further validated by the study of Radkevych et al. (2023), which underscores the critical importance of enhancing pedagogical competence among maritime professional instructors to meet the demands of the rapidly evolving maritime industry.

Moreover, according to (Maryani et al., 2021), teachers with longer working experience and higher education levels show increased pedagogical competence, as experience and education positively impact professional development and teaching effectiveness.

Table 2: Summary Table of Pedagogical Competence of Maritime Professional Instructors According to Demographic Profile

Category		Mean	SD	Description
A.	Entire Group	4.50	.438	Very High
B.	Length of Teaching Experience			
	Longer	4.80	.122	Very High
	Middle	4.34	.657	Very High
	Shorter	4.51	.372	Very High
C.	Rank			
	Management Level	4.47	.452	Very High
	Operational Level	4.50	.448	Very High
D.	Highest Educational Attainment			
	Bachelor's Degree	4.48	.368	Very High
	Masteral	4.57	.477	Very High
	Doctorate	4.22	1.107	Very High
E.	Classification of Instructors			
	Deck	4.53	.359	Very High
	Engine	4.37	.589	Very High
	Allied	4.72	.162	Very High

Level of Pedagogical Competence of Maritime Professional Instructors When Grouped According to Rank

Operational level instructors demonstrate a strong ability to appreciate and motivate students' ideas while exhibiting a need for improvement in granting students more control over the learning process. Their overall pedagogical competence reflects effectiveness in teaching and engaging students, yet it also highlights the necessity to foster greater student autonomy alongside their motivational strategies. Similarly, management level instructors excel in motivating students and instilling good learning habits, but they too face challenges in allowing students to take control of their learning. Collectively, both operational and management-level instructors exhibit high pedagogical competence, suggesting a robust teaching environment enriched with effective motivational techniques, while also indicating areas for enhancement in encouraging student autonomy. The lower scores in granting students' control may stem from a reliance on traditional, teacher-centered methods, where instructors feel the need to maintain full authority to meet educational standards and ensure comprehensive coverage of the curriculum, often underestimating students' maturity and responsibility to manage their own learning.

Pedagogical Competence of Maritime Professional Instructors When Grouped According to Length of Teaching Experience

Maritime professional instructors with shorter teaching tenures exhibit a strong ability to appreciate students' good ideas and efforts, although they show a need for improvement in granting students' control over their learning processes. This suggests a focus on recognizing student contributions while indicating opportunities to empower students in their educational journey. Instructors with moderate experience, teaching between 11 to 22 years, excel in motivating students and instilling good learning habits but also tend to adopt a more teacher-centered approach, maintaining significant control over the learning environment. In contrast, instructors with nearly 23 to 33 years of experience demonstrate exemplary performance across a range of pedagogical competencies, including facilitating creative and critical learning, promoting communicative learning, and respecting diversity. Their extensive experience contributes to exceptional efficacy in their teaching practices, highlighting the correlation between teaching longevity and pedagogical skillfulness.

The overall result shows that maritime professional instructors across all experience levels demonstrate a very high level of pedagogical competence, as evident in the mean obtained at 4.50, with a standard deviation of 0.438.

Maritime professional instructors, including seafarers-turned-maritime educators and MET instructors, exhibit a promising level of pedagogical competence, as indicated by studies focusing on their commitment to teaching, self-reported technology proficiency, and environmental competence development (Estimo, 2020; Radkevych et al., 2023; Sharma & Nazir, 2021).

Pedagogical Competence of Maritime Professional Instructors When Grouped According to Highest Educational Attainment

At the Bachelor level, the study indicates a very high level of pedagogical competence, particularly in recognizing students for their excellent ideas and efforts, as well as in motivating them and instilling good learning habits. These findings align with existing research that emphasizes the importance of positive reinforcement and intrinsic motivation in engaging undergraduate students. However, there is a notable opportunity for improvement in empowering students to take more control over their learning processes, as autonomy has been shown to enhance engagement and performance at this level. Similarly, maritime professional instructors at the Masteral level exhibit strong pedagogical competence, especially in motivating students and effectively delivering course content. Yet, they too face challenges in allowing student control, suggesting a need for further development in fostering student autonomy and self-directed learning. At the Doctoral level, educators demonstrate exceptional pedagogical competence, achieving very high performance across various competencies, including inspiring critical thinking, creating an effective classroom environment, and promoting student responsibility. This highlights the advanced skills and professionalism of doctoral educators in facilitating a comprehensive learning experience. The result aligns with the research by Kushwaha and Dube (2023), which emphasizes the importance of high academic achievements for academic careers and leadership positions.

Pedagogical Competence of Maritime Professional Instructors When Grouped According to Instructors' Classification

Professional instructors in the Deck, Engine, and Technical Allied disciplines exhibit exceptional pedagogical competence across various teaching aspects. Deck Instructors particularly excel in motivating students and instilling good learning habits, showcasing their strong ability to engage and inspire effectively. However, they demonstrate a slightly lower emphasis on granting students' autonomy in their learning processes, which, while still positive, indicates room for growth. These findings align with existing research that emphasizes the significance of instructor motivation and student-centered approaches in maritime education. Engine instructors also show very high competence, especially in appreciating students for their good ideas and efforts, which fosters essential skills and a lifelong love for learning. Nonetheless, like their Deck counterparts, they also exhibit a lower focus on student control over the learning process. Conversely, Technical Allied Instructors demonstrate exemplary proficiency in maintaining safe and orderly classrooms, highlighting their capacity to create conducive learning environments crucial for maritime education. However, there remains an opportunity for improvement in encouraging greater student autonomy within their teaching practices.

The findings show that balancing motivating students and providing structured guidance is crucial in maritime training, where theoretical knowledge and practical skills are essential (Abad & Manalo, 2020). While maintaining a structured and safe environment is crucial, empowering students to take ownership of their learning journey can enhance engagement, motivation, and overall learning outcomes. Encouraging student involvement in decision-making processes and fostering a sense of autonomy can lead to increased interest and investment in their education, ultimately contributing to a more enriching educational experience for both students and instructors (Vujičić et al., 2020).

Pedagogical Competence of Maritime Professional Instructors When Taken as a Whole

Data indicate that Maritime Professional Instructors collectively display a very high level of pedagogical competence across various teaching domains. They are particularly skilled at motivating students and instilling good learning habits, which significantly contributes to the academic and personal development of their students. However, while the overall competence is commendable, there are identifiable areas for further growth. Specifically, the emphasis on granting students control over their learning processes is slightly lower, suggesting an opportunity for instructors to enhance student empowerment and involvement in shaping their educational experiences. This focus on fostering greater student autonomy could lead to improved learning outcomes and a more enriching educational environment.

These findings are most relevant to those of Estimo (2020) on the level of competence of maritime professional instructors in various pedagogical aspects such as facilitating learning, classroom management, use of technology, student motivation, assessment, and professional development. Overall, the findings confirm that maritime professional instructors demonstrate a commendable level of pedagogical competence. Their ability to inspire, create engaging learning environments, and adapt teaching strategies to meet diverse student needs is noteworthy. Their consistent performance at very high levels across most aspects underscores their effectiveness in facilitating meaningful learning experiences for their students.

Table 3: Level of Pedagogical Competence of Maritime Professional Instructors When Taken as a Whole Group

Pedagogical Competence	Mean	SD	Interpretation
1. Facilitate and inspire students to learn creatively and critically.	4.68	.549	Very High
2. Create and maintain a conducive classroom atmosphere.	4.58	.619	Very High
3. Design and develop technology-based materials (video, audio, multimedia, etc.) to enhance learning materials, experiences, and evaluations.	4.45	.643	Very High
4. Appreciate students for giving good ideas or efforts.	4.76	.460	Very High
5. Motivate and instill good learning habits among students.	4.79	.412	Very High
6. Assess what students have learned rationally.	4.63	.610	Very High
7. Allow students to have some control over the learning process.	3.83	.935	High
8. Promote communicative language learning and responsibility through activities and discussions.	4.47	.553	Very High
9. Maintain a safe and orderly classroom that facilitates students' learning.	4.69	.545	Very High
10. Engage students in collaborative learning activities that promote interaction.	4.37	.749	Very High
11. Undergo professional upgrading to advance my teaching expertise.	4.36	.782	Very High
12. Develop professional relationships and networks.	4.39	.751	Very High
13. Establish a respectful environment for a diverse population of students.	4.57	.738	Very High
14. Adapt to various teaching styles to accommodate different student learning styles.	4.49	.705	Very High
15. Know very well the courses that I teach.	4.52	.723	Very High
16. Encourage students to bring life experiences into the classroom and create activities that draw on those experiences.	4.37	.802	Very High
17. Develop clear and measurable learning outcomes.	4.49	.705	Very High
18. Provide realistic student-centered lessons and activities based on concepts learned by the students.	4.40	.717	Very High
19. Provide prompt and helpful feedback on assignments, quizzes, activities, and examinations that enhance learning.	4.59	.639	Very High
20. Ability to use effective teaching strategies and instructional aids that engage learners to achieve desired outcomes.	4.57	.701	Very High
Over-all Mean	**4.50**	**.438**	Very High

Challenges Encountered by Maritime Professional Instructors in the Delivery of Instruction

The results gathered in determining the different challenges encountered by maritime professional instructors that impact their teaching effectiveness and overall well-being are hereby presented in Table 9.

As shown in the results, the topmost challenge, as indicated by 31 participants and ranking first, is difficulty concentrating due to financial concerns. This challenge reflects the significant distraction and stress that financial worries can impose, affecting instructors' focus and effectiveness in their work. The challenge of limited resources and skills follows closely, as noted by 25 participants, and ranked second, highlighting the need for better support and continuous professional development to enhance instructional capabilities. Additionally, fatigue and tiredness from inadequate sleep ranked third with 22 mentions, underscoring the importance of well-being and work-life balance for instructors' overall performance. On the other end of the spectrum, lacking technical skills received a minor emphasis, with only one respondent citing it as a concern, suggesting that while technical competence is essential, it may not be as pressing as other challenges faced by maritime professional instructors.

According to Erno (2022), inadequate financial literacy among teachers, particularly in areas like saving, investing, and retirement planning, can have long-term consequences on their decision making and overall productivity, as financial worries can be a significant distraction.

Table 4: Challenges encountered by Maritime Professional Instructors

Challenges	*F*	*Rank*
• I have difficulty in concentrating due to financial concerns.	31	1
• I have limited resources and skills necessary to do the tasks.	25	2
• I feel fatigue/tiredness caused by inadequate sleep.	22	3
• I have inadequate background knowledge and skills in teaching.	15	4
• I have difficulty in adjusting to various teaching styles.	13	5.5
• I have an uncomfortable learning environment.	13	5.5
• I have difficulty in preparing the lesson plan (Detailed Teaching Syllabus) and notes to be provided to students.	11	7
• I have difficulty teaching BSMT students with Marine Engineering terms or vice versa.	9	8.5
• I have poor communication or lack of clear direction to students.	9	8.5
• I do not have the patience in dealing with misbehaving students.	8	10
• I do have difficulty in managing my time.	7	11
• I have difficulty in managing big classes.	5	12
• I have difficulty in handling more than three teaching preparations.	4	13
• I have an overloaded class schedule with little time to rest in between.	3	14
• I lack technical skills.	1	15

A Significant Difference in the Pedagogical Competence of Maritime Professional Instructors According to Rank

The analysis reveals that there are no significant differences in the pedagogical competence of Maritime Professional Instructors when categorized by rank into operational and management roles. The findings indicate that both groups exhibit similar levels of pedagogical competence, suggesting that the rank of instructors does not notably influence their teaching effectiveness. This outcome highlights the consistency in pedagogical skills across different roles within the maritime education framework, reinforcing the notion that effective teaching practices are upheld regardless of rank.

Table 5: t-test for Significant Difference in the Pedagogical Competence of Maritime Professional Instructors When Grouped According to Rank

Rank	n	Mean	Sd	df	t	p-value	Interpretation
Operational	45	4.50	.448	68	.287	0.775	Not Significant
Management	25	4.47	.452				

A Significant Difference in the Pedagogical Competence of Maritime Professional Instructors According to Length of Teaching Experience, Highest Educational Attainment, and Classification of Instructors

The analysis presented indicates that there are no significant differences in the pedagogical competence of maritime professional instructors based on their length of teaching experience. Instructors across short, mid-range, and long experience categories demonstrate similar levels of pedagogical effectiveness. This finding aligns with previous research, suggesting that factors such as motivation, engagement, and reflective teaching practices play a crucial role in influencing teaching effectiveness, rather than merely the number of years spent in the profession.

Additionally, the study reveals no significant differences in pedagogical competence based on the highest educational attainment of instructors. Despite varying degrees of education, from bachelor's to doctoral levels, the results indicate that higher educational qualifications do not necessarily translate into superior teaching competence. Instead, practical teaching skills may be more significantly influenced by teaching experience, training in instructional methods, and relevant industry expertise, highlighting the importance of practical application in maritime education.

Furthermore, when examining the pedagogical competence of instructors classified as Deck, Engine, or Allied, the study finds no statistically significant differences among these groups. This suggests that instructors' pedagogical abilities are not confined to their specific area of expertise. Educational institutions can benefit from this insight by leveraging the diverse instructional strengths of instructors across different classifications, thereby enhancing students' educational experiences through a broader range of pedagogical approaches rather than focusing solely on specific areas of expertise.

Table 6: One-Way Analysis of Variance (ANOVA) Results for Significant Difference in Pedagogical Competence of Maritime Professional Instructors When Grouped According to Length of Teaching Experience, Educational Attainment, and Classification

Categories		n	Mean	Sd	$F_{(2,71)}$	p-value	Interpretation
Length of Teaching Experience							
	Short (1-10 years)	55	4.51	.37258	2.256	.113	Not Significant
	Mid (11-22 years)	15	4.34	.65792			
	Long (23-33 years)	5	4.80	.12247			
Educational Attainment							
	Bachelor	50	4.48	.36832	0.957	0.389	Not Significant
	Masteral	22	4.57	.47713			
	Doctoral	3	4.22	1.1071			
Classification							
	Deck	43	4.53	.35992	2.338	0.104	Not Significant
	Engine	23	4.37	.58900			
	Allied	9	4.71	.16202			

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Enhancement Program Designed to Enhance the Teaching Strategies of the Maritime Professional Instructors

Enhancement Program for Maritime Professional Instructors

Rationale: This enhancement program aims to optimize teaching strategies for maritime professional instructors based on identified findings to address challenges and further elevate pedagogical competence. By refining instructional methods and addressing obstacles, instructors can enhance student engagement, learning outcomes, and overall teaching effectiveness in Maritime Higher Education Institutions.

OBJECTIVES

The following are the objectives of the enhancement program to enhance the teaching strategies of maritime instructors:

1. To increase utilization of high-frequency teaching strategies.
2. To enhance technological integration in teaching practices.
3. To improve pedagogical competence and assessment practices.

Continuous Evaluation

Assess the program's impact regularly through feedback mechanisms, performance evaluations, and student outcomes to ensure effectiveness and relevance.

Table 7: Enhancement Program Designed to Enhance the Teaching Strategies of the Maritime Professional Instructors

Objective	Program or Activities	Implementing Strategies	Person(s) Involved	Time Frame	Success Indicator
Improve Pedagogical Competence and Assessment Practices	Workshop and mentorship programs on the use of role playing, case studies, project-based learning, reflections, and journal writing as teaching strategies.	1. Conduct seminar-workshop on the use of the identified teaching strategies in terms of: 2. Alignment of assessment in the ILOs; 3. Drafting of rubrics and mechanics; 4. Actual conduct of the Activity. 5. Peer Teaching. A professional instructor who opts to choose role-playing will team teach with a general education instructor who will prepare for the rubrics and mechanics while the technical aspect such as scenarios will be prepared by the professional instructor. 6. Mentoring the mentor. Instructor may ask a general education instructor to mentor them to make 2-3 guide questions for reflection or journal writing based on their topic including rubric and mechanics. 7. Encourage the use of questioning, collaborative learning, and project-based learning techniques	HR Faculty Deans Program Heads	1 year	Enhanced pedagogical competence and assessment practices demonstrated through improved teaching effectiveness, higher student engagement, and better alignment of assessments with Intended Learning Outcomes (ILOs).

Objective	Program or Activities	Implementing Strategies	Person(s) Involved	Time Frame	Success Indicator
Enhance Technological Integration in Teaching Strategies	Training workshops on the use of technology in teaching.	1. Conduct assessment on specific technological training needs. 2. Provide hands-on training on the use of power point presentation as to standard font size, graphics and how to imbed videos. 3. Recommend training workshops on the use of simulators and other technology use in teaching.	IT Department, Trainers	Ongoing	Successful technological integration in teaching strategies, as evidenced by increased proficiency and confidence among instructors in using technology.

DISCUSSION

The significance of the results regarding the pedagogical competence of maritime professional instructors lies in their implications for both educational practice and policy within maritime education. The findings underscore that factors such as teaching experience, educational attainment, and specific classification do not significantly influence instructors' effectiveness in teaching. This challenges common assumptions that more experience or higher degrees automatically equate to better pedagogical skills, suggesting that other elements, such as motivation, engagement, and reflective practices, play critical roles in enhancing teaching competence.

In the context of existing literature, such as the study by Vujičić et al. (2020), this research reinforces the idea that the effectiveness of instructors is multifaceted and cannot be solely attributed to years of experience or educational qualifications. By highlighting the importance of practical teaching skills and industry expertise, the study aligns with the broader discourse on teacher effectiveness, which emphasizes the need for continuous professional development and training in instructional methods. This insight can help educators and policymakers focus on fostering a more holistic approach to instructor development that prioritizes engagement and practical skills over mere qualifications.

Moreover, the results suggest that educational institutions can effectively utilize the diverse pedagogical strengths of instructors across various classifications (Deck, Engine, and Allied) to enhance student learning experiences. This finding encourages a collaborative and interdisciplinary approach in maritime education, where instructors can share best practices and instructional strategies. By leveraging the collective expertise of instructors from different areas, educational programs can provide a richer and more varied learning environment, ultimately contributing to the overall success of maritime training and the development of competent professionals in the field.

CONCLUSION

The research findings highlight the necessity of a balanced approach in maritime education that combines traditional teaching methods, such as lectures and assessments, with interactive and practical strategies. This integration is essential for creating comprehensive learning experiences that cater for the diverse needs of students. Maritime professional instructors are recognized for their commendable level of pedagogical competence, reflecting their ability to inspire students, foster engaging learning environments, and adapt their teaching strategies effectively. Their sustained performance at high levels across various teaching dimensions underscores their capability to facilitate meaningful learning experiences, which is crucial for student success.

However, the study also identifies significant challenges that maritime professional instructors face, which may hinder their teaching effectiveness and overall well-being. Issues such as financial constraints, limited resources and skills, and fatigue from inadequate sleep can impede instructors' concentration and focus, ultimately affecting their energy levels and alertness. Additionally, the research reveals that there are no significant differences in pedagogical competence based on rank, length of teaching experience, highest educational attainment, or classification of instructors. This finding suggests that factors like teaching experience, training in instructional methods, and industry expertise may be more influential in developing effective teaching skills rather than rank or educational background. By acknowledging these insights, educational institutions can better support instructors in addressing their challenges while promoting professional development that enhances pedagogical effectiveness.

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Enhancing Safety of Navigation with ECDIS Standardization and S-Mode Adoption

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ABSTRACT

The International Maritime Organization (IMO) has encouraged flexibility in the design of an Electronic Chart Display and Information System (ECDIS), resulting in a variety of capabilities, interfaces and functions. However, this diversity can create challenges in consistently presenting, interpreting and using critical navigational data, increasing the potential for navigational errors. The study explores the implementation of S-Mode, a standardized user interface for navigation equipment, to enhance situational awareness, safety and operational efficiency in maritime navigation. A quantitative survey was conducted with 417 deck officers who have experience with ECDIS of various types onboard ships. The study used Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to analyze the data and evaluate the research hypotheses with descriptive analysis for research variables and participant profiles using AMOS and SPSS software, focusing on how the ease of use and usefulness of S-Mode influences its adoption among maritime professionals. The findings indicate that introducing S-Mode significantly improves responsiveness, information credibility, and operations quality, meeting critical navigational needs more effectively.

The SEM analysis also showed that S-Mode reduces human error and facilitates recognition of different ECDIS models, highlighting the role of the interface in enhancing safety and efficiency. The study concludes by emphasizing the need for continuous and specialized type-specific training for ECDIS systems and advocates for establishing industry-wide standards in interface design to ensure consistency and safety in maritime navigation.

Key-words:
ECDIS, S-Mode, Standardization, Safe Navigation, Perceived Usefulness, Training.

INTRODUCTION

Over the past 20 years, the IMO has given ECDIS manufacturers greater flexibility in terms of equipment capacity, software interfaces and additional features. This has led to significant variations between ECDIS models. However, these differences in how important information is shared, understood and used have increased the risk of catastrophic accidents due to improper use of equipment. To ensure that navigational officers have faster access to essential data and features that support safe navigation, improving ECDIS standards is essential. Until then, the industry should prioritize comprehensive, targeted specific standard training and ongoing skills development. This will ensure that all officers are fully aware of the system limitations and capabilities, enabling its intended operation and reducing the potential for accidents due to human error (IMO, 2019).

The IMO mandates Standards of Training, Certification, and Watchkeeping (STCW) for masters and officers in charge of navigational watches on ships equipped with ECDIS. To meet the 2010 Manila Amendments to the STCW Convention and Code, these officers must complete general ECDIS training. According to STCW Convention regulation I/14, masters and officers serving on ships with ECDIS must familiarize themselves with the ship equipment, including ECDIS, as outlined in the Guidance for Good Practice (IMO, 2022). Before taking control of navigational watches, operators should receive type-specific training to develop the skills needed to operate the onboard ECDIS, including its backup setup (NI, 2012; AMSA, 2017). While deck officers are trained and familiarized with ECDIS operations, including ENCs, chart symbols, safety contours, no-go zones, and passage planning procedures, maintaining ECDIS competency remains challenging (Weintrit, 2022).

The Maritime Safety Committee issued, in session No. 86 of 2009, new instructions for installing the Electronic Chart System (ECS) on ships, starting in July 2012, according to the type and load of each ship. The gradual start of ships relying on ECDIS systems as an essential means of navigation has led to the emergence of fundamental defects in the systems that directly affect the safety of maritime navigation. Therefore, the International Hydrographic Organization has issued a set of tests to identify and study these defects until they are eliminated (Lawson, 2018) by scientific methods and approaches with the companies that manufacture these systems to raise their degree of reliability to increase the level of maritime navigation safety and preserve the marine environment. With the entry into force of the ECDIS system and the reliance of many ships on electronic maps instead of paper maps, it is time for the authorities responsible for maritime navigation safety in the Arab Republic of Egypt to take the necessary and vital measures to ensure the safety of navigation on the Egyptian coasts, including, but not limited to, raising the efficiency of surveying maps on the Egyptian coasts and issuing instructions and guidelines to ensure the security and safety of the use of electronic map systems for ships planned to pass through the Gulfs of Suez and Aqaba, and the Suez Canal, as well as ships planned to enter Egyptian ports, to raise the level of maritime navigation safety and preserve the marine environment on the Egyptian coasts (Youssef et al., 2024).

This study adopts an interpretive approach, employing a survey questionnaire distributed to ECDIS trainees with shipboard experience using a quantitative method. The objective is to identify and discuss the various advantages and disadvantages of ECDIS standardization from the perspective of these trainees. Therefore, this paper covers the ECDIS standardization mechanism, introduces ECDIS training courses, summarizes previous research, and provides an overview of current training programs. It also details the research methodologies and materials used, presents the study findings and concludes with a discussion and recommendations.

The research problem highlights that since its inception, the IMO has been concerned with ensuring maritime safety in all its elements and with navigation safety. It has issued many decisions whose goal was to improve maritime safety and prevent maritime accidents. With the increase in many accidents, in which the human element was the most responsible in most cases, the importance of benefiting from the rapid development witnessed in electronic device technology has emerged to reduce the factors causing these accidents (Weintrit, 2019).

The core issue of this research is the lack of standardization in ECDIS interfaces, which leads to challenges in crew training, increased risk of human error, and inconsistencies in navigational safety practices. This research paper emphasizes the importance of deck officers regularly maintaining and enhancing their ECDIS knowledge and skills through ongoing or refresher training, ensuring efficient utilization as evidenced by navigational assessments, audits, and external inspections such as Port State Control (PSC) and Ship Inspection Report (SIRE) as they are two key elements related to maritime safety and the management of ECDIS. The study aims are to evaluate the effectiveness of implementing a standardized interface, known as S-Mode, for ECDIS to address the challenges caused by the current lack of standardization and to facilitate the adoption of the S-Mode by investigating factors influencing this adoption using various technology adoption models.

ECDIS STANDARDIZATION MODE

S-Mode can be described as a standardized user interface for ECDIS that offers a uniform display, menu structure, and operational settings across different systems to simplify training, reduce human error, and enhance navigational safety (Weintrit, 2010; Zalewski, 2019). The Nautical Institute (NI) has actively contributed to developing e-navigation, incorporating the S-Mode concept. This concept, aimed at boosting operational safety and facilitating efficient training through a uniform display, menu system, and input device, has been refined over years of member input. First introduced in Seaways in March 2007, S-Mode received significant industry support as some of shipping companies like Maersk and MSC have praised S-Mode for its practical benefits, including reduced crew training and reduced human error risk. Pilot organizations like the UK Maritime Pilots' Association also noted its efficiency (Hagen, 2017).

The International Safety Management (ISM) Code mandates that officers be familiar with their ship navigational equipment, including ECDIS, to ensure safe operations, the S-Mode may facilitate this by offering a standardized interface, reducing the time and complexity involved in familiarizing crew members with different ECDIS models (Behera et al., 2021). Pilots often face significant challenges in quickly adapting to various ECDIS models with different interfaces, especially during approaching and departures from ports, S-Mode can address this by providing a consistent interface that minimizes confusion and enhances safety during critical pilotage operations. Shore-based training facilities also struggle to decide which specific tools to purchase for optimal student instruction, often not reflecting the actual tools on ships. Ship managers have limited influence over the technology provided by ship owners but must ensure that every vessel has qualified officers. Training institutions typically lack the resources and space to invest in a wide range of equipment samples for instruction (MacKinnon et al., 2015).

Role of S-Mode in ECDIS and e-Navigation

The "S-Mode" feature should be standard on all future navigation systems, defaulting to a standard display when activated and fully configurable via a standard menu system. Standard functions will be included, such as altering range and using EBL/VRM and parallel indexing. S-Mode aims to offer high functionality and ensure that anyone skilled in using it can efficiently operate navigation systems on any vessel equipped with it (Weintrit, 2010). S-Mode allows pilots or mariners to quickly configure systems with their preferred settings, overlay customized display characteristics, or access specialized information by saving preferences on a storage device or within the system. The IMO has suggested incorporating S-Mode into the STCW Convention, requiring changes to existing training frameworks. This includes revising syllabi, creating simulation exercises, and developing examination criteria. Training institutions are expected to implement dedicated modules focusing on theoretical knowledge and practical application, ensuring officers are proficient in navigating with a standardized ECDIS interface. This approach aligns with global standards to enhance maritime safety and operational efficiency (IMO, 2019; Vidan et al., 2018).

The default range and size of data presentation on ECDIS should be carefully set, with "Range / Scale" recommended at 3Nm and corresponding radar equipment at 6Nm as per the IMO Performance Standards for INS's Appendix 6 for route monitoring and collision avoidance tasks (IMO, 2007). With appropriate display offset, these values ensure clear chart information for route monitoring at 3Nm and adequate anti-collision operations at 6Nm. However, for fast ships traveling over 20 knots, reaction times can drop below 10 minutes, potentially leading to misconceptions about the range setting. Many modern ECDIS systems allow user-selectable scales to be converted to range and vice versa, while others only change the scale (Kastrisios and Pilikou, 2017). The ECDIS chart display for route monitoring must have a compelling dimension of at least 270 mm by 270 mm, with the backup system chart presentation at 250 mm or 250 × 250 mm, as per IMO Resolution MSC.232(82) (IMO, 2006). The IHO specifies S52 requirements for ECDIS display panels, defining resolution as the lowest number of lines per millimeter (L) determined by L=864/s, where s is the smaller size of the chart display area. For instance, with s=270mm, the pixel size is 0.312mm. While smaller displays are allowed, most ECDIS installations use 19" or larger flat panels to meet IMO ECDIS performance and display resolution requirements (IMO, 2006; Zalewski, 2019).

Implications of Implementing S-Mode in ECDIS Systems

The new IHO ENC Product Specification S-101 (Guideline, 2018) aims to simplify determining data coverage for the 3Nm range. According to S-101, when the system viewing scale is below the minimum display scale, data within the Data Coverage feature is not displayed unless the SENC lacks a smaller-scale dataset, which will display the data at all more minor scales. An overscale indication must be shown when the viewing scale exceeds the highest display scale (Palikaris and Mavraeidopoulos, 2020). A message must also appear on the same screen as the chart whenever a dataset covering the ship position has a maximum display scale that is more incredible than the mariner's selected viewing scale (MSVS). Misunderstandings about ECDIS default settings, such as "Off Center, with an appropriate look ahead" and "Selected Sea area: Around own ship with appropriate offset," persist. S-Mode standards may use ambiguous terms rather than standardized ones like "appropriate" (Zalewski, 2019).

The stabilization of data display is a problematic default option in S-Mode. S-Mode rules present data as "sea" stabilized in radar and "ground" stabilized in ECDIS. This aligns with collision regulations, where sea stabilization is used for radar and ground stabilization for course monitoring on charts. However, users of existing INS systems, which often default to ground GNSS stability for ECDIS and radar, may find this confusing. This setup allows easy transmission of ARPA targets and radar footage to chart displays. Still, new default values necessitate caution when assessing AIS and ARPA vectors and their potential fusion in ECDIS (Zalewski, 2019). Another issue with S-Mode default settings is the look-ahead feature. The ECDIS look-ahead is set to "Look-ahead time 6 min," while the radar look-ahead reads "Off Center, with Appropriate Look-Ahead." The term "look ahead" can be misleading, as it denotes offset distance in one technology and predicted time in another. Modern ECDIS systems rarely use look-ahead terminology, opting for alternative functions instead, which could lead to further confusion (Rutkowski, 2018).

Several international standards and IMO instruments address system design and information display (IMO, 2006, 2007; Zalewski, 2019). The S-Mode rules were developed using these standards and Human-Centered Design (HCD) as foundations. While this approach is generally expected to yield positive outcomes, it can have negative implications if source standards are adopted uncritically. For instance, conflicts can arise among radar equipment, ECDIS, and INS functions within the S-Mode framework. Simulated tests before adopting new ship equipment will help determine if S-Mode recommendations significantly improve navigation safety. Some S-Mode instructions may conflict with established seafarer practices without such testing (Tomczak, 2012). User feedback testing is crucial to ensure compliance with the new Performance Standards for the Presentation of Navigation-Related Information on Shipborne Navigational Displays (IMO, 2019).

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

This section reviews the literature on critical variables and their relationships. Structural Equation Modeling (SEM) has been widely used to examine maritime solution adoption factors. Lu et al. (2007) found that perceived utility and security protection did not significantly impact the adoption of liner shipping solutions. In a 2023 study, Makizadeh et al. explored the influence of information desire on perceived usefulness in marine sports on Qeshm Island. Analyzing data from 300 participants using SPSS and AMOS revealed a positive link between information needs and perceived usefulness. Lu et al. (2007) also provided SEM guidelines focusing on service acceptability and safety in liner shipping, finding that security measures influence perceived usability, based on 85 valid responses from top Chinese export enterprises.

Yang et al. (2022) examined the effects of social interaction technology on job performance and anxiety in ocean freight forwarding, using SEM to identify seven constructs, ultimately showing a link between perceived security and usability. Tsai (2016) explored seafarers' attitudes toward ECDIS by surveying deck officers on 110 vessels, finding that perceived usefulness significantly impacts their attitude toward using the system, with 138 valid responses out of 440 surveys showing a positive trend. Handayani and Dewi (2019) examined the influence of perceived ease of use on attitudes towards the Seagull Training Lab for marine English, collecting data from 374 participants, including three teachers. The study highlighted mixed opinions among teachers and students. Hsu and HSU (2012) compared the impact of perceived ease of use on attitudes toward ECDIS between inexperienced maritime students and experienced shipmates, using a sample of 144 students. They found a significant link between ease of use and positive attitudes toward ECDIS in navigation. Pan et al. (2016) studied the design of a marine education information system for college students, revealing that ease of use and utility enhance learning when the system is simple and straightforward, thus positively affecting attitudes toward its usage.

A survey of 110 ships revealed that deck officers' positive attitudes toward ECDIS are strongly linked to their intention to use it, highlighting the system potential to enhance maritime safety (Tsai, 2016). Pan et al. (2016) explored how marine education information systems impact college students' learning, finding that more superficial and understandable systems improve learning outcomes. Their regression analysis demonstrated a 65.6% predictive capacity toward user attitudes, emphasizing the need to promote maritime safety. Studies by Antwi-Boampong et al. (2022) and Alharbi et al. (2022) examined factors influencing technology use, identifying social influence, performance expectations, effort expectations, and environmental conditions as key drivers. Their research, involving 374 participants from the marine and port industries, underscored the significance of these factors in shaping behavioral intentions toward technology use.

RESEARCH METHODS

Figure 1 outlines how various factors like Responsiveness, Security, Information Quality, Information Credibility, and Needs of Information influence the Perceived Usefulness and Perceived Ease of Use of the ECDIS S-Mode system. These perceptions shape the user's Attitude Toward Use, which affects their Behavioral Intention to use the system and ultimately determines the Actual Use of the system. The model helps understand what drives system adoption and user engagement.

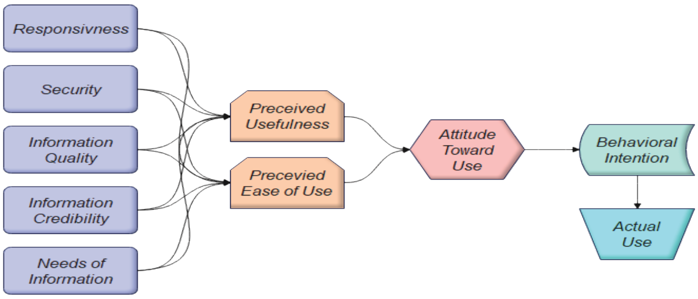

Figure 1 The Framework of ECDIS S-Mode Study

Based on this framework, these hypotheses are raised:

- ***H1: There is a significant relationship between Independent Variables and Perceived Usefulness***
- ***H2: There is a significant relationship between Independent Variables and Perceived Ease of Use***
- ***H3: There is a significant relationship between Perceived Usefulness, Perceived Ease of Use, and Attitude Toward Use***
- ***H4: There is a significant relationship between Attitude Toward Use and Behavioral Intention***
- ***H5: There is a significant relationship between Behavioral Intention and Actual Use***

Trainees from the Arab Academy for Science, Technology and Maritime Transport (AASTMT) who have a background in using ECDIS for ship navigation were involved in an extensive survey conducted during an ECDIS refresher course held in a simulator complex. Out of the 700 surveys that were given to the trainees, 425 of them were filled out completely by participants who chose to participate. However, eight surveys were not considered for analysis because they contained data leaving a total of 417 valid responses that were studied.

The evaluation focused on implementing "S Mode" in electronic navigation instruments, assessing various aspects based on established literature (Sek et al., 2010; Erkan and Evans, 2016; Rahman et al., 2017; Singh et al., 2020). This thorough examination seeks to enhance comprehension of ECDIS standardization and how it influences the efficiency and safety of navigation practices as a whole. Table 1 outlines the respondent demographics of the participants surveyed and showcases a range of ages represented in the data. The biggest age bracket is the 30- to 39-year-olds making up 27.1% of the group surveyed; next comes the 22 to 29 age group at 26.1% and the 50 to 59 age categories at 19.4%. The diverse age range allows for an examination of trends related to age and variations, in answers.

Regarding professional qualifications, 44.1% of the respondents hold a Chief Mate Certificate of Competency (CoC), indicating advanced expertise and specialized training. Additionally, 33.1% possess a Bachelor's degree and a 2nd Mate CoC, highlighting a solid foundation in maritime education. A significant 22.8% have obtained a Master's CoC, representing the group highest academic and professional qualification. This diverse educational background enhances the study robustness, providing a comprehensive perspective on the experiences and insights of deck officers regarding ECDIS standardization and its role in maritime operations.

Table 1: Descriptive Statistics of Respondents Profile

	Frequency	Percent	Total
Age			
22-Less than 30	109	26.1	417
30- Less than 40	113	27.1	
40- Less than 50	75	18.0	
50- Less than 60	81	19.4	
60 or older	39	9.4	
Education			
Bachelor's degree + 2nd Mate CoC	138	33.1	417
Chief Mate CoC	184	44.1	
Master CoC	95	22.8	

RESULTS AND FINDINGS

The study used structural equation modeling, or SEM, to evaluate the research hypotheses and interpret the data. The SEM was carried out using AMOS 24. First, a measurement model was created to verify the model that was being examined. The measurement model fit to the data was evaluated using confirmatory factor analysis (CFA). Next, the multicollinearity and normalcy hypotheses were verified. Lastly, descriptive analysis for research variables and participant profiles was given using SPSS version 25.

Data Testing Using Validity and Reliability

As shown in Table 2, validity and reliability tests are performed to assess the investigated data. Average Variance Extracted, or AVE, is a tool for evaluating convergent validity, where all AVE values are between 73.498% and 87.055%. This means that all AVE values are greater than 50%. In addition, the factor loadings are computed to reflect the convergent validity, where all loadings are shown to be between 0.724 and 0.878. This means that all loadings are more significant than 0.4, reflecting adequate validity for the constructs under study. Additionally, the Kaiser-Meyer-Olkin (KMO) values are calculated to assess the suitability of the sample. The sample is deemed

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sufficient for that construct if the appropriate KMO value for a given build is at least 0.5. All KMO values were between 0.500 and 0.975, showing an adequate sample under study.

Table 2: Validity and Reliability Test

Variables	KMO	AVE %	Cronbach's α	Items	Factor Loadings
Respon-siveness	.764	86.644	.923	RES1	.869
				RES2	.861
				RES3	.869
Security	.874	86.586	.948	SEC1	.854
				SEC2	.874
				SEC3	.865
				SEC4	.870
Information Quality	.760	85.386	.914	IQ1	.847
				IQ2	.856
				IQ3	.858
Information Credibility	.873	86.362	.947	IC1	.868
				IC2	.867
				IC3	.865
				IC4	.856
Needs of Information	.500	84.901	.822	NoI1	.849
				NoI2	.849
Perceived Usefulness	.971	76.884	.962	PU1	.773
				PU2	.751
				PU3	.784
				PU4	.774
				PU5	.755
				PU6	.765
				PU7	.770
				PU8	.774
				PU9	.774
Perceived Ease of Use	.947	73.498	.940	PEU1	.737
				PEU2	.768
				PEU3	.731
				PEU4	.725
				PEU5	.725
				PEU6	.724
				PEU7	.735
Attitude Toward Use	.975	81.822	.972	ATU1	.807
				ATU2	.833
				ATU3	.794
				ATU4	.820
				ATU5	.816
				ATU6	.823
				ATU7	.831
				ATU8	.813
				ATU9	.827
Behavioral Intention	.764	87.055	.926	BI1	.870
				BI2	.864
				BI3	.878
Actual Use	.758	85.530	.915	AU1	.840
				AU2	.860
				AU3	.866

Measurement Model using the Confirmatory Factor Analysis

The CFA is used to perform the measurement model, and the model fit indices indicate that the model fits the data well. This had been shown as the minimum discrepancy or chi-square divided by the degrees of freedom (CMIN/DF) was 1.075 (< 2.00); the Bentler-Bonett normed fit index (NFI) was 0.952 (> 0.90); goodness of fit (GFI) was 0.905 (> 0.90); the probability of getting as more considerable discrepancy as occurred with the present sample (p-value) was 0.000 (P-value < 0.05); adjusted goodness of fit index (AGFI) was 0.900 (> 0.90); and the Tucker-Lewis index (TLI) was 0.996 (> 0.95); the comparative fit index (CFI) was 0.996 (> 0.90). Also, the root means square residual (RMR) was 0.022 (< 0.1); the root mean square of approximation (RMSEA) was 0.013 (< 0.1). The factor loadings are displayed on arrows in Figure 2, which indicates good factor loadings for the CFA and depicts the implemented confirmatory analysis.

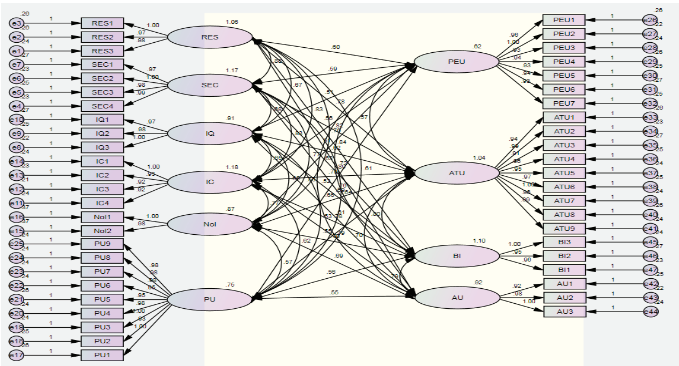

Figure 2: CFA for the Measurement Model

Table 3 presents the factor loadings of the statements allocated to each construct in the measurement model, displayed after the model fit indices for the study model are accepted. All factor loadings are determined to be within 0.904 and 1.00, and all P-values are below 0.05. This indicates that all factor loadings are higher than 0.4, indicating a valid model.

Table 3: Item Loading after Confirmatory Factor Analysis

			Estimate	SE.	CR.	P
RES3	<---	RES	.982	.036	27.252	***
RES2	<---	RES	.973	.036	26.719	***
RES1	<---	RES	1.000			
SEC4	<---	SEC	.985	.032	30.895	***
SEC3	<---	SEC	.980	.032	30.236	***
SEC2	<---	SEC	1.000			
SEC1	<---	SEC	.969	.033	29.354	***
IQ3	<---	IQ	1.000			
IQ2	<---	IQ	.976	.038	25.360	***
IQ1	<---	IQ	.974	.039	25.017	***
IC4	<---	IC	.915	.031	29.092	***
IC3	<---	IC	.921	.031	30.043	***
IC2	<---	IC	.932	.031	29.631	***
IC1	<---	IC	1.000			
NoI2	<---	NoI	.983	.052	19.061	***
NoI1	<---	NoI	1.000			
PU1	<---	PU	.999	.041	24.300	***
PU2	<---	PU	.926	.039	23.709	***
PU3	<---	PU	1.000			
PU4	<---	PU	.976	.040	24.588	***
PU5	<---	PU	.949	.040	23.734	***
PU6	<---	PU	.949	.039	24.122	***
PU7	<---	PU	.976	.040	24.529	***
PU8	<---	PU	.984	.040	24.561	***
PU9	<---	PU	.976	.040	24.500	***
PEU1	<---	PEU	.960	.044	21.988	***
PEU2	<---	PEU	1.000			
PEU3	<---	PEU	.928	.042	21.991	***
PEU4	<---	PEU	.941	.044	21.607	***
PEU5	<---	PEU	.931	.043	21.657	***
PEU6	<---	PEU	.937	.044	21.327	***
PEU7	<---	PEU	.935	.043	21.903	***
ATU1	<---	ATU	.943	.034	28.094	***
ATU2	<---	ATU	.988	.033	29.502	***
ATU3	<---	ATU	.911	.033	27.326	***
ATU4	<---	ATU	.962	.033	28.742	***
ATU5	<---	ATU	.951	.033	28.780	***
ATU6	<---	ATU	.974	.034	28.913	***
ATU7	<---	ATU	1.000			
ATU8	<---	ATU	.964	.034	28.321	***
ATU9	<---	ATU	.988	.034	29.206	***
AU1	<---	AU	.923	.037	24.931	***
AU2	<---	AU	.979	.037	26.426	***
AU3	<---	AU	1.000			
BI3	<---	BI	1.000			
BI2	<---	BI	.946	.035	27.268	***
BI1	<---	BI	.959	.034	28.393	***

DESCRIPTIVE ANALYSIS

In Table 4, the study variables descriptive analysis is displayed. Respondents generally gave these dimensions a positive rating. For instance, Responsiveness received a mean score of 3.1559, while Security and Information Quality averaged 3.1247 and 3.0935, respectively. Information Credibility was rated slightly lower with a mean of 3.0312, and Needs of Information had a mean of 2.9664. With a mean score of 3.3381, Perceived Usefulness was highly preferred, closely followed by Perceived Ease of Use at 3.5132. Attitude Toward Use, with a mean of 3.5060, and Behavioral Intention, with a mean of 3.5755, also reflect positive perceptions. Actual Use received the highest mean score at 3.6091. It is important to note that while these means suggest a positive outlook, the standard deviations for each variable vary, implying some level of variability in respondents' opinions, which could be further explored in subsequent analyses. These results collectively provide a robust foundation for understanding and improving various dimensions within the context of the study.

Table 4: Descriptive Analysis of the Research Variables

Variables	Mean	Std. Deviation	Frequency				
			1	2	3	4	5
Respon-siveness	3.1559	1.08848	30	94	109	149	35
Security	3.1247	1.14303	39	90	110	136	42
Information Quality	3.0935	1.05538	28	80	184	75	50
Information Credibility	3.0312	1.09697	32	101	153	84	47
Needs of Information	2.9664	1.07140	33	112	143	94	35
Perceived Usefulness	3.3381	1.06442	25	42	189	89	72

Perceived Ease of Use	3.5132	1.03564	13	59	119	153	73
Attitude Toward Use	3.5060	1.16874	15	88	84	131	99
Behavioral Intention	3.5755	1.15803	15	66	117	102	117
Actual Use	3.6091	1.12370	10	70	106	118	113

Normality Testing for the Research Variables

As shown in Table 5, the Kolmogorov-Smirnov test of normality was formally used to evaluate the normalcy assumption for the study variables. Given that the corresponding P-values are below 0.05, this suggests that the study variables are not regularly distributed. When a formal test suggests that the results are not normally distributed, an informal test is employed to evaluate near normality. The outcomes of a non-official normalcy test are shown in Table 5. If the results for kurtosis and skewness fall between ±1, the data are regarded as broadly usual.

Table 5: Testing of Normality

	Kolmogorov-Smirnov[a]			Skewness	Kurtosis
	Statistic	Df	Sig.		
Responsive-ness	.222	417	.000	-.257	-.769
Security	.205	417	.000	-.217	-.824
Information Quality	.236	417	.000	.084	-.342
Information Credibility	.197	417	.000	.103	-.598
Needs of Information	.178	417	.000	.091	-.621
Perceived Usefulness	.239	417	.000	-.143	-.266
Perceived Ease of Use	.223	417	.000	-.368	-.474
Attitude Toward Use	.215	417	.000	-.305	-.995
Behavioral Intention	.171	417	.000	-.297	-.900
Actual Use	.190	417	.000	-.310	-.922

Testing Multicollinearity

Multicollinearity is detected using the Variance Inflation Factor (VIF), which also displays the level of correlation between the study variables. Table 6 VIF values are all less than 5, indicating that multicollinearity between the independent variables is not a problem.

Table 6: VIF Values for Independent Variables

Independent Variables	VIF
Responsiveness	3.409
Security	3.080
Information Quality	2.003
Information Credibility	2.246
Needs of Information	2.770

Testing the Research Hypotheses

The findings from the analysis of the relationship between independent and dependent variables are shown in this section. The resultant correlation matrix is shown in Table 7, and it can be shown that Responsiveness, Security, Information Quality, Information Credibility, Information Needs, and Perceived Usefulness have a significant positive association (P-value 0.05; r > 0). Additionally, there is a substantial positive link (P-value 0.05; r > 0) between Responsiveness, Security, Information Quality, Credibility, Information Needs, and Perceived Ease of Use. Additionally, a strong positive correlation exists between Attitude toward Use and Perceived Usefulness, Perceived Ease of uUe, and Perceived Usefulness (P-value 0.05; r > 0).

Furthermore, Behavioral Intention and Attitude Toward Usageage have a solid favorable correlation (P-value 0.05; r > 0). Additionally, Actual Use and Behavioral Intention have a strong positive association (P-value 0.05; r > 0).

Table 7: Correlation Matrix for the Research Variables

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Responsiveness	r	1									
	P-value										
	N	417									
2. Security	r	.788**	1								
	P-value	.000									
	N	417	417								
3. Information Quality	r	.651**	.618**	1							
	P-value	.000	.000								
	N	417	417	417							
4. Information Credibility	r	.678**	.666**	.554**	1						
	P-value	.000	.000	.000							
	N	417	417	417	417						
5. Needs of Information	r	.726**	.702**	.649**	.680**	1					
	P-value	.000	.000	.000	.000						
	N	417	417	417	417	417					
6. Perceived Usefulness	r	.743**	.714**	.652**	.672**	.693**	1				
	P-value	.000	.000	.000	.000	.000					
	N	417	417	417	417	417	417				
7. Perceived Ease of Use	r	.795**	.764**	.702**	.680**	.724**	.743**	1			
	P-value	.000	.000	.000	.000	.000	.000				
	N	417	417	417	417	417	417	417			
8. Attitude Toward Use	r	.773**	.786**	.653**	.648**	.697**	.666**	.802**	1		
	P-value	.000	.000	.000	.000	.000	.000	.000			
	N	417	417	417	417	417	417	417	417		
9. Behavioral Intention	r	.758**	.763**	.634**	.620**	.645**	.620**	.835**	.809**	1	
	P-value	.000	.000	.000	.000	.000	.000	.000	.000		
	N	417	417	417	417	417	417	417	417	417	
10. Actual Use	r	.738**	.732**	.651**	.698**	.740**	.659**	.809**	.797**	.800**	1
	P-value	.000	.000	.000	.000	.000	.000	.000	.000	.000	
	N	417	417	417	417	417	417	417	417	417	417

**. Correlation is significant at the 0.01 level (2-tailed).

The influence of the research factors is shown by the SEM analysis in Table 8. That is what might be seen:

In support with the first premise: Responsiveness was found to have a sizable beneficial impact (Estimate = 0.128 > 0; P-value = 0.049 < 0.05), Security (Estimate = 0.138 > 0; P-value = 0.012 < 0.05), Information Quality (Estimate = 0.157 > 0; P-value = 0.003 < 0.05), Information Credibility (Estimate = 0.123 > 0; P-value = 0.015 < 0.05), and Needs of Information (Estimate = 0.206 > 0; P-value = 0.019 < 0.05) on Perceived Usefulness. Moreover, the dependent variable variation in perceived usefulness is about 59.9%, as explained by the independent variables, according to the R-squared value of 0.599. From the results, it was found that the need for information (0.206) is the most critical factor that affects perceived usefulness, followed by information quality (0.157), security (0.138), responsiveness (0.128), and information credibility (0.123), respectively.

The second hypothesis: Observation revealed that there is a notable benefit of Responsiveness (Estimate = 0.245 > 0; P-value = 0.000 < 0.05), Security (Estimate = 0.110 > 0; P-value = 0.022 < 0.05), and Information Quality (Estimate = 0.189 > 0; P-value = 0.000 < 0.05) on Perceived Ease of Use, while, there is an insignificant effect of Information Credibility (P-value = 0.145 > 0.05), and Needs of Information (P-value = 0.162 > 0.05) on Perceived Ease of Use. Furthermore, the dependent variable's Perceived Ease of Use R-squared value of 0.658 suggests that the independent factors account for around 65.8% of the variation in the dependent variable. According to outcomes, it was found that Responsiveness (0.245) is the most crucial factor that affects Perceived Ease of Use, followed by Information Quality (0.189), Security (0.110), Needs of Information (0.106), and Information Credibility (0.064), respectively.

The third hypothesis: It is evident that there is a noteworthy benefit between Perceived Usefulness (Estimate = 0.244 > 0; P-value = 0.000 < 0.05) and Perceived Ease of Use (Estimate = 0.762 > 0; P-value = 0.000 < 0.05) on Attitude Toward Use. Additionally, the dependent variable's Attitude Toward Use R-squared value of 0.556 suggests that the independent factors account for around 55.6% of the variation in the dependent variable.

The fourth hypothesis noted a notable benefit to Attitude Toward Use on Behavioral Intention (Estimate = 0.792 > 0; P-value = 0.000 < 0.05). Additionally, the dependent variable, Behavioral Intention, may be explained by Attitude Toward Use to the tune of about 59.8% based on the R-squared value of 0.598.

The fifth hypothesis: The Behavioral Intention was found to have a noteworthy favorable impact on aAtual Use (Estimate = 0.742 > 0; P-value = 0.000 < 0.05). Furthermore, based on the R-squared value of 0.640, the dependent variable, Actual Use, may explain approximately 64% of the variation in the dependent variable.

Table 8: SEM Analysis for the Research Variables

1			Estimate	P	R^2
Perceived Usefulness	<---	Respon-siveness	.128	.049	.599
Perceived Usefulness	<---	Security	.138	.012	
Perceived Usefulness	<---	Information Quality	.157	.003	
Perceived Usefulness	<---	Information Credibility	.123	.015	
Perceived Usefulness	<---	Needs of Information	.206	.019	
Perceived Ease of Use	<---	Respon-siveness	.245	***	.658
Perceived Ease of Use	<---	Security	.110	.022	
Perceived Ease of Use	<---	Information Quality	.189	***	
Perceived Ease of Use	<---	Information Credibility	.064	.145	
Perceived Ease of Use	<---	Needs of Information	.106	.162	
Attitude Toward Use	<---	Perceived Usefulness	.244	***	.556
Attitude Toward Use	<---	Perceived Ease of Use	.762	***	
Behavioral Intention	<---	Attitude Toward Use	.792	***	.598
Actual Use	<---	Behavioral Intention	.742	***	.640

AGFI = 0.861, CFI = 0.975, CMIN/DF = 1.510, GFI = 0.875, and RMSEA = 0.035 are all within acceptable ranges for the model fit indices. The SEM model used to analyze the impact of the research model is depicted in Figure 3.

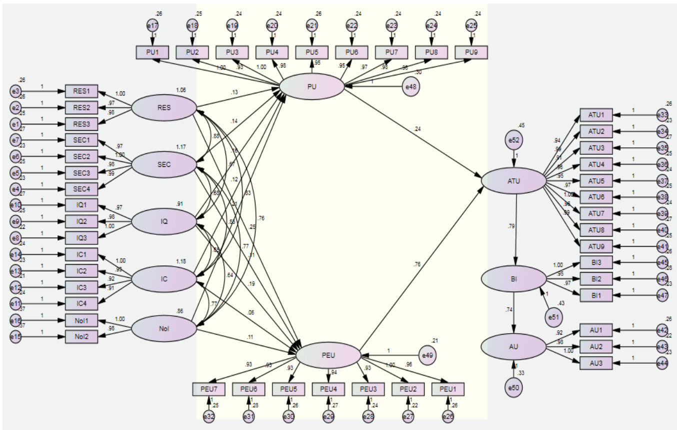

Figure 3: SEM for the Research Variables

DISCUSSION AND CONCLUSION

The goal of these increasingly demanding technical specifications over the last two decades has been to meet IMO performance requirements while granting numerous manufacturers the autonomy to decide on the equipment capabilities, software menu structures, interfaces, behavior, and other features. Different system design components began to exhibit variations in ECDIS models, prompting industry associations like the Nautical Institute to explore standardization. Performance requirements are inadequate to form the foundation of a functional and user-friendly system design because of this tendency. Users expected to switch between systems cannot afford the intensive user training necessary to run each system efficiently. According to the first hypothesis, Responsiveness, Information Quality, and Information Needs significantly improve perceived usefulness. These outcomes align with the findings of some investigations such as those of Lin and Kim, (2016) and Al-Eqab and Adel (2013). However, these outcomes conflict with the findings of some investigations such as Kang and Namkung (2019 and Filieri et al. (2021), which may be attributed to differences in user context and the evolving landscape of ECDIS technology, suggesting that older research may not fully capture recent technological advancements or the heightened emphasis on user-centric designs specific to maritime needs.

Regarding the second hypothesis, although information requirements and credibility minimally affect Perceived Ease of Use, Responsiveness and Information Quality have significant positive impacts, consistent with findings by Jo and Park (2023) and Mazur and Nowakowski (2017). In contrast, Khalilzadeh et al. (2017) and Hansen et al. (2018) report differing results, likely due to their focus on broader technology adoption frameworks that do not account for the specific operational pressures of maritime navigation. This discrepancy highlights how sector-specific nuances, such as the immediate need for reliable and intuitive interfaces in critical navigation scenarios, can shape user perceptions differently than in general technology contexts.

The third hypothesis demonstrates that Perceived Utility and Ease of uUe greatly enhance attitudes toward usage, aligning with studies by Suki and Suki (2011), Elkaseh et al. (2016), and Abdullah et al. (2016). These findings underscore the importance of intuitive design and practical utility in maritime settings, where user familiarity with navigation systems directly impact safety and operational efficiency. The divergence from other research may stem from differing levels of user experience and the dynamic nature of technological updates, which are more pronounced in the specialized field of maritime ECDIS usage.

For the fourth hypothesis, the strong positive impact of Attitude Toward Use on Behavioral Intention is consistent with findings by Yeo et al. (2017) and Salim et al. (2019). Still, it contrasts with some studies like Ramprakash (2016) and Alharbi et al. (2022). This difference could be attributed to variations in the user population. Maritime officers often face higher stakes in system adoption decisions due to the direct link between navigation technology and safety, unlike users in less safety-critical environments. Similarly, the fifth hypothesis reveals that behavioral intention favorably impacts actual use, aligning with studies by Park et al. (2012) and Alharbi et al. (2022). The discrepancy with earlier research can be linked to the evolving training environments and regulatory pressures unique to the maritime industry, which continually shape user behavior in ways not captured by broader, less specialized studies.

In conclusion, each training method has its strengths and challenges. The maritime context necessitates a balance between intuitive system design and thorough training due to the expanding number of ships without traditional navigation tools and the increasing diversity of ECDIS models. The findings emphasize that relying solely on the individual commitment of officers is insufficient. Introducing minimum standards for specific training is crucial to ensure officers have the necessary skills, familiarity, and confidence to operate various ECDIS models effectively, recognizing unique system features and responding to specific settings and indications.

A limitation of this paper is the potentially restricted generalizability due to the sample size of 417, which may not represent diverse ECDIS users and overlook regional and cultural differences. This could affect the applicability of the findings across different contexts. Additionally, reliance on self-reported data introduces biases such as social desirability bias. Future research should use a larger, more diverse sample to improve accuracy and complement self-reports with observational studies and interviews.

RECOMMENDATIONS

- Prioritize S-Mode adoption on high-risk vessels, like tankers and passenger ships in congested waterways. This will reduce navigational errors and enhance safety in critical maritime zones.

- Develop tiered ECDIS training based on user experience, incorporating scenario-based exercises for advanced users. This ensures all officers are well-prepared for real-world challenges, minimizing accidents.

- Establish industry-wide interface design guidelines to standardize critical ECDIS functions across manufacturers. This reduces familiarization time and human error, allowing seamless skill transfer between different systems.

- Mandate routine software updates and enhanced cybersecurity measures for ECDIS systems to protect against cyber threats and ensure reliable operation.

- Foster collaboration between maritime

academies and ship operators to create training programs with real-world simulations, ensuring that training is directly relevant to actual ship operations, thereby improving maritime safety.

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Non-Native English-Speaking Seafarers - An Investigation into Communicational Challenges and Consequent on High Retention Rates

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ABSTRACT

Purpose: *This study investigates the challenges faced by non-native English-speaking seafarers in the maritime industry that would affect their employability and rate of retention. The study aims to explore strategies to elevate seafarers' professional communicational skills, through quality education, as per Sustainable Development Goal (SDG) 4, and effective recruitment, retention, and work diversity practices as per SDG 8 (Decent Work and Economic Growth) and SDG 10 (Reduced Inequalities).*

Methodology/Approach/Design: *a sequential explanatory approach was employed that integrates quantitative and qualitative methodologies. Initially, quantitative data are collected through online questionnaires, providing preliminary insights into generic communicational challenges among non-native English-speaking seafarers. These insights guide the selection of participants for subsequent qualitative semi-structured interviews with seafarers and maritime employers. The qualitative data are analyzed utilizing commercial NVivo software, focusing on thematic coding and correlation analysis.*

Findings/Results: *significant psychological, technical, and cultural barriers to effective English communication among maritime students, including fear of criticism, lack of interest, and difficulties in understanding accents. Recommendations included integrating advanced technological tools, interactive learning methods, and broader incorporation of English across maritime courses. The analysis revealed the crucial role of technical skills and English proficiency, with implications for recruitment, training, and workplace inclusivity. Technological innovations and comprehensive training approaches are suggested to address these challenges and improve seafarers' employability and career development.*

Key-words:
Maritime communication, English proficiency, seafarers' career development, qualitative research, maritime training, diversity, inclusion, sustainable development goals (SDGs).

INTRODUCTION

The international nature of maritime work necessitates diversity and inclusion, with multinational crews often enhancing collaboration and engagement (Heirs et al., 2021). However, this diversity also introduces communicational challenges, particularly for non-native English speakers Communication is critical in the maritime industry, with English serving as the lingua franca. Miscommunications can lead to severe consequences, including accidents and increased stress levels among crew members (Arulnayagam, 2020). Studies indicate that 80% of global trading ships are staffed by non-native English speakers, complicating effective communication due to different accents and cultural backgrounds (Fan et al., 2017). This gap in communication skills affects employability, career progression, and job satisfaction (Farag & Elashkar, 2016).

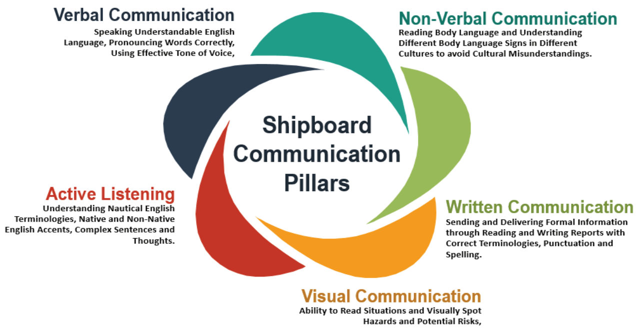

Fig. 1. Shipboard communication pillars, Source: WMU Journal of Maritime Affairs (2015)

As summarized in Figure 1, shipboard communication competence is beyond achieving high English scores in traditional classroom examinations, as it includes verbal, non-verbal, written, visual, and listening skills. To address these issues, maritime education and training institutions must develop curricula that enhance English communication skills, particularly focusing on real-life scenarios and diverse accents. This research aims to create a communicative maritime competency framework, assess current communication competence among non-native English-speaking seafarers, bridge the gap between their skills and employability, and recommend improvements for Maritime English education.

This study is crucial for promoting diversity and inclusion in the maritime workforce and supporting sustainable development goals (SDGs) related to quality education, and decent work. Enhancing the communication skills of non-native English-speaking seafarers can improve their career prospects, contributing to the global maritime economy and fostering a more inclusive and efficient maritime industry. To achieve this goal, a sample was selected to be interviewed for further investigation and to conduct a qualitative analysis. Interviews have been conducted with seafarers from different ranks, and maritime employers to further understand and analyze the English communication challenges seafarers face working on international ships, the impact of poor English proficiency on the seafarer's career and the ship environment and employer, the urgency of addressing this communication gap, and the suggested solutions and enhancements to be made. In addition, an in-depth analysis of new qualitative interviews was extracted and analyzed to obtain more accurate results and detailed recommendations.

LITERATURE REVIEW

Although the International Maritime Organization (IMO) conventions set standards for seafarers to have a working knowledge of English, communication failures persist and continue to cause maritime accidents. John and Brooks (2017) conducted a quantitative analysis of radio communication transcripts from the Vessel Traffic Service (VTS) in the UK and the International Maritime Pilots' Association (IMPA), which revealed that non-native speakers often deviated from the Standard Marine Communication Phrases (SMCP) standards, especially in greetings, numbers, and time expressions. Non-native speakers tended to use more informal greetings and ad-hoc strategies like repetition and paraphrasing to overcome communication difficulties, which could lead to misunderstandings and inefficiencies.

Farag et al. (2016) highlighted the broader manpower concerns in the maritime industry, emphasizing the need for promoting maritime vocations, advancing maritime education, and addressing the early retirement of seafarers. They pointed out that despite their qualifications, Egyptian seafarers struggle to find opportunities on international vessels due to a global shortage of competent officers.

As the maritime industry shifts towards autonomous shipping, more endeavors and innovation are needed in tailoring training programs to the specific needs of the ship crew and maritime personnel, with a deeper focus on generic skills that include communication and teamwork (Meštrovi et al., 2024).

METHODOLOGY

This study adopts a sequential explanatory approach, integrating both qualitative and quantitative methodologies, sequentially, to address the research questions comprehensively as illustrated in Figure 2.

The qualitative component of the study employs semi-structured interviews, which are a hybrid of structured and unstructured interview formats. Semi-structured interviews combine predetermined questions with the flexibility to explore emerging topics. This approach allows for a detailed exploration of participants' experiences, perceptions, and recommendations regarding English language proficiency in maritime contexts.

For having validated results, the semi-structured interviews are conducted using a comprehensive sampling strategy with two different pools of candidates; (1) twelve non-native English-speaking seafarers from different ranks, and (2) nine maritime employers in shipping companies. The interviews are designed to gather in-depth information about the participants' English language learning experiences, the significance of language proficiency for their careers, and their suggestions for enhancing language skills among non-native English-speaking seafarers. The interviews are conducted virtually to accommodate participants from diverse locations.

Data analysis for the qualitative phase involves several steps. The interviews are transcribed manually and analyzed using qualitative data analysis software such as NVivo™, which facilitates the organization, coding, and retrieval of data. The analysis process includes summarization, categorization, and coding of data segments based on a theoretical framework or emerging themes. The results from the qualitative analysis are used in conjunction with the quantitative findings to test the study's hypotheses and to provide a comprehensive understanding of the relationship between English language proficiency and seafarers' employability. For further in-depth analysis, quantitative data were extracted from the qualitative interviews and analyzed to obtain more accurate results and detailed recommendations, by extracting variables related to themes across the different questions and answers. This was done by using (1) frequency analysis: counting occurrences of each theme across responses to identify prevalent issues, (2) percentage analysis: calculating the percentage of responses that mention specific themes to value their significance, and (3) correlation analysis: finding correlations between variables to understand relationships.

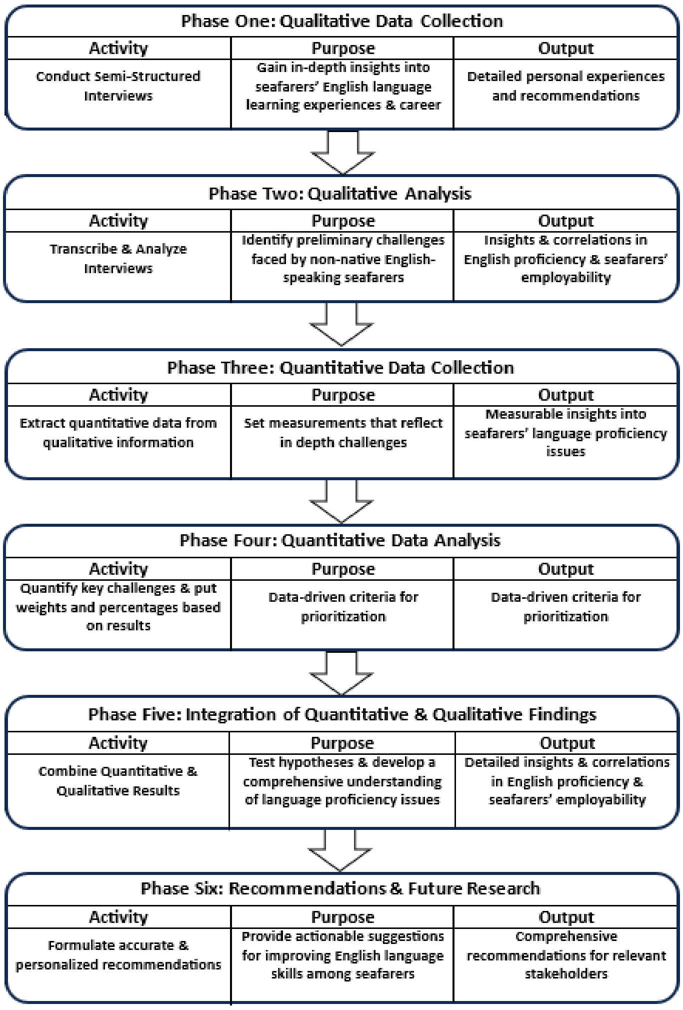

Fig. 2. Research phases (Source: The Researchers)

ANALYSIS AND RESULTS

Qualitative Analysis for Seafarers

Table 1: Summary of Qualitative Interviews with Seafarers about their "English Communication" Challenges working on International Ships with other Seafarers from Different Nationalities

Interview Question	Themes/Responses
Q1: What specific challenges have you encountered while working on foreign ships, particularly related to language and communication?	Discrimination/bullying due to accent; comprehending various English accents; lack of cultural awareness; difficulty with fast-paced English; language barriers among shipmates; lack of cultural exposure; challenges due to diversity in accents; challenges for minority genders; potential communication risks; cultural and psychological challenges.

Interview Question	Themes/Responses
Q2: Can you describe any difficulties you have faced while communicating in English on a ship? What specific situations or interactions led to these challenges?	Misunderstandings due to accents; time consumption in communication; misunderstandings in informal communication; difficulty understanding Native English speakers; preference for communicating with same nationality; challenges due to lack of cultural awareness; feeling left out or indifferent; exposure to new terminologies/ vocabulary.
Q3: In your opinion, how adequate was your training in English communication before boarding? What specific aspects of the training do you feel were lacking?	Insufficient practical training; lack of exposure to different accents; reliance on on-the-job learning; inadequate training on communication etiquette/ethics; incompatibility of academic training with practical needs; need for more advanced training; focus on technical skills over language skills.
Q4: What specific changes or improvements would you suggest for maritime English education and training programs? How could these changes better prepare seafarers for effective communication on board?	More practical training; enhancement of listening skills; continuous guidance and feedback; discussion activities with native/non-native speakers; emphasis on English as a communication skill; selection of seafarers with prior English study; continuous practice; learning maritime terminologies and accents; integration of cultural awareness; fostering independence and self-learning mindset; raising awareness on the importance of English education.

Based on Table 1, the analysis of interview responses reveals several key challenges in English communication for seafarers on international ships. These challenges include difficulties understanding various English accents, which can lead to misunderstandings and inefficiencies, particularly in the high-paced environment of ship operations. Additionally, issues like cultural insensitivity and discrimination are prevalent, with a lack of cultural awareness causing misunderstandings and conflicts. The interviews also highlight that training for seafarers is often insufficient, especially regarding practical exposure to different accents and cultural nuances. There is a clear need for more comprehensive maritime English education that addresses language proficiency, cultural competence, and communication etiquette.

Respondents recommend improving English communication skills through more practical training, ongoing guidance, and feedback. They stress the need to prioritize English in maritime training, integrate cultural awareness, and encourage self-learning. Key issues identified include challenges with accents and pronunciation, cultural and psychological barriers, inadequate Maritime English training, and the impact of noisy, stressful environments. Gender-related challenges also affect female seafarers. Addressing these issues is essential for better communication and inclusivity in the maritime industry.

QUANTITATIVE ANALYSIS

This section presents the quantitative analysis of the challenges faced by maritime professionals working on foreign ships, problems encountered in English communication on board, and the adequacy of their English communication training, and analyzed based on the information presented in Table 2.

Table 2: Quantitative Data Analysis from Qualitative Interviews with Seafarers about their “English Communication” Challenges working on International Ships with other Seafarers from Different Nationalities

1. Challenges Faced Working on Foreign Ships	
1.1 Communication Challenges	41.67%
○ Discrimination or bullying due to accent: 8.33% ○ Comprehending other English accents: 8.33% ○ Difficulty understanding native speakers: 8.33% ○ Unsmooth communication due to lack of English development: 8.33% ○ Noise and stress affecting communication: 8.33%	
1.2 Cultural and Social Integration Challenges	41.67%
○ Lack of cultural awareness: 16.67% ○ Lack of background in other cultures: 8.33% ○ Exclusion due to other languages: 8.33% ○ Cultural and psychological challenges being the only different nationality: 8.33%	
1.3 Specific Demographic and Situational Challenges	16.67%
○ Gender-related challenges: 8.33% ○ Routine and day-to-day duties: 8.33%	
2. Problems Communicating in English on a Ship	
2.1 Accent and Pronunciation Issues	33.34%
○ Accent issues: 16.67% ○ Issues with accents: 16.67%	
2.2 Social and Cultural Communication Issues	25%

○ Misunderstood informal communication: 8.33% ○ Shyness in asking for clarification: 8.33% ○ Cultural misunderstandings: 8.33%	
2.3 Lack of Communication Challenges	16.67%
○ No communication challenges: 16.67%	
2.4 Specific Situational Challenges	8.33%
○ Feeling indifferent and left behind: 8.33%	
3. Adequacy of English Communication Training	
3.1 Insufficient and Inadequate Training	91.67%
○ Basic English training lacks depth and practical application: 8.33% ○ Training does not address the needs of multinational crews: 8.33% ○ Reliance on on-the-job learning with minimal formal training: 8.33% ○ Training duration is too short to cover essential communication skills: 8.33% ○ Lack of training on communication etiquette and cultural sensitivity: 8.33% ○ Focus is primarily on Maritime English rather than comprehensive cross-cultural communication: 8.33% ○ Training is effective only for crews of the same nationality: 8.33% ○ Curriculum is not aligned with real-world communication needs: 8.33% ○ Training emphasizes basic communication rather than fluency: 8.33% ○ Marine's certificates do not sufficiently prepare seafarers for real-life scenarios: 8.33% ○ Training programs are designed for students but lack lifelong applicability: 8.33%	
3.2 Prioritization of Technical Skills Over English	8.33%
○ English language skills are often undervalued compared to technical competencies: 8.33%	

Source: Data collected from qualitative interviews conducted with maritime professionals regarding their English communication challenges on international ships.

Challenges Faced Working on Foreign Ships

Communication and cultural integration issues are prominent, with 41.67% of respondents citing problems such as accent-related discrimination, difficulty understanding various English accents, and fast-paced speech. These issues are exacerbated by background noise and stress, indicating a need for better language training and communication protocols. Cultural and social integration challenges also affect 41.67% of respondents, with gaps in cultural awareness and exclusion due to language differences. Gender-related issues and routine tasks were reported by 16.67%, highlighting the need for targeted inclusivity measures.

Problems Communicating in English on a Ship

The data reveal significant challenges in communicating effectively in English on ships, particularly related to accent and pronunciation, which accounted for a substantial 33.34% of the reported problems. Respondents noted that both personal accent issues and the diverse accents of fellow crew members hindered clear communication. Additionally, social and cultural factors contributed to misunderstandings, with 25% of respondents highlighting challenges such as misinterpreted informal communication, shyness when seeking clarification, and cultural misunderstandings. Interestingly, a notable 16.67% of participants reported experiencing no communication challenges, suggesting that some individuals adapt effectively to the multilingual environment. However, specific situational challenges, like feelings of indifference or being left out, affected 8.33% of respondents, indicating the emotional impact of communication barriers in maritime settings. Overall, the results underscore the need for improved training and support to enhance communication skills among seafarers.

Adequacy of English Communication Training

A notable 91.67% of respondents deemed their English training inadequate, citing insufficient focus on cross-cultural communication and ongoing learning. Only 8.33% felt their training was overly technical, revealing a need for better alignment with practical communication needs.

Qualitative Analysis: Maritime Employers

Table 3: Summary of Qualitative Interviews with Maritime Employers

Interview Question	Themes/Responses
Q1: What qualities are important to you when recruiting seafarers?	Technical and communication skills; ambition and adaptability; simplicity and high emotional intelligence; certification; behavior, work loyalty, and discipline; certification from trusted entities; qualifications and competence; practical experience and knowledge of sea laws; academic and work experience.
Q2: What are the main barriers to hiring English-speaking seafarers in your company?	Difficulty in finding competent talent; market saturation with basic English speakers; lack of specialized assessment tests; challenges in headhunting talented and fluent English speakers.
Q3: Do you think your inability to communicate in English will affect your hiring decision? Why?	Yes, verification of candidates' skills and abilities; the importance of English proficiency in multinational companies; the necessity of assessing behavioral skills in English; the importance of English skills testing during interviews; organizational culture and alignment; HR as a role model for communication standards.
Q4: What are the types of English exams or certificates required from your company to hire seafarers?	Bachelor's degree in English; general English certificates (e.g., TOEFL, IELTS); specialized Maritime English certificates; in-house English assessments and interviews; recruitment agency assessments; written English exams focusing on maritime reports and professional communication; technical and behavioral interviews conducted in English.
Q5: How successful is your organization in attracting seafarers to work on your ships? And what are the benefits you provide?	Long-term contracts; attractive incentives and wages; good onboard conditions and work-life balance; policy encouraging female seafarers; ongoing training programs; promising future with the company; acceptable salaries and good work environment.
Q6: Tell us if the organization has faced any challenges in hiring and attracting seafarers to work on your ships.	Limited pool of candidates due to few maritime universities; need for tailored talent assessment tools; fostering workplace diversity; maintaining relationships with universities; creating attractive salary schemes; challenges in hiring emotionally intelligent and highly communicative seafarers.
Q7: If there are challenges, how will they be met?	Investment in training and onboarding; outsourcing external talent assessors; developing diversity values; maintaining university relationships; updating rewards and incentives; including emotional intelligence training; promoting employer brand; utilizing technology for recruitment.
Q8: Is there any area that you think needs improvement to attract seafarers to your organization?	Creation of a friendly and collaborative work environment; emotional recognition and awards; continuous development and training; clear career path; performance-based rewards; positive word-of-mouth reputation; awareness of non-financial benefits; use of technology in day-to-day work; updating salary structure.
Q9: What is the seafarers' turnover rate of your organization?	Various turnover rates range from 22% to 35%.
Q10: What are the reasons your senior management usually leaves your organization?	Seeking better opportunities, growth, or financial offers; settling in onshore jobs; retirement.
Q11: To what extent the lack of proficiency in the English language among seafarers had caused problems or challenges in your organization?	Misunderstandings leading to cultural gaps and silos; hindrance to career growth and opportunities; potential harassment and gender-related misunderstandings; impact on work quality and response efficiency; organizational image and reputation; productivity and error rates; learning and self-development limitations.
Q12: Could you please explain if your organization has problems managing a multicultural crew on your ships?	Synchronizing different nationalities under one culture; promoting English communication over mother tongues; ensuring safety and avoiding miscommunication hazards; fostering cultural diversity appreciation; addressing accommodation and cultural gaps; enforcing discrimination-free policies.
Q13: How do you rate whether your seafarers are satisfied with their work?	Worker satisfaction surveys; adherence to policies and procedures; referrals and rehiring rates; refusal of offers from other organizations; absence of problems and complaints; engagement in events and meetings; community and teamwork spirit.
Q14: Do you have a system for receiving feedback from sailors on your ships?	Surveys, reports from officers and captains, periodic interviews, complaints and suggestions system, periodic meetings.
Q15: Can you explain the pillar situations in which you would not want to keep officers in your organization?	Poor performance and lack of development; non-compliance with policies; harassment or lack of respect; failure in duties and quality; safety violations; troublemaking behavior; repeated errors; non-compliance with instructions; bad attitude.

Source: Data collected from qualitative interviews with maritime employers regarding their perspectives on recruiting and managing seafarers.

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Table 3 highlights the key qualities sought in seafarers, including technical skills, ambition, adaptability, emotional intelligence, and discipline. Employers face challenges such as sourcing skilled talent, and market saturation with basic English speakers. English proficiency is crucial for effective communication, verified through exams like TOEFL, IELTS, and specialized Maritime English tests. Successful recruitment depends on offering competitive benefits, long-term contracts, and supportive work conditions. Organizations can improve recruitment by investing in training, using tailored assessment tools, promoting diversity, and updating incentives. Fostering a collaborative work environment and competitive salaries are essential for attracting and retaining seafarers.

Maritime Employers Quantitative Data Analysis from Qualitative Interviews

Recruiting seafarers' hinges on technical proficiency, communication skills, certification, and emotional intelligence, essential for operational efficiency and safety. Challenges include the cost of English assessments, which impact hiring and organizational culture. Addressing these issues involves thorough English testing, diligent HR practices, and creating supportive work environments with stability, career development, and competitive incentives. Managing multicultural crews can leverage diversity but requires overcoming communication barriers and maintaining safety. Continuous improvements in training, salary structures, and feedback systems are crucial for enhancing satisfaction and performance in the maritime industry.

Table 4: Quantitative Data Analysis from Qualitative Interviews with Maritime Employers

1. Most Important Recruitment Qualities
- Technical skills: 70% - Communication skills: 60% - Emotional intelligence: 30% - Certification: 40%
2. Barriers to Hiring English-speaking Seafarers
- Competency in English: 80% - Cost of assessments: 20%
3. Impact of English Proficiency on Hiring
- Importance of English testing: 60% - Organizational culture impact: 40% - HR responsibility: 50%
4. English Exams/Certificates Required
- General English certificates: 50% - Maritime English certificates: 30% - In-house assessments: 20%

Source: Data collected from qualitative interviews with maritime employers regarding recruitment qualities, barriers to hiring, and English proficiency requirements for seafarers.

DESCRIPTIVE ANALYSIS

The quantitative analysis reveals key insights into maritime recruitment priorities and challenges. According to Table 4, technical skills are the most crucial recruitment quality, highlighted by 70% of respondents, reflecting the industry need for expertise in ship operations. Communication skills are also vital, with 60% emphasizing their importance for effective verbal and written interaction among seafarers. Emotional intelligence, noted by 30%, is increasingly valued for its role in team dynamics, while certification is important for 40% of respondents, ensuring formal qualifications and industry compliance.

English proficiency is a significant barrier, cited by 80% of respondents, underscoring its role in communication, safety, and regulatory compliance. The cost of assessments, though less impactful at 20%, remains a financial consideration.

Regarding English proficiency, 60% stress the need for rigorous English testing, reflecting its importance in global communication and operational efficiency. Organizational culture, noted by 40%, shows how English proficiency affects workplace dynamics in multicultural crews. HR responsibility, acknowledged by 50%, highlights the role of human resources in maintaining language standards. General English certificates are required by 50%, Maritime English certificates by 30%, and in-house assessments by 20%, indicating a need for both standardized and industry-specific language evaluations. These factors collectively impact recruitment, emphasizing technical and communication skills, and English proficiency for effective maritime operations.

DISCUSSION

The analysis reveals critical insights into the maritime industry recruitment and training practices for seafarers. Key findings underscore the paramount importance of technical skills, with 70% of respondents emphasizing their necessity for effective ship operations and technical tasks. Communication skills, including English proficiency, are also crucial, as highlighted by 60% of respondents. This is essential for ensuring clear and safe interactions, particularly in multinational settings. Additionally, emotional intelligence and formal certifications are valued, reflecting the need for seafarers who can handle both technical responsibilities and interpersonal dynamics.

As for the qualitative results, the difficulties seafarers face in understanding various English accents are well-documented in maritime literature. The responses from the interviews corroborate these findings, indicating that accent and pronunciation are significant barriers, leading to misunderstandings and feelings of discrimination among seafarers. Barriers to recruitment include significant challenges related to English proficiency. A substantial 80% of respondents identified English competency as a major obstacle, critical for effective communication and regulatory compliance. These barriers highlight the need for targeted solutions to enhance the recruitment process. Technological innovations, such as virtual reality and artificial intelligence, present valuable opportunities for improving language learning and communication. Standardizing English testing protocols and developing inclusive communication policies can streamline recruitment and improve operational efficiency. By implementing these recommendations, maritime employers can better address the challenges identified and enhance their recruitment and training strategies, fostering a more effective and supportive working environment for seafarers.

Cultural awareness and sensitivity are critical components of effective maritime communication. The interviews reveal that a lack of understanding of cultural norms and practices can lead to misunderstandings and potential conflicts. Additionally, gender-related issues, as noted by Kitada (2010) and Belcher et al. (2003), exacerbate the challenges faced by minority groups in maritime settings. These studies support the interview findings that emphasize the need to address diversity and inclusion issues to create a more inclusive and supportive work environment for all seafarers.

Also, the gaps in training regarding English communication skills, as reported by the respondents, align with the findings of previous studies. Many respondents feel that their training was insufficient, particularly in terms of practical training and exposure to different accents. This is consistent with the work of Horck (2010), who argues that maritime education and training programs often lack a comprehensive approach to language proficiency and cultural competence. The respondents' emphasis on the need for practical training, continuous guidance, and feedback suggests that maritime education should focus not only on language proficiency but also on cultural competence and communication etiquette. This holistic approach is essential for preparing seafarers to navigate the complex communication landscape of the maritime industry.

In examining the key challenges faced by seafarers, several critical issues emerge. Firstly, accent and pronunciation pose significant barriers, affecting both speakers and listeners and contributing to feelings of discrimination among seafarers. Secondly, insufficient training in Maritime English and communication etiquette further complicates effective communication at sea. Horck (2010) and other studies emphasize the need for more comprehensive and practical training approaches. Moreover, the communication environment aboard ships, characterized by noise and stress, reduces efficiency and sometimes excludes non-native language speakers. Lastly, gender-related issues exacerbate challenges for female seafarers in predominantly male environments, as noted by Belcher et al. (2003).

Based on Tables 1, 2, 3, and 4, the responses from the interviews shed light on significant challenges faced by seafarers regarding English communication on foreign ships. These challenges range from linguistic barriers, such as difficulties in understanding different accents and dialects, to broader issues like discrimination and cultural insensitivity. One common theme is the impact of accents on communication. Seafarers often struggle to comprehend various English accents, leading to misunderstandings and inefficiencies in communication. This challenge is exacerbated by the fast-paced nature of communication onboard ships, where clear and concise communication is crucial for safety and efficiency.

Cultural awareness also emerges as a key issue. Seafarers may encounter difficulties due to a lack of understanding of cultural norms and practices, leading to misunderstandings and potential conflicts. Additionally, minority genders may face specific challenges in such environments, highlighting the importance of addressing diversity and inclusion issues in maritime settings.

The interviews also reveal gaps in the training provided to seafarers regarding English communication skills. Many respondents feel that the training they received was insufficient, with a lack of practical training and exposure to different accents cited as significant issues. This suggests a need for a more comprehensive and practical approach to maritime English education, focusing not only on language proficiency but also on cultural competence and communication etiquette. In terms of improvements, respondents emphasize the importance of practical training, continuous guidance, and feedback to enhance English communication skills. They also stress the need for greater emphasis on

English as a communication skill in maritime education and training programs. Integrating cultural awareness and fostering a self-learning mindset are also seen as essential aspects of improving English communication in the maritime industry. These suggestions echo the recommendations by Bailey et al. (2006), who highlighted the need for ongoing training and support to improve communication skills among seafarers.

The qualitative results from the interviews highlighted several key challenges faced by non-native English-speaking seafarers, such as linguistic barriers, discrimination, and cultural insensitivity. These findings align with Intersectionality Theory, which emphasizes how various social identities intersect to shape individuals' experiences. For instance, the difficulties seafarers face in understanding different English accents and dialects can be seen as a result of the intersection of language proficiency with their national and ethnic identities. Additionally, the reported instances of discrimination and cultural insensitivity suggest that seafarers' linguistic and cultural backgrounds intersect to create unique challenges in their professional environments. The quantitative data may reveal correlations between seafarers' language proficiency and their experiences of discrimination or job satisfaction. For example, statistical analysis could show that seafarers with lower English proficiency are more likely to report feelings of exclusion or discrimination, supporting the idea that language barriers intersect with other aspects of identity to influence their work experiences.

The qualitative interviews also shed light on the push and pull factors influencing seafarers' career decisions. For example, a lack of confidence in English communication was identified as a push factor, deterring seafarers from pursuing certain job opportunities. On the other hand, proficiency in English was seen as a pull factor, attracting seafarers to companies that value effective communication. Quantitative analysis could examine the relationship between English proficiency and career progression. For example, regression models might show that higher English proficiency is associated with better job opportunities, higher salaries, and greater job satisfaction. Surveys could also identify specific push factors (e.g., fear of miscommunication) and pull factors (e.g., career advancement opportunities) that influence seafarers' employment decisions.

The qualitative data revealed significant gaps in the training provided to seafarers regarding English communication skills. Many respondents indicated that their training was insufficient, with a lack of practical exercises and exposure to different accents. This finding is consistent with the Communicative Competence Theory, which highlights the importance of not just linguistic competence but also the ability to use language effectively in various social and cultural contexts. Quantitative results could measure the effectiveness of current training programs by comparing the communicative competence of seafarers who received different types of training. Surveys might assess seafarers' self-reported competence in specific skills (e.g., understanding instructions, and engaging in cross-cultural communication) and correlate these with their training backgrounds. Additionally, statistical analysis could identify the impact of improved training programs on job performance and safety outcomes.

The integration of these theories with the study's results provides a multidimensional understanding of the challenges faced by non-native English-speaking seafarers. Intersectionality Theory helps explain how language proficiency interacts with other identity factors, leading to varied experiences of discrimination and inclusion. Push-pull factors illuminate the motivational and deterrent influences on seafarers' career choices, highlighting the critical role of language proficiency. Communicative Competence Theory underscores the need for comprehensive training that goes beyond basic language skills to include cultural and social competencies. By aligning the qualitative insights with quantitative evidence, the study can offer robust recommendations for improving English language training programs, fostering inclusive workplace environments, and enhancing the overall well-being and career satisfaction of non-native English-speaking seafarers.

IMPLICATIONS

The study exploration of the challenges faced by non-native English-speaking seafarers has significant implications for the SDGs, which aim to promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all. Understanding and addressing the linguistic and cultural barriers encountered by seafarers can directly contribute to achieving these objectives by enhancing their employability, job satisfaction, and overall contribution to the maritime industry.

SDG 4: Quality Education

The study underscores the importance of education in improving English proficiency among non-native-speaking seafarers. Enhancing maritime education with comprehensive language training, practical skills, and cultural competence supports SDG 4 by boosting seafarers' employability and equipping them for diverse environments, aligning with the goal of inclusive, equitable quality education and lifelong learning.

SDG 8: Decent Work and Economic Growth

The study highlights language proficiency as key to seafarers' career opportunities and job satisfaction. Improving language training and cultural competence can enhance work quality and safety, supporting SDG 8. By investing in comprehensive training, using immersive technology, and fostering inclusive workplaces, the maritime industry can promote decent work and economic growth, aligning with SDG 8's goals of sustainable economic growth, full employment, and decent work for all.

SDG 10: Reduced Inequalities

The study emphasizes reducing inequalities in the maritime industry, where language barriers and cultural differences often hinder seafarers' employment and career advancement (Devereux, 2017). Targeted language training, inclusive policies, and supportive environments can help address these issues. Promoting diversity and inclusion will reduce economic inequalities and ensure equal opportunities for all seafarers, aligning with SDG 10's goal of reducing inequality and promoting inclusive growth.

CONCLUSIONS AND RECOMMENDATIONS

- Incorporate real-life scenarios and role-playing exercises to improve practical communication skills.
- Provide extensive training that covers different English accents including listening exercises with various accents and discussion activities with both native and non-native speakers.
- Offer ongoing training and development programs rather than one-time courses to ensure sustained proficiency in English communication.
- Ensure ongoing training and feedback through English learning coaches.
- Implement cultural sensitivity training to enhance understanding and collaboration among multinational crews.
- Address gender-related challenges by promoting inclusive practices and providing support networks for minority groups on board.
- Foster an inclusive environment where all crew members feel valued and included, regardless of their nationality, gender, or background.
- Ensure that English communication skills are given equal importance to technical skills in maritime training programs.
- Collaborate with maritime institutes to revise curricula to include a balanced focus on language and technical competencies.
- Develop policies to minimize the use of non-English native languages among same-nationality groups.
- Verify certifications thoroughly to ensure compliance with international standards. Streamline certification verification processes to expedite onboard readiness and compliance assurance.
- Invest in comprehensive language training programs that improve seafarers' English proficiency. Offer ongoing language support and incentivize language proficiency through career advancement opportunities.
- Explore cost-effective English assessment solutions without compromising quality. Consider leveraging digital platforms for assessments and negotiations with assessment providers to reduce costs (Ölçer et al., 2023).
- Standardize English testing protocols across recruitment and deployment phases. Implement consistent evaluation criteria and benchmarks to ensure uniform language proficiency standards.
- Foster an inclusive organizational culture that values linguistic diversity and proficiency. Promote cross-cultural communication initiatives and multicultural awareness among crew members.
- Empower HR departments with resources and training to effectively manage language-related challenges. Provide ongoing support for HR personnel in navigating linguistic diversity and promoting linguistic competence.

FUTURE RESEARCH

Future research could explore several key areas to enhance maritime education and operations. Cultural competence studies could examine how cultural awareness impacts communication and teamwork on ships, leading to improved training programs. Longitudinal studies on language proficiency could track the effectiveness of various training methods over time, offering insights for curriculum improvements in maritime educational entities and ongoing development through the employment journey. Technological innovations like VR and AI could be investigated for their potential to revolutionize language learning and communication skills onboard. Gender-specific research could address the unique challenges faced by women seafarers, focusing on effective policies for gender equality.

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Examining the Effect of Full-Mission Simulation Training on the Safety and Education in the Maritime Sector

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ABSTRACT

Purpose: *This contemporary research assesses full-mission simulation as a training tool incorporated within the curriculum of the Arab Academy for Science, Technology and Maritime Transport with focus on operational safety and education aspects.*

Design/Approach/Methodology: *Using a structured SWOT approach in the research the internal strengths and weaknesses as well as external opportunities and threats related to the full mission tool are shown. The simulator is very effective in simulating the marine environment and providing trainees with practical exercises, however, there are problems such as high usage costs and the risk of overwhelming the trainees. This study seeks to mitigate this problem by proposed a concurrent use of virtual reality (VR) interoperability with full-mission simulator. This is expected to improve the quality of the training, cut down the training costs and increase the capability of developing different scenarios. Combining these systems in training and simulation proposes wide advantages including an efficient and logical program that ensures efficient outcomes.*

Findings: *From the study VR integration is the way forward in addressing the challenges faced currently and helping the Academy remain on top of maritime education and training development.*

Key-words:
Simulation based training , AASTAT. Marine full-mission simulator , SWOT analysis , Using V.R virtual realty in marine training , The role of Augmented realty A.R in ships maintenance training.

INTRODUCTION

Real ships equipment is the most efficient way to teach maintenance and the operation of ship electrical and automation systems. It is a pre-requisite according to the convention for the proper maintenance and operation of these systems, or at least raising of the existing need. Hence, the need to equip seafarers, such as the onboard electro-technical officers and the marine engineers, with the state of art modern marine equipment and automation systems, is impressive (Hontvedt, 2015). Such bodies are advocated by categorization of primary bodies of which helps inboard teaching. Inasmuch as marine electro-technical systems tend to dominate the non-distracted operations, there is never sufficient time to carry out the virtual absentees of sea electrical systems and make their demoralizing (Zinchenko et al., 2019).

The simulator system fully reproduces the working modes of ships and carries out engineer actions for the automated equipment and systems on ships. It encompasses all-round training on the principles and practices of monitoring, control and management of mechatronic systems which include principal investigation of the parameters, their modification and depiction. Due to its very many functionalities, the simulator enables numerous operational, controllership, and managerial structures for the exercise of many functional failures being practiced. It accentuates the functional usage of automatic control systems under emergencies and drills relevant to watch-keeper's behavior for fault identification, problem finding, and equipment repair (Connolly, 2018).

In consequence, the full mission simulator complex (FMS), whose functional purpose is the professional training and the qualification testing of the marine specialists, in particular, the electro-technical officers and marine engineers, is completely in adherence to the requirements which are stipulated in the electrical and electronic sections as well as the Control Systems and competencies requirement for such professionals (Nosov et al., 2019). The simulator addresses the needs of practical training as well as the needs of the competence assurance system of engine room personnel. It mimics the actual working environment such that the trainees acquire and demonstrate maintenance and repair skills and perform satisfactorily in competence tests. The simulator creates managed working conditions including emergencies or operational events and makes it possible to reproduce numerous operational events (Zinchenko et al., 2020).

Inside the simulator, students operate a power plant and separate electromechanical plants both in automatic and manual modes. The operational parameters can be monitored using the actual manual controls or a computer workstation. In addition, the simulator has on-line access to the materials intended for teaching, learning and referential purposes (Rystedt et al., 2018).

Consequently, this paper attempts to support the case for the use of full mission simulators in the training of sea farers through an examination of the potential impact they have in relation to the development of the skills and abilities of electro-technical officers and marine engineers.

LITERATURE REVIEW

The present section reviews the existing literature explaining the importance of the use of training simulations supranational as applied specifically to seafarers through an application of full mission simulators. These studies are aimed at the effect of the use of these simulations by seafarers across various nations over the years. The literature reviewed extends within the period from 2017 to 2022.

Sanfilippo (2017) advances a comprehensive multi-sensor fusion system for the Offshore Simulator Centre AS. The main objective of this framework is to improve the risk management processes in the designing, execution and evaluation of sophisticated sea operations with the use of innovative risk-evaluation methods. Not only could the system obtain information from the simulator scene, but also from the subject matter which consists of audio, video, biometric data, and other sensor data. The current research highlights the role of briefing and debriefing in training, and the value of this study is in the incorporation of these activities into the suggested structure.

Sellberg (2017) uses 34 different articles from several journals for the evaluation of the application of simulators in maritime education and training. As a result of this review, it is possible to classify three fundamental spheres of research: education, human factors and maritime professions. The research underlines a lack of knowledge about the kind of instructional designs that lead to effective learning through simulations and suggests that further research is necessary to boost practice-based evidence.

Sellberg (2018) is concerned with training buildings simulation regarding all its phases. Such solution is implemented by Al-Tadawi B2 and Al-Bina real estate in Abu Dhabi.

Azzawi (2014) mentions that such possibilities are adequate for aiding education and training. The author, however, points out that these possibilities reflect the inherent potential of learners to make sense of connections between broadly defined ideas and more situational specific details, as it applies across all stages of training.

Sharma Ranak, Adam, and others (2018) classify the maritime occupations as among the most hazardous, so the authors see the need for operator preparation using simulator training. The research stresses the importance of developing instructional approaches that take into account the peculiarities of the structure and activities of the maritime industry and suggests computer supported collaborative learning to advance maritime education and training.

Hjelmervik et al. (2018) observe that people who, because of their training, undertake more complex problem solving in stages performed better than those who were introduced to complex problems too early in their training. The researchers doubt the assumption that new challenging features would not be incorporated within training simulators without the sufficient amount of research because technology and computer capacity enable this. Performance on complex tasks, however, improves when the interface is subsequently enhanced in terms of functional fidelity during the training.

Benedict et al. (2018) examine how fast time simulation can be used in the case of maritime training. It is concluded that this type of technology holds quite a promise for application in both shortings and de-briefings, as well as while teaching and learning maritime education. Different experiments carried out in various maritime centres of learning illustrate the benefits of using fast time simulation for simulator-based training enhancement.

Sellberg and Lundin (2018) explore simulators in maritime centers for training purposes, in particular, in terms of assisting in the training of navigation. The investigation makes it clear that instructional support during simulations is an evolving process of applying adequate judgment on the relevance of proposals to actual work. It was also explained how time relates to the improvement of students' learning experiences in the course of the simulation.

Pham (2019) regards simulation-based training as one of the most effective methods of enhancing the competencies of seafarers within the context of maritime education and training (MET). Nevertheless, the study points out that in the maritime industry, simulation-based training is quite often not taken to its full advantage, as it is poorly applied most of the time. Mallam and others (2019) explore the influence of technological development on maritime education and training, particularly looking at virtual, augmented, and mixed reality. The paper elaborates upon maturing haptic interaction technologies in HMD immersive environments for applications of MET and operations, which may act as disruptive marine simulator technology.

Nazir et al. (2019) assess the improvement of execution regarding the differences of maritime simulator within Europe through qualitative methods specifically semi structured interviews with various institutions. This study demonstrates the variability of training in the use of simulators even if the integration of simulator training within the curriculum is more or less the same due to some common appreciation and adoption of similar approaches within European institutions.

Markopoulos et al. (2019) write about the design and construction of virtual education technologies for the purposes of the training on marine safety. During this study, the designers of the system introduce for the first time a prototype of the Mar. VR training system intends for general use in a variety of naturally occurring settings such as office, training center and even onboard ship.

Yushan et al. (2020) conduct a qualitative multiple case study in which they study the extendable simulators in use at three firms. The study pointes to the inconsistency of the simulators used in research and the application of the models developed and claims that the simulator is the medium linking marine research institutions and industries.

Markopoulos and Luimula (2020) present a new virtual training system designated Immersive Safe Oceans Technology for the training of safety procedures in the maritime industry. Restoration of mariner competency is achieved by presenting four new training episodes which illustrate professional usage of this technology in implementing training of maritime personnel where virtual reality applications played an important role.

Liu et al. (2020) develop the use of a head-mounted display for human factors evaluations and an LNG firefighting VR simulator for training. The study concludes that the (VR) environment is suitable for training since the trainees are able to experience stress and concentrate as they would.

Wahl (2020) tries to understand when and where the learning takes place in the computer-based simulation training, computer-supported collaborative work. It is observed that the quality and fidelity of training is affected by trainer-trainee interaction, task characteristics and simulator technology.

Ernstsen and Nazir (2020) scrutinize the validity and reliability of a computer-aided performance assessment (CAPA) tool in the marine pilotage industry. It is found that CAPA is far more reliable than normal evaluation of technical competencies in the evaluation of training and evaluation methods.

Senčila et al. (2020) evaluate the possibilities to use Full Mission Bridge simulation for investigations of safe passage conditions with regard to different seaport constructions. The simulations are stressed as crucial components in promoting safe and navigable waters even when complicated seaport development procedures are being undertaken.

Lee and Duffy (2021) carry out a systematic literature review of sailing, aviation, underwater, and ground transportation simulator applications. It is evident that simulator-based learning is critical in the training of a crew and in the prevention of accidents, but it was important to point out that not enough attention is paid to using simulation for land-based transportation.

Pan et al. (2021) adopt actor-network theory in the context of training curriculum and utilization of simulators in training institutions, offshore entities and along sea coast line authorities. The study claims that the distribution of students, professors and industry utilizes the self-network formed by the marine industry usage of simulators.

Voloshynov et al. (2021) present analytical evaluation of the most common and effective practices of VR simulator application in the education process of future sailors. The study provides a summary of advancement of VR technology for use in professional competency development of the marine workforce and the possibilities of virtual education courses in maritime learning.

Aronsson et al. (2021) study simulator fidelity regarding the time critical, distracted and dynamic nature of an operational scenario as viewed from an activity theory lens. There are gaps between the intended training and its real application; this raises the concern of designing training programs that are well structured and have training objectives that can be evaluated and attained.

Kim et al. (2021) and others also address the changes brought by COVID-19 pandemic into the simulators-based trainings and education for the maritime sector. A SWOT analysis of the challenges provides useful recommendations on action steps that MET stakeholders can take to mitigate existing challenges and enhance better strategies in future.

Belev et al. (2021) investigate the relationship between the current shortcomings of the available maritime training and the prospects of maritime industries' evolution. The study urges the use of tactical perspectives and alternative methods of instruction in training sea industry practitioners in anticipation to their change.

Mansuy et al. (2021) conduct a qualitative study of real-time ship maneuvering simulators during nautical studies design. The study distinguishes the real-time simulation (simulations conducted in an actual timeframe) from fast time simulation focusing on pros and cons of dealing with both methods.

Hjellvik and Mallam (2021) review a trend that emerges in the maritime sector which is the use of cloud-based simulation of maritime activities, which is fully software based as compared to the onboard simulation equipment. The study ascertains the role of student self-efficacy in predicting the outcome of training in cloud-based simulation environments.

Jamil and Bhuiyan (2021) study the various deep learning elements embedded in maritime simulation programs. The study sheds light on the relationship between deep learning tasks and the effectiveness of focused maritime simulation training and how things should be done differently in the future.

De Oliveira et al. (2022) undertake a systematic peer-review on the keystones of maritime simulators and identified 36 sources. The perspective of the study makes a distinction between physical and functional fidelity and observes that there may be further subjective judgment in high-fidelity simulators and that this may lead to negative training effects.

Chan et al. (2022) investigate the level of situational awareness of junior officers during navigational bridge watching using a bridge watch simulator. The study notes that most of the respondents are not familiar with the system when there are faults and thus, more training on situational awareness is necessary.

Weissenberger (2022) assesses the practice of VR simulators in the education of Norwegian Coastal Administration pilot services. The findings of the study are that the VR simulators are found to be engaging and effective as they enhance user immersion and scenario-based training for marine pilots.

During Covid-19 pandemic, Bhuiyan and Sohal (2022) review the merit of simulation-based training in a cloud environment. Their study points out some of the difficulties related to the use of cloud simulation such as the need for instructor training, access to speedy and reliable internet and creating virtual learning space.

Rakka (2022) examines the use of cloud-based simulators in Indonesian Maju Marine Education and Training in the times of COVID pandemic. This study reveals that cloud simulators are gaining considerable popularity as an alternative method in MET institutions.

Hwang and Youn's research (2022) looks at the use of simulation training for remote operators of autonomous ships. The study argues that, to teach the trainees effectively, different scenarios of navigation should be developed, suggesting ways to create bulk and pertinent scenarios using registered movements of actual vessels.

RESEARCH METHODOLOGY

At this stage a SWOT analysis is utilized to assess the efficacy of the training simulators used at the Arab Academy for Science Technology and Maritime Transport. SWOT is an abbreviation denoting Internal vat Structural Organ Echo and its External Structural Organ Echo to be undertaken for all levels of disparity of a system. A SWOT analysis helps find out the internal and external opportunities, weaknesses, threats, and strengths of the brand or any topic.

Such analysis in relation to marketing strategies has undergone a number of mutations both on the theoretical and practical levels. In a clear manner, a SWOT analysis helps to assess the internal and external factors of a business or project, and classifies them as Strengths, Weaknesses, Opportunities, and Threats. SWOT helps in initiating the internal strengths and weaknesses and external opportunities and threats of the organization. In most product development processes, the dependency and creed of arranging the four quadrants of SWOT analysis is not easy irrespective of how simple a SWOT matrix appears to be. There is some literature on the evolution of the method SWOT.

They employ both a number of ways to enhance the sharing of ideas between different people and to organize the thinking process towards specific orders (Brad and Brad, 2015).

To conduct SWOT analysis qualitative research is needed and therefore focus group discussions are carried out. Five focus group discussions are conducted with 15 expert and seafarers who train students in the use of full mission simulator at the Arab Academy for Science, Technology and Maritime Transport and the subjects are asked on a full-mission simulator (the simulation that is made use of within the AASTMT). These focus group discussions consist of six questions, which may be categorized as follows:

How do you rate the training system of simulation in the AASTMT?

What are the advantages of full-mission simulation?

What are the disadvantages of full-mission simulation?

What is the case in favour of full-mission simulation?

What is the case against full-mission simulation?

What are the prospects for further development of the training simulation system at the Academy?

SWOT ANALYSIS

This section analyzes the collected data from the five focus groups for the aim of identifying the points of strengths, weaknesses, opportunities and threats of full-mission simulator. Accordingly, this section is divided into four sub-sections.

Strengths

The focus group yields various development strength points, which are being put up. The strength points discuss the need of this simulation since it is an effective tool of trainings where seafarers learn how to interact with all the necessary instruments inside the ship, undergo specialized training with new crafts and ship equipment as well as navigational areas. It also imparts physical and technical training to the trainees as well as assessment of how well they perform certain artistic tasks in the process of troubleshooting. The focus groups also mention Engine Room Simulator and the engine room department discipline training. All these concluding observations are put forward by the focus groups in the following ways.

Three-dimensional simulation of a ship and all its functional instruments and displays fully enclosed in the ship. Helping to gain experience with interactive representation and shipment of teamwork abilities for seamen. Understanding the neighborhood ship and its customers in relation to ships in the proximity and analyzing the weather scope. Takes care of most of the regulatory gaps and challenges to workplace learning principles since high level of fidelity is maintained. A practical categorization of functionalities for offering new crafts, ship equipment encouraging safe case scenarios for navigation only to specialists training only.

Useful device for assessing sailing risk during seaport construction or improvements. High degree of physical and behavioral fidelity. Provided a high level of functionality including real time computer simulation for training in navigation. Development of Engine Room Simulator is motivated with a goal of teaching, training, and assessment of the personnel from the Engine department. Core physical and technological knowledge. Employee tracking as well as measuring and reporting performance objectively. Assure the progress of activities as well as troubleshooting.

Weaknesses

Arguments against full-mission simulator usability are also analyzed through the focus groups. Two main weaknesses that took the stage are subjective elements such as the high costs, the high time consumption and the high energy materials consumption. These two aspects deal with the hardware aspect of the simulation. Weakness stems from such pain points:
It takes a long time and a lot of resources to make changes by adding new features.

Need a large and expensive hardware, hardware room and constantly manpower to utilize.

Effective segregation of individual outlooks and inputs with the aim of getting a complete picture of the ocean based on the ship movement.

A lot of attention is paid to the stimulating elements such as the external environment, stress and time.

Opportunities

Besides individual interviews, opportunities are defined through the focus group discussions. The opportunities refer to the capacity of this simulation to work together with other devices or simulations, e.g. virtual reality, dynamic selection, artificial intelligence and other devices which help in the training and collecting the trainees' data. Opportunities also mention the experience enhancement of how new or unexpected situation might be incorporated to measure the trainees' adaptation towards this situation. In the last one, attention is directed towards eye tracking. Opportunities that are derived from the focus groups are as follows:

Simulations on-board aid in the generation of scenarios.

Simulations on-board aid in evaluating the extent of skills and coordination the trainees will employ.
There is a possibility of interfacing this with more sophisticated technologies, virtual reality for instance.
Dynamic Selection is incorporated.This will enhance the understanding of students of credible facts about the other types of vessels and some additional ones.
There is a possibility of eye-tracking among learners.
There are opportunities to implement artificial intelligence.
Other training will involve interaction with electronic devices which helps learners understand the effectiveness of the trainees in their daily tasks.

Threats

The final feature to be pulled out from the SWOT analysis concerns the threats to the training system ability and the main weakness feature in any exercise simulation training system through the last couple of years must be conclusively the Corona Virus, where it brings to complete halt most of the simulation options that depend on land operations. Another factor that is equally critical is the constraining factor of economic resources, where full-simulation model is already going to incur huge amounts of costs, that absence in the economic resources could cause the simulation to halt. Focus groups also mention lack of technology resources, lack of information and trainees' credibility to act as a serious barrier to the implementation of the full-mission simulations. The following points are mentioned in the focus groups.

The challenge of using this simulation during the period of Covid 19.
The unavailability of financial resources that can provide for the use of the simulation.
Technological resources are limited.
There are limitations with the amount of information.
It will lose its validity for the students.
Evaluation of Deployment Activities of the Full-Mission Simulator and Augmented Reality Interactivity

Strengths and Opportunities

One of the most common verbs used to describe the full mission simulator is that it helps to reproduce the actual operational environment. As such, the trainees can obtain practical oriented expertise in a safe environment. Such qualifications can be enhanced because the simulator is combined with many other high technologies, such as VR.

When blended with the use of fully functional mission simulators, virtual reality offers an effective training platform that can portray emergency situations and complicated navigational as well as engine room activities with even a higher level of fidelity. This combination not only enhances the trainees' situational awareness, but rather helps in creating new techniques in training which were not possible earlier. For instance, VR may cause learners to perform unexpected actions outside the things being rehearsed in training, such as causing bad weather or equipment breakdown to see how well the trainees function under stress.

Weaknesses and Threats

Despite the strengths, the analysis also reveals closer weaknesses and threats regarding the pool of the full-mission simulator available on the market. Significant obstacles such as exorbitant costs, long lead times, and extensive resources needed for upkeep and modification exist. Such financial and operational requirements could curtail the number and range of training exercises that would be carried out, which in turn would affect the skills acquisition of the seafarers on a continuum basis.

A further major problem policy is that in some circumstances the learners can be crowded by the external factors like noise, limited time within the simulator, and the pressure of undertaking the drills, which do not entirely reflect the situation in real life. More so, the danger of not having enough money and lack of technology particularly spreading out to during the period of COVID 19 adds to the hurdles of embracing and sustaining the full mission simulator.

Table 1: SWOT Analysis of Full-Mission Simulator Implementation

Category	Details
Strengths	- High fidelity in simulating real-world scenarios. - Accurate replication of ship conditions and instrumentation. - Provides hands-on experience in a controlled environment. - Allows for advanced troubleshooting and technical training. - Supports specialized training in new crafts, ship equipment, and navigational areas. - High level of physical and behavioral realism.
Weaknesses	- High costs associated with maintenance and updates. - Significant resources required to operate and update the simulator. - Potential for overwhelming trainees with external distractions and stress. - Time-intensive process for adding new features.
Opportunities	- Integration with advanced technologies such as VR. - Development of new training modules using VR. - Enhanced situational awareness through immersive training. - Ability to simulate rare and complex scenarios. - Improved data collection and analysis through integrated systems.
Threats	- High financial and operational demands. - Economic constraints, especially during pandemics like COVID-19. - Technological limitations and reliance on outdated systems. - Loss of credibility if simulations do not adequately prepare trainees for real-world challenges.

Integration with Virtual Reality as a Strategic Response

Among these challenges, a more radical approach where virtual reality is integrated in the full-mission simulator as a way out is suggested. It saves physical facilities since training is real to a high degree, thus taking up less costs than in the physical resources. This model also provides the possibilities in overcoming unforeseen and rare scenarios, which in most times may be hard to achieve in the capabilities of traditional simulator systems.

Moreover, using VR helps address some of these operational issues by allowing learners to train in an environment that is less chaotic and overwhelming than real situations, where they are likely to get lots of disturbances and unnecessary pressure. Taking into account the use of VR, the Academy can upgrade the training programs, which will help seafarers navigate the ongoing shifts of seas better.

In conclusion, it is true that the full-mission simulator at the Arab Academy for Science, Technology and Maritime Transport Sports Sciences exhibits some clear advantages in the training of seafarers for real life, however, its integration with virtual reality is necessary to address the weaknesses and threats that have been identified. Such a union serves not only to improve the efficiency of the training offered, but also helps the Academy keep pace with the developing technologies in the field of maritime education and training.

Table 2: Impact of Integrating Virtual Reality with Full-Mission Simulator

Aspect	Impact
Cost-Effectiveness	- Reduces the need for extensive physical resources, potentially lowering operational costs. - Allows for more frequent updates and scenario development without significant financial investment.
Training Realism	- Enhances the realism of training by simulating immersive and interactive scenarios. - Allows for the introduction of unexpected variables, such as sudden weather changes or equipment failures.
Trainee Experience	- Provides a more controlled and focused training environment, reducing the likelihood of distractions and stress. - Enhances engagement and retention through immersive experiences.
Flexibility and Adaptability	- Offers greater flexibility in developing training scenarios, allowing for the simulation of a wider range of situations. - Enables the Academy to quickly adapt training programs to emerging maritime challenges and technologies.
Long-Term Sustainability	- Improves the sustainability of training programs by reducing reliance on costly physical updates. - Ensures that the Academy remains at the forefront of maritime education by continuously integrating cutting-edge technology.

CASE STUDIES

Simulation Training in Aviation

The aviation industry is known as one of the first industries to adopt simulation-based training, especially for the pilot. Full-flight cockpit simulators are needed as professional pilot training devices in which pilots can be taught to deal with different flight situations including contingency situations.

The aviation industry illustrates the specific regard associating high fidelity in training simulators for high-risk high stakes operations. These simulator hacks are regarded as helping to enhance the readiness and safety of airplane operating personnel. The achievements registered with aviation simulators can be replicated in maritime training regarding enhancing the sophistication and realism of maritime simulators.

Full-Mission Bridge Simulator for Port Development

The Full Mission Bridge Simulator is extensively used in the process of designing and constructing Klaipeda Seaport in Lithuania when it undergoes extension. The simulator is used for navigation safety evaluation and for the training of pilots and other personnel able to navigate the newly or altered port space.
This case study investigates the use of simulators in port expansion to prevent accidents whilst navigating through newly or altered channels. The facility to represent various kinds of vessels, states of weather and various emergencies is found very useful for avoidance of accidents and for maximization of activities in the port.

Using Virtual Reality in Training for Maritime Safety

According to the research by Markopoulos et al. (2019), Marine VR training system is designed to increase the maritime safety with VR technology. The system provides a VR-based development for training scenarios focusing on safety practices of maritime personnel like fire safety and evacuation of personnel on board.

The utilization of VR in maritime training is increasing and allows the development of environments that provide high levels of interaction with trainees. This enables the trainees to practice even in high-risk scenarios and the effect this would have on their performance in actual emergency situations.

Genre for Training Managers - Marine Engineering. Categories Inside – Engine Room Simulators

The Arab Academy for Science, Technology and Maritime Transport puts up an Engine Room Simulator for training purposes for the marine engineers. The trainee can engage themselves in the handling and servicing of ship's engine or engine room facilities and perform the other duties given the change in the weather and other environments.

In this sense, specific training with Engine Room Simulators appears to be essential for learning the practical aspect of a marine engineer from the technical point of view. They enable a practical learning approach in terms of daily operations, repair activities, and crises which help protect and optimize the vessel engineering systems.

The Role of Augmented Reality (AR) in Ships Maintenance Training

Application of augmented reality is implemented in a ship maintenance training center located in Europe. The use of AR headsets in AR training allows the use of real ship components as the interface during trainees' learning of complex maintenance procedures with the help of virtual guidance overlaid on to them.

This spoken information may prove invaluable for novices performing complex tasks and help bridge the gap between theoretical knowledge and practical application of delivering supporting training facets to trainees. This method enhances the efficiency and precision of the performance of the maintenance tasks and considerably decreases the probability of human errors.

Simulation based Training for Offshore Oil and Gas Operations

A special simulator for training personnel for offshore oil and gas operations is developed at the Offshore Simulator Center, Norway. The simulator models the offshore working environment and its inherent hazards with an emphasis on safety, emergency situations, and operational performance.

Special simulations as in offshore oil and gas would be instrumental in personnel preparing for oil and gas operations. Their importance in training cannot be overemphasized, especially on global practices where some risk is involved.

Virtual Simulation as a Tool for Maritime Education Throughout COVID-19 Pandemic

During COVID-19, several maritime training institutions move to cloud-based simulation systems to continue with the training despite the restrictions to physical gatherings. These systems enable the students to carry out simulations from a distance ensuring that they do not miss out on any aspects of their studies.

Spending time training on simulations is possible regardless of the reasons for a disruption of such as a pandemic because of cloud-simulation. Nevertheless, issues such as lower fidelity and presence of internet dependency need to be tackled if this way of training is to be rewarded 'sane instead of prohibitiveority.

Such case studies present the application and efficacy of simulation-based training in various facets of the maritime and other related enterprises and as such raise the level of safety, efficacy, and readiness for a particular environment.

CONCLUSION

In conclusion, the critical analysis of the full-mission simulator at the Arab Academy for Science, Technology, and Maritime Transport ascertains its significance to the training and preparation processes of seafarers regarding future maritime operations. Some of its virtues such as how realistic the situations are and the provision of real time simulations makes the simulator a very central device in maritime learning. However, the analysis also pinpoints internal qualities that represent serious weaknesses such as financial constraints, the requirements for excessive maintenance and the stress and distractions which might overwhelm the trainees.

To mitigate these issues and improve the training programs, the researchers find the combining of (VR) with the full-mission simulator parts as a viable option. VR does not only make training more realistic and engaging as regards train enacting the various scenarios, but also enables provision of economical, adaptable and innovative approaches to improving maritime training. The Academy can harness the complementary advantages of both technologies to augment operational sustainability whilst ensuring effective training preparedness that adequately equips seafarers to meet the actual environmental conditions.

To sum up, although the full-mission simulator will always be part of the maritime staff training strategy, it must be combined with VR technologies to lift that barrier which prevents the Academy from remaining at the very top of maritime education and training. As a result, the Academy will be able to develop innovative, impactful, and long-lasting training solutions, which would be of great importance in today's maritime industry.

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