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The Consequences of Container Vessel Collisions with Quay Cranes: A Case Study

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Abstract

In the last few years, several container terminals have faced accidents of collision between vessels and ship-to-shore (STS) gantry cranes, causing damage and losses to the Port and terminal. The notion of port management should be designated to oversee the increasing amount of containers, particularly in the event of accidents or emergencies.

The primary research gap is that the majority of current literature predominantly depends on simulations, leading to a lack of empirical data. Accordingly, this article analyzes the impact and consequences of the collision involving an 8,000+ TEU container vessel and two Post-Panamax gantry cranes on container terminal operations, productivity, and related financial costs and losses, assigning empirical data. The study employs quantitative methods using port performance indicators (PPIs), which are well-established in maritime literature for measuring terminal efficiency, to quantify the impact of container ship STS gantry crane collisions at a container terminal. Pre- and post-incident PPIs show how the collision affected productivity, resource distribution, and service standards. Losses are assessed using financial indicators. The accident results revealed an increase in the Berth Occupancy Rate from 24% to 43%, a 40% rise in ship turnaround time, an increase in waiting time, a drop in the number of vessels, and a financial loss.

The research contributes to providing PPI-based empirical quantification of STS collision impacts based on PPI, facilitating a better understanding of how vessel and STS incidents influence terminal production and performance using actual data. The study employs PPIs as measures of time, ship, STS, and financial loss to assess terminal disruption.

Keywords:
Container terminals, STS gantry cranes, Port management, Port performance indicators.

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1. Introduction

Transportation of goods and people is the core role of the maritime industry. Seaboard trade in 2019 is 11.08 billion tons, 2020 is 10.65 billion tons, 2021 is 12.027 billion tons, and in 2024 it reaches 12.720 billion tons, rising from 7.8 billion tons in the 2008 financial crisis. UNCTAD projects a moderate and steady growth in seaborne trade volume for the medium term between 2024 and 2028, indicative of the sector's resiliency (UNCTAD, 2019, 2020, 2021, 2023, 2024, 2025).

Containerized cargo globally had a substantial increase exceeding 6%. Attained second position in several categories of products in 2024 (UNCTAD, 2025). Container terminals serve as a primary hub in the expansion of international trade. Terminals should adapt containers to increase volume regardless of their spatial constraints (Zaerpour et al., 2019). Container terminals should serve huge vessels efficiently with minimum time and competitive rates. Accordingly, terminal operators, port authorities, and shipping lines should allocate resources towards advanced technologies to enhance infrastructure and operating efficiency (Gharehgozli et al., 2014)

To uphold secrecy and safeguard the reputation of the container terminal and the shipping line pertinent to this research, the terminal was designated as "Terminal X" and the vessel as "CONT Z". While maneuvering CONT Z to the berth at Terminal X, assisted by two tugboats, CONT Z collided with the starboard bow with two gantry cranes at Terminal X, resulting in significant damage to both cranes.

This research objective is to examine the effects and ramifications of the collision between an 8,000+ TEU container carrier and two Post-Panamax gantry cranes concerning terminal productivity and associated financial expenses and losses. The research questions are: what are the operational and productive consequences of the accident? What are the expected financial losses as a consequence of the accident?

2. Background

Container terminals manage global containerized trade volumes, which saw robust growth in 2024, with an increase of 6%, totaling over 170 million twenty-foot equivalent units (TEUs) (UNCTAD, 2025). Ship-to-shore (STS) gantry cranes are crucial for the efficient operation of ports as they facilitate the handling of containers between the quay and the vessel. Accordingly, accidents of STSs cause terminal operational disturbance.

PPIs assess efficiency using throughput (TEUs/hour), cycle time (minutes per move), berth utilization (%), and energy consumption (kWh/TEU). UNCTAD in 2012 suggested indicators as dwell time and crane productivity, where Crane dormancy leads to instantaneous and prolonged interruption. Recently, ports were ranked by the container performance index (CPPI), assigning AIS data regarding port call efficiency (World Bank, 2024). STSs may fail due to lack of maintenance, poor operational processes, heavy weather, and accidents. STS stoppage should be minimized to avoid negative impact on terminal operation, throughput, and efficiency (Waves Group, 2024).

Accidents involving STSs, especially collisions with ships, pose severe threats, causing structural failures, injuries, fatalities, and multimillion-dollar losses (Transportation Safety Board of Canada [TSB], 2020). Recent incidents, such as the YM Witness colliding with four cranes in Turkey (Schuler, 2024) and a crane collapse in Keelung, Taiwan (Seatrade Maritime, 2024), underscore the urgency of addressing these risks.

Container vessels dock at terminals outfitted with STSs to facilitate the transfer of containers to/from the yard by trucks or automated guided vehicles (AGVs). Literature presents several optimization challenges, such as minimizing STS waiting time by truck scheduling, which indirectly enhances STS efficiency, as derived from graph theory and DDQN (Cheng et al., 2025). Rodrigue's (2025) study noted that longitudinal orientations and site limitations may elevate the probability of collision, including narrow berths. To mitigate uncertainty instances that arise following accidents, Pan et al. (2025) developed hierarchical reinforcement learning for storage allocations. Yang et al. (2025) examined methods for integrating AGV lanes with the scheduling of additional equipment at U-shaped terminals to mitigate emissions, although they did not assess the effects of crane damage.

Historical research, like Li and Vairaktarakis's (2004) examination of container handling techniques and Viss et al.'s (2001) analysis of AGV requirements, underscores the importance of optimizing productivity. Nonetheless, collisions can impede this objective: a vessel colliding with STS can suspend operations, as seen by the Ever Summit incident in Vancouver, when pilot error of distance (2.13 meters) led to the crane's boom collapsing (TSB, 2020). Critically, previous literature lacks empirical data and predominantly depends on simulations, as shown in studies of Hu et al. (2021), X. Li et al. (2021), Hu (2023), Zhao et al. (2024), and Kong and Ji (2024). Moreover, Zhang et al. (2025) from the dataset simulated ripple effects, showing crane failures cause yard congestion and 20% delays. Accordingly, the lack of empirical data is considered a literature gap.

3. Methodology

The study employs quantitative methods to assess the impact of container ship STS gantry crane collisions at a container terminal, utilizing port performance indicators (PPIs) to evaluate the degree of operational disruptions, as these indicators are well-established in maritime literature for measuring terminal efficiency, as noted by Cullinane and Wang (2010) and UNCTAD (2022). Where the hypothesis is: H1: vessel and STS collision affect terminal productivity, efficiency, and cause financial losses; H0: vessel and STS collision do not affect terminal productivity, efficiency, and do not cause financial losses. PPIs, with the support of the trend analysis, provide a comparative assessment of performance pre- and post-incident, underscoring the collision's effect on productivity, resource distribution, and service standards. Moreover, financial metrics are employed to assess the financial losses. The PPIs are shown in Table 1.

The basic data gathered from the port terminal operator and port authority encompasses all raw data necessary for calculating key performance indicators, such as throughput rate, crane utilization, vessel turnaround time, and waiting time. These indicators provide a comparative assessment of performance pre- and post-incident, emphasizing the collision's effect on productivity, resource allocation, and service levels, alongside the financial data required to quantify financial losses. Secondary data was gathered from several sources, including port authority records, terminal operator documentation, shipping lines, gantry manufacturers, and industrial reports and surveys, to document the quantitative and qualitative dimensions of the terminal's activities prior to and after the collision.

Table 1: Assign PPIs

No.	Name	Description / Objective	Formula	Rationale behind choosing PPI
1	Average Anchor Time	Time between the start and end of the stay at anchor	Σ Hours at anchor / No. of vessels	The waiting time of vessels prior to berthing is commonly utilized as an indicator of congestion.
2	Average Time in Port (turnaround time)	The time the vessel spends in port, i.e., from its arrival to its departure from the port.	Σ (Time of Departure – Time of arrival port) / N° of vessels	Ship turnaround time is a key service KPI in UNCTAD's port performance analysis and global port performance reporting.
3	Average Gross Berthing Time	The time the vessel spends at its berth, from throwing first mooring line to removing the last mooring line.	Σ (Time of last line – Time of first line) / N° of vessels	Berth time and occupancy are fundamental to berth-capacity analysis
4	Average Net Working Time	Time from the start of cargo to the end of cargo operations	Σ (Time end cargo – Time start cargo) / N° of vessels	UNCTAD training materials on terminal productivity highlight the significance of including or excluding delays and breakdowns in performance interpretation.
5	Average Berthing Occupancy Rate	The average gross time the vessel stays berthed at the quay over a given period.	Σ (Service Time at berth (in hours) x Meters used) / Σ (Total Available hours x Meters)	Due to decrease operational efficiency or incident-related interruptions, occupancy rises, causing queue and longer anchor time.
6	Working Ship Output (WSO)	Tons (or TEUs) per ship per productive (or working) hours	Σ TEU handled / Σ Productive hours	Output and productivity indicators (throughput per unit time) are extensively utilized in port management measurement frameworks.
7	Berth, Ship, and Operations (BSO)	Tons (or TEUs) per ship per berth hours	Σ TEU handled / Σ Service hours	Research and toolkits often employ berth-hour denominators for performance evaluation.
8	Ship productivity indicator (PSO)	Tons (or TEUs) per ship per port hours	Σ TEU handled / Σ Port hours	End to end time in port measures are extensively utilized for evaluating port performance and the effects of trade facilitation.
9	Crane production rate	measures how much a crane is covering a share of berth productivity for a period	Σ (Crane productivity in TEU per year) / berth through put in TEU per year	fundamental operational drivers of port call performance as indicated by the World Bank

Source: Author

The time frame encompasses a six-month period before the collision and a six-month period after it, regarding the PPIs, while the gantries were installed three years prior to the collision. The financial data encompasses a consistent timeframe to assess overall income before and after, as well as the financial growth of the terminal over the past three years, with the objective of evaluating potential future losses.

This research used a single-case study approach as indicated by Yin (2018), selecting a case purposively due to its rarity and significant operational implications, which will allow for detailed contextual analysis and enhance research robustness. Therefore, the comparative element is incorporated by comparing pre- and post-accident performance within the same terminal, treating the incident as a normal occurrence. This quasi-experimental design isolates the impact of the collision while accounting for external variables, such as market demand fluctuations, through time series analysis.

On the other hand, limitations should be considered where single case limits generalization to other terminals, where factors such as crane design, terminal size, and traffic changes. The focus on PPIs and financial aspects could neglect intangible effects such as safety culture or environmental repercussions, which necessitate future qualitative elaborations.

4. Case study: The accident scenario

The case vessel is a Container Ship, 20 years old. Her length overall (LOA) is 323 meters, and her width is 43 meters, with a total TEU capacity of 8,000+. At the same time, the STS named STS12 and STS13 are 2 Super Boost Panamax Double Handle Frames with safe working loads of 65 and 75 tons, respectively.

According to accident reports from a group of specialists who analyzed the case, and a video recording of the CCTV system, it was found that: During the berthing maneuver at 22:45 local time, the ship's speed reached approximately 2.5 m/s. This high speed generated a high impact energy of approximately 16,750,000 J (16.75 MJ) and a significant impact force of approximately 10,350,000 N (10.35 MN) in the direction of the cranes. The following table illustrates the monitoring of the ship's excessive speed at local time from the bit (0) at the start of the berth to the point of impact between bits 4 and 5, as shown in Table 2.

Table 2: Ship's excessive speed at local time from the bit (0) till collision

The ship is in front of bit no.	Local time	Duration	Speed in m/sec	Speed in knots
0 – 1	22:46:48	00:00:08	3.75	7.29
1 – 2	22:46:59	00:00:11	2.73	5.3
2 – 3	22:47:08	00:00:09	3.33	6.4
4 – start of collision	22:47:17	00:00:09	3.33	6.4
Average speed			**3.28**	**6.38**

Source: Terminal operator & accident reports

The collision may cause damage to the infrastructure of the terminal, such as the quay (Stehmeyer et al., 2016). The impact energy and forces caused the severing and collapse of 7 fenders and deformation of 7 fenders. The following images in Figure 1 show the impact on the starboard side of the ship, causing cuts, deformities, and dents in the bow of the ship; deformities, dents, and cuts in the hull of the ship, as well as other forces in the perpendicular direction that caused the cranes to move and collide with crane number STS11. Taking into consideration weather conditions, wind, and visibility are within normal ranges.

Figure 1: Impact of collision on the ship's side
Source: accident reports

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According to the experts report regarding STS12, the right side (Land Side) is severely deformed, buckled, and twisted in the direction of the three axes (X, Y, and Z). The buckling value is approximately 60 mm. The internal support of the Partial Beams is also deformed and buckled, with an internal buckling value of approximately 55 mm. Thirty-two (32) driving and driven wheels of the STS deviated and came out of the track of the berth rail. Undoubtedly, these extreme deviations in different directions (180 degrees) led to maximum stress exceeding the elastic limits, thus causing the wheel motors and gearboxes to reach the yield point. It should be noted that all electric motors were in brake mode during the automatic stop of the STS12. This means that torsional stress occurred in the vertical and horizontal columns, vertical and horizontal supports, and the driving and driven gears. Visual inspection revealed a noticeable oil leak from all gearboxes due to the combined stresses resulting from the enormous impact energy and force, which are directly proportional to the total load and the square of the speed exceeding the limits. In addition to significant deviations in the upper parts, the dimensional differences between the fixed and moving parts are clearly visible as shown in fig 2.

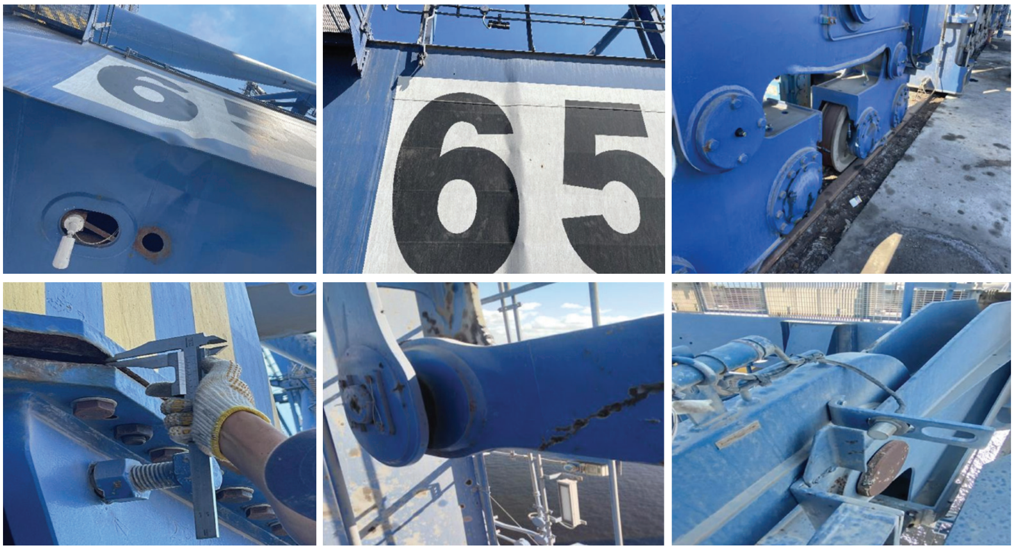

Figure 2: STS12 damage
Source: Accident reports

While STS13 experienced a severe and extensive cut in the seaward side of the port leg (20mm thick) and the internal longitudinal and transverse supports at the Partial Beam level, as well as significant and noticeable deformation, buckling, and twisting, in the direction of the three axes (X, Y, and Z). This demonstrates the stresses and strains resulting from the high energy of the impact and the immense force of the collision on the port leg and the internal longitudinal and transverse supports on the seaward side, deviation and exit of (32) (Driving Wheel & Driven Wheel) from the track of the platform rail. Misalignment and deviation of the out-reach boom arms of the STS, significant deviations in the upper parts, and dimensional differences between the fixed and moving parts, as shown in Figure 3.

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Figure 3: Level of damage in STS13
Source: Accident reports

The experts' technical analysis describes the damage and recommends replacing the STS with a new one, as repairs do not ensure proper alignments and stress management. Terminal operations were suspended for 12 hours following the crash. Figure 4 illustrates that about 380 meters of berth length are inoperative owing to required repairs. Furthermore, STS12 and STS13 are temporarily secured in the indicated place pending a final judgment. Where the recommendation complies with the literature, where crane damage leads to high repair or replacement costs (Tran et al., 2018; Bovnegra et al., 2023)

The terminal forfeited one-third of its berth length for an estimated duration of 6 to 12 months until the STS manufacturer's final report is completed, the court renders its decision, the STS rails are repaired to facilitate the movement of STS12 and STS13, and rail extensions are implemented to enable the unobstructed movement of STS11 and STS10.

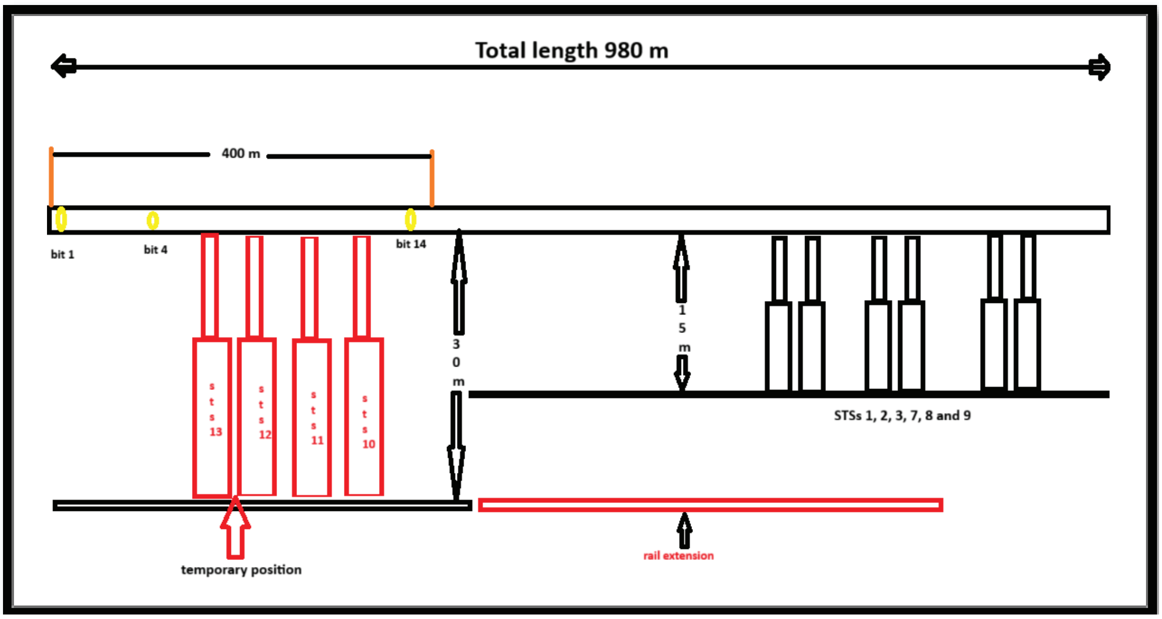

Figure 4: Terminal berth condition after collision
Source: Author, Data source: Terminal operator

5. Results and Discussion

A large amount of work addresses the elements that influence port competitiveness. Recently, researchers have released review articles addressing port selection in container markets (Moya & Valero, 2016). Moya and Valero examine the function of port authorities in the decision-making process of shipping and landside stakeholders regarding port selection. The authors determine that port-selection criteria vary based on whether the influencing elements are within the purview of port authorities or not, and whether the context involves ocean traffic or inland shipping. The principal determinants of port selection for interoceanic traffic are port expenses, geographical positioning, hinterland connectivity, port infrastructure, and port efficiency (Moya & Valero, 2017).

Accordingly, this research utilizes quantitative approaches to examine the impact of accidents between container ships and STS gantry cranes at a container terminal, employing PPIs to measure the extent of operational disruptions and their influence on terminal efficiency, shipping company customers, and financial losses.

5.1. Time indicators

Minimizing waiting times for vessels, so reducing their duration in ports, especially at the quay, is indisputably a priority. The waiting time of a vessel is contingent upon the efficacy of the allocation and scheduling of essential resources, including berthing places, quay and yard cranes, and other cargo handling and transportation apparatus (Siddaramaiah et al., 2021).

Fig 3 presents the terminal time measures before and after the collision, where trend analysis indicated that net-working time and gross berth time are nearly stable trends, while the ship turnround time had an upward trend from an average of 24 hours to an average of 40 hours because of the increase in waiting time, as shown in Fig 3. The upward trend in waiting time reached 20 hours, while the maximum waiting time was 8 hours in seasonality.

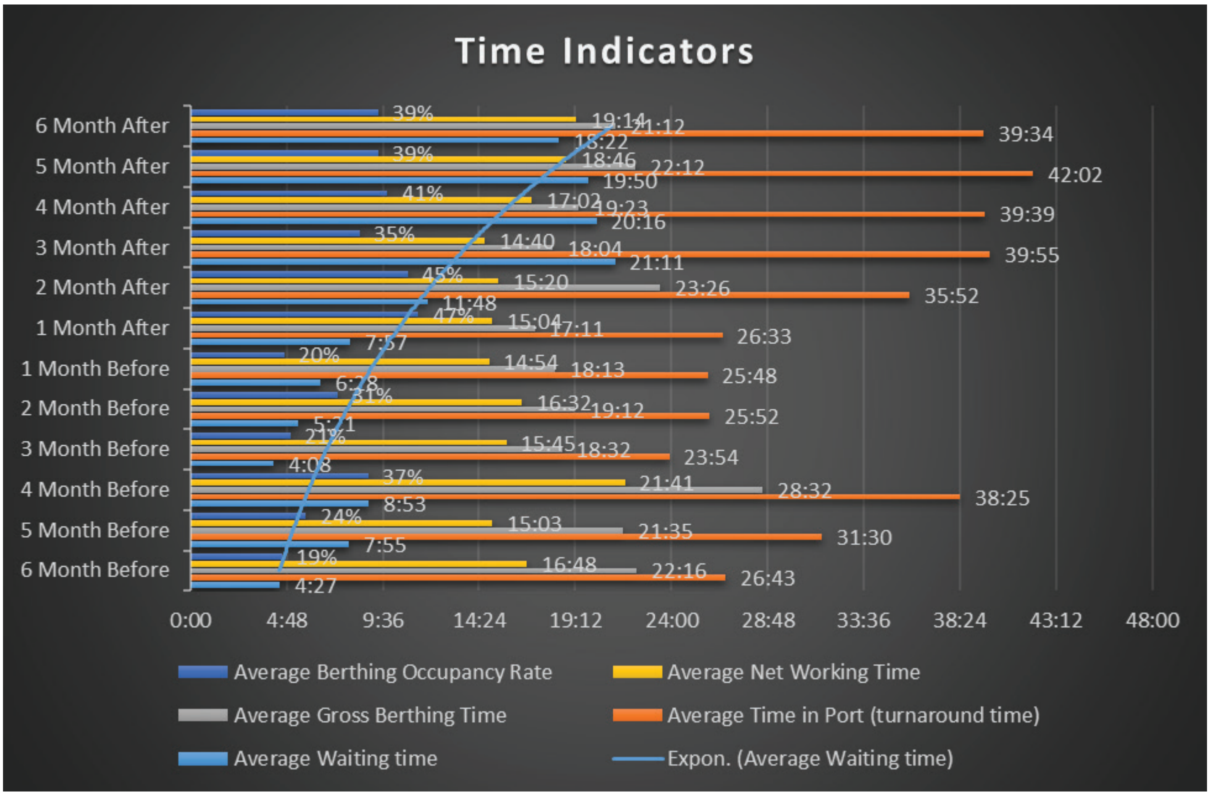

Figure 5: Time indicators
Source: Author

Vessels are designed for navigation; hence, the more they navigate, the greater their earnings. Consequently, ship owners and shipping lines anticipate expedited operations at ports to attain reduced Vessel Turnaround Times (VTTs), thereby augmenting the frequency of loading trips annually. Hence, in our case study, VTT had increased by more than 40% due to the collision.

By analyzing Berth Occupancy Rate (BOR) and waiting time with the number of vessels for a period of 6 months before and after the collision to avoid the effect of seasonality, as shown in table 3 found that there is upward trend in BOR from 24% in the 2nd quarter to 43% in the 3rd quarter, and 39% in the 4th quarter followed by upward trend in average waiting time from average

5.3 hours in the 2nd quarter to average 14 hours in the 3rd quarter and 19 hours in 4th quarter as a complying to queuing theory, in addition to downward trend in number of vessels as indication of start of losing terminal customers.

Table 3: Terminal berth occupancy rate

Date	BOR	NO of Vsl	Average Waiting Time	1/4 BOR	Quarterly Average waiting time
6 Months Before	19%	37	4:27	27%	7:25
5 Months Before	24%	38	7:55		
4 Months Before	37%	47	8:53		
3 Months Before	21%	38	4:08	24%	5:19
2 Months Before	31%	51	5:21		
1 Month Before	20%	36	6:28		
1 Month After	47%	41	7:57	43%	13:39
2 Months After	45%	34	11:48		
3 Months After	35%	26	21:11		
4 Months After	41%	30	20:16	39%	19:29
5 Months After	39%	31	19:50		
6 Months After	39%	33	18:22		

Source: Author

5.2. Ship performance indicators

The operational efficiency of container vessel passages, defined as voyages between two ports, is critical for key container shipping players, including shippers, ship operators, port operators, and port authorities (Cui et al., 2024). The Berth Allocation Problem (BAP) has been the subject of numerous studies due to its intricacy and propensity to have a major impact on VTT. However, it is crucial to note that VTT is not simply reliant on berth allocation; other considerations include the number of moves, the number of STSs, the distance between the yard and the berth, and many others (Hendriks et al., 2012). As a result, it is possible to conclude that the production of a terminal is dependent on the efficient utilization of three essential resources: land, labour, and machinery (Cullinane & Wang, 2010). As a result, the impact of the human factor on container terminal productivity should not be overlooked, even though it is sensitive and difficult to define, gather data, and analyze.

Table 4 provides ship performance indicators where the number of vessels had a downward trend after the collision, SWO, BSO, and average TEU/ship had a normal cyclical trend, which indicates that terminal management is optimizing the utilization of labour and machinery. On the other hand, PSO dropped dramatically after the incident to 21.9 TEU/port-hour after 6 months due to the increase in the waiting time.

Table 4: Ships performance indicators

Month	No. ship/month	Total TEU/month	Average TEU/ship	Average LOA	WSO	BSO	PSO
6 Months Before	37	36116	976.1	186.4	58.4	43.8	36.6
5 Months Before	38	38219	1005.7	188.2	66.8	46.6	31.9
4 Months Before	47	52866	1124.8	190.1	52.1	39.5	29.3
3 Months Before	38	40299	1060.5	180.7	67.3	57.3	44.4
2 Months Before	51	51412	1008.1	187.9	61.0	52.5	38.9
1 Month Before	36	41195	1144.3	193.3	76.8	62.9	44.4
1 Month After	41	42704	1041.6	197.0	69.0	60.6	39.2
2 Months After	34	32769	963.8	199.4	63.0	41.2	26.9
3 Months After	26	27269	1048.8	199.5	71.4	57.9	26.3
4 Months After	30	27612	920.4	195.4	54.0	47.4	23.2
5 Months After	31	27902	900.1	194.1	48.0	40.5	21.4
6 Months After	33	28600	866.7	192.1	45.0	40.9	21.9

Source: Author

Waiting time and PSO are two important indicators for ship operators, where the increase of the former and the decrease of the latter may lead to loss of terminal customers, and from the decreasing number of vessels per month, it can be concluded that the factors have a negative impact on the terminal after the collision.

5.3. STS performance indicators

The STS productivity table 5 delineates the productivity in TEU for each STS in the terminal, together with their respective contributions to terminal berth throughput and the annual net working hours for each STS, thereby highlighting the significance of STS12 and STS13 for the terminal.

Table 5: STSs productivity, share, and net working hours

Year	STS02	STS03	STS07	STS08	STS09	STS10	STS11	STS12	STS13
22/23 STS total production in TEU	586	5504	28911	33899	21365	47170	70795	62086	83791
Crane production rate	0.17%	1.6%	8.2%	9.6%	6.0%	13.3%	20.0%	17.5%	23.7%
Net working Hr/year	34.13	255.78	1833.58	1258.09	772.2	1818.9	2518.43	2142.04	2931.67
23/24 STS total production in TEU	739	4151	57743	50133	23979	47855	50133	57908	84690
Crane production rate	0.18%	1.0%	14.2%	12.4%	5.9%	11.8%	12.4%	14.3%	20.9%
Net working Hr/year	32.55	216.4	2060.26	1681.25	938.0	1996.1	2810.1	2107.12	3015.78
24/25 STS total production in TEU	215	7588	50350	67073	32366	59036	67073	63658	93663
Crane production rate	0.05%	1.6%	10.8%	14.3%	6.9%	12.6%	14.3%	13.6%	20.0%
Net working Hr/year	14.82	326.27	1810.43	2085.75	977.3	2053.9	2877.63	2117.13	2979.85

Source: Author

From table 5, it is noticed that STS12 handles between 13.6% to 17.5% of the quay productivity, while STS13 handles between 20% to 23.7% of the quay productivity, which indicates the importance of both STSs to the terminal because before the collision, both STSs were responsible for an average of 38% of the quay productivity.

By analyzing STS monthly production through the incident year, the output is shown in Table 6, where STS12 &13, starting from the incident, are totally unusable, and STS10 &STS11 have a reduction in their productivity of more than 60% compared to the period before the collision. Moreover, STSs from STS3 to STS09 have increased their use to increase productivity by several thousand TEUs per month, which represents huge stress on the STSs.

Table 6: STSs' monthly productivity for the year 2025

Month	STS02	STS03	STS07	STS08	STS09	STS10	STS11	STS12	STS13
6 Months Before	0	935	3552	4564	4541	5022	7850	3422	6228
5 Months Before	0	854	4183	5374	3951	5169	6513	5540	6635
4 Months Before	0	1894	7395	8843	6893	5773	9483	5427	7158
3 Months Before	0	583	3800	4550	3961	5734	6698	7070	7903
2 Months Before	0	1301	7394	9093	3329	5124	8928	6679	9564
1 Month Before	0	221	3405	5384	1568	6593	7541	6938	9545
1 Month After	0	4695	13048	13054	7311	3023	1573	0	0
2 Months After	0	1987	11208	9882	5307	2043	2342	0	0
3 Months After	0	2828	9565	7382	5298	1294	902	0	0
4 Months After	0	2456	9672	7420	5310	1260	1494	0	0
5 Months After	0	1874	10458	8476	4989	1247	858	0	0
6 Months After	0	2855	6814	6877	5877	3489	2658	0	0

Source: Author

Magala and Sammons (2008) argued that the decision-makers mentioned (shippers, freight forwarders, and shipping lines) approach port selection differently and pursue distinct objectives, contingent upon the role of ports in facilitating their operations. From a marine standpoint, shipping companies structure their service networks to optimize economies of scale (Guy & Urli, 2006) by making decisions that maximize their revenues (Talley & Ng, 2012). Land decision-makers endeavor to reduce expenses (Talley & Ng, 2012): freight forwarders strive to deliver value-added services to their ultimate clients, while shippers face additional decisions within the supply chain (Magala & Sammons, 2008).

Port efficiency is a crucial factor influencing port selection for both inland decision-makers and ocean carriers (Chang et al., 2008; Chou, 2010; Park & Min, 2011; Steven & Corsi, 2012). As shown below in Table 7, a synthesis of the most relevant and commonly cited indicators, as well as their implications for shipping company decision-making, and whether they are affected in the present case or not.

Table 7: The commonly cited indicators affecting shipping company decision-making

No.	Performance Indicator	Description	Source in literature	Impact
1	Port Throughput	This is the volume of cargo handled by a port over a given period and is widely recognized as a crucial measure of port capacity and future development. High throughput indicates a port's ability to handle large volumes efficiently, which is attractive to shipping companies seeking reliable and scalable operations.	(D. Yang et al., 2023; Hwang & Huang, 2025; Kalkschmied & Stricker, 2025)	Negative impact – a slight decrease in port throughput
2	Ship Turnaround Time	The total time a vessel spends in Port, including berthing, loading/unloading, and administrative procedures. Minimizing turnaround time is critical for shipping companies to maintain schedules and reduce costs.	(Johnson & Styhre, 2014; Zhang, Luo, et al., 2025)	Negative impact – increase in turnaround time
3	Waiting Time in Port	Unproductive time is spent by vessels waiting for berths, cargo handling, or administrative processes. Reducing waiting time improves energy efficiency and operational costs for shipping companies.	(Johnson & Styhre, 2014; S. Li et al., 2016)	Negative impact – increase in waiting time
4	Handling Efficiency	Measured as the quantity of cargo handled per hour, this indicator directly affects vessel scheduling and port selection. Higher handling efficiency leads to faster operations and lower costs	(Daryani et al., 2019; Zhong et al., 2020; D. Yang et al., 2023)	Negative impact – decrease rate of TEU/ port time
5	Port Turnover Rate	The number of ship calls or vessel arrivals at a port over a period, reflecting the Port's capacity to process cargo and vessels. While a high turnover rate can indicate efficiency, it may also lead to congestion if not supported by adequate infrastructure	(Yang et al., 2023)	Negative impact – decrease in the number of vessels
6	Berth Utilization and Allocation	The intensity and effectiveness of berth usage, including the matching of ship tonnage to berth capacity. High berth utilization can signal efficient operations, but may also indicate potential congestion and longer waiting times	(S. Li et al., 2016; Zhong et al., 2020)	Negative impact – increase of BOR
7	physical attributes, such as the Number of Cranes	These physical attributes determine a port's ability to accommodate large vessels and handle cargo efficiently. Adequate infrastructure is a key factor in port selection, but studies suggest that focusing solely on physical infrastructure is insufficient without considering operational and technological factors.	((El-Refaei & Idris, 2024; Hwang & Huang, 2025)	Negative impact – 2 STS out of order

Source: Author

Terminal operators have financial difficulties due to escalating operational costs. Shipment delays impede delivery networks. Delays in product deliveries might incur financial losses for companies (N. K. Tran et al., 2024). A decline in client attendance may occur if services are prolonged excessively; shipping companies could easily relocate during periods of inactivity, adversely affecting the terminal's revenue due to the cumulative loss of contracts (Kaizer et al., 2017), as in the case study where the number of vessels using the terminal decreases gradually. Frequent or severe incidents may elevate insurance premiums at the terminal, hence increasing overall costs. Due to claims exerting pressure on coverage, expenses typically escalate in conjunction with the level of risk (Sunaryo & Hamka, 2017). Accordingly, the decline in terminal performance will result in customer attrition, as evidenced by the reduction in the number of vessels frequenting the terminal, as shown in Table 4.

5.4. Financial losses

The terminal is designating the financial year that commences on July 1 and concludes on June 30 of the subsequent year, with the collision occurring at the end of the 2024/2025 fiscal year. As shown in Figure 6, the terminal achieved a throughput of 366,127 TEU in the fiscal year 22/23, generating income from handling fees of $56,929,802.52. In the subsequent year 23/24, throughput increased to 422,268 TEU, resulting in income of $67,399,978.49. For the year 24/25, throughput further escalated to 476,720 TEU, with income amounting to $73,146,135.10, reflecting a 15% yearly income growth. According to the PPIs, the 15% growth won't be reached till the STS is restored to its previous condition, which presents a loss of 6 million USD for the next 2 years, with a total of 12 million USD till the installation of the new STS. In addition to the losses of reputation, where the value of reputational loss = surcharge rate (r) × average value per container (v) × daily throughput (U) × disruption time (T) (Y. Zhang et al., 2020; Y. Zhang & Lam, 2015), with a value of 6,740,000 for the next 2 years.

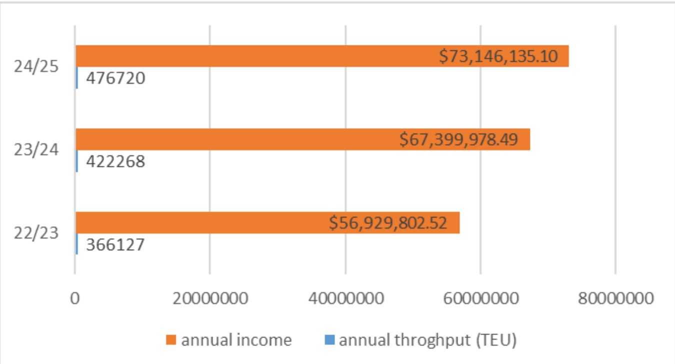

Figure 6: Annual terminal income and throughput
Source: Author

According to bills and official offers, Temporary reinforcement and securing of the crane legs damaged cost 235000 USD, reinstalling the cranes on the rails and re-utilizing the remaining section of the platform cost 764000 USD. The official offer for supplying 2 new STSs is 26000000 USD, and after deducting depreciation, the station will incur an amount of 19200000 USD. The official offer for supplying and installing fenders and STS rail counted for 881500 USD.

Parola et al elucidate the significance of port authorities from a marketing perspective in their work. Utilizing 86 qualitative interviews performed at port authorities, they developed a multidimensional framework for the strategic positioning of these entities. The writers establish five marketing objectives across several levels of contact (Parola et al., 2018). After the incident, the Port needs to focus on marketing to retain and attract customers to create strong bonds through communication and value-added services to ensure customer satisfaction (Caliskan & Esmer, 2019). These incur additional expenses for the planning and execution of the terminal marketing strategy.

6. Conclusion

A collision between a vessel proceeding to berth and terminal STS, resulting from the vessel's excessive speed, inflicted damage on berth finders, damage to two STSs, and the STSs are out of rails, causing damage to the rails, and led to a closure of 35% of the quay length due to STS rail damage. The two STSs malfunctioning, resulting in operational disruptions evidenced by PPIs, including increased BOR from 19% up to 47%, waiting time from 4.5 hours to 21 hours, port time from 24 hours to 41 hours, WSO from 77 to 45, BSO from 63 to 41, and the number of TEUs managed by other STSs as a minimum before and maximum after collision. Additionally, there is a decline in the number of vessels visiting the terminal from 51 to 26, PSO from 44.4 to 21.4, and terminal efficiency, which will ultimately lead to customer attrition and reputational damage, thereby negatively impacting the terminal. The financial losses encompass not only the expenses associated with two STSs but also the costs for berth repairs, STS rail repairs and extensions, a decline in terminal throughput which had been increasing by 15% over the past three years, and the value of reputational damage, totaling almost 90% of the terminal income from the handling operations, in addition to the costs incurred for implementing the marketing plan.

A collision between a vessel and terminal STSs in a medium-sized terminal causes deep operational disturbance, loss of reputation, loss of customers, and financial losses. All these losses need years to recover.

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Sociocultural and Psychological Influences on Egyptian Maritime Students' Well-being and Academic Performance: Implications for Maritime Education and Training (MET)

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Abstract

Purpose: *The research explores the predictive relationship of sociocultural, psychological, and lifestyle distractions on maritime students' well-being and performance in Maritime Education and Training (MET) in terms of motivation, resilience, and digital distraction.*

Design/Methodology/Approach: *A quantitative cross-sectional survey of 535 students was undertaken using a 17-item Likert-scale questionnaire that examined lifestyle distractions, sociocultural factors, and psychological/academic well-being. Descriptive statistics and Pearson correlation were used to analyze the data.*

Findings: *The results revealed that the lifestyle distractions were positively related to psychological stress for maritime students, whilst the sociocultural factors, such as family and cultural identity, were positively related to motivation and emotional resistance factors. Regression analysis also showed that the adverse psychological impact of lifestyle distractions was partially mitigated by the influences of sociocultural factors.*

Research Implications/Limitations: *This research underscores the complexity of student well-being, but the study is limited in terms of sample and design. Further longitudinal research is recommended.*

Practical Implications: *MET institutions should develop a holistic approach with psychological, cultural, and digital self-regulation interventions to enhance student performance.*

Originality: *The study offers a holistic view of the connections between behavioral, cultural, and psychological aspects of MET.*

Keywords:

Maritime Education and Training (MET), Psychological health, Sociocultural, Academic, Lifestyle distractions, Maritime students, Stress, Resilience.

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1. Introduction

Maritime Education and Training (MET) is a supportive element in training the future seafarers who are bound to work in a more complex, globalized, and technologically enhanced maritime economy. Besides technical skills and working ability, modern scholarship has developed a new direction toward the psychological and sociocultural aspects of maritime education, contributing to it as a key factor in the academic performance of the students and their future professional preparation. Maritime students regularly experience a blend of high levels of academic work, simulation-based assessment, and high levels of discipline, and anticipated professional pressure that comes with future seafaring duties. All of these factors lead to increased stress, anxiety, and emotional stress that can have a direct or indirect relationship with academic success and well-being (Mapua, 2024; Pazaver & Kitada, 2025). Moreover, the multicultural nature of the maritime industry implies that students have to deal with various cultural values, communication patterns, and behavioral norms; thus, sociocultural adaptation becomes an important part of their educational process (Russo et al., 2025).

Although the importance of maritime human factors is increasingly being considered by scholars, there is still a significant gap in the research on the synergistic effect of lifestyle practices, sociocultural interaction, and psychological states in MET environments. The existing literature has primarily addressed the dimensions separately since some of the studies have focused more on the mental health outcomes, such as stress, anxiety, and depression among students (Yasmin, 2025), whereas other studies have focused more on the institutional or pedagogical dimension, such as curriculum design, training effectiveness, and learning systems founded on simulation (Kardiono, 2025). However, more recent results suggest that the welfare of students cannot be attributed to the related factors but, rather, leads to a complicated and dynamic interplay between behavioral patterns, cultural backgrounds, and psychological strength (Kamis et al., 2026). This incomplete understanding brings up a natural problem: the lack of an empirical paradigm that will explain how all these mutually reinforcing variables affect each other and affect academic success and well-being in maritime academic institutions.

A sociocultural approach indicates that expectations of the family, cultural identity, and peer interactions are good predictors of student motivation, self-concept, and emotional stability. As it has been demonstrated by prior research, high cultural attachment can be utilized as a protective factor, which can make individuals less vulnerable and easier to adjust to the adverse academic and work environments (Russo et al., 2025). Similarly, inclusive learning environments have been associated with psychological adaptation and increased academic engagement of maritime students, facilitating cultural integration and peer support (Senbursa, 2025). Nevertheless, the extent to which these sociocultural variables interact with the psychological strains in dictating the overall student performance is not well researched, particularly in systematic maritime training programs.

Lifestyle practices, in particular, relating to digital interaction and social media usage, have also come to the forefront in how students are influenced in their academic life. Although digital technologies may provide high-quality educational material, excessive consumption or unregulated use of these technologies may result in a deficit of attention, reduction in attention span, and cognitive load, and, ultimately, worsen academic performance (Mofatteh, 2020; Toriia et al., 2023).

This paper will fill this gap. Maritime education is globally based and multicultural in nature; the focus of the current study is the Egyptian context of maritime education. Thus, the results should be viewed in the context of the sociocultural and institutional environment of maritime education in Egypt, not as universal in all maritime academies, by discussing the reciprocal correlations of lifestyle habits, sociocultural factors, and psychological health, and discussing the combined predictive relationships of these factors on the overall academic performance in a MET setting. The particular aim of the research is to identify the degree of lifestyle-related distractions among the maritime students, how the sociocultural factors influenced the motivation and psychological stability, and the psychological and academic status of the students concerning the factors. In doing so, it provides a complete empirical understanding of the interplay of these dimensions within a maritime educational context.

Hypotheses about the study are informed by some of the literature reviewed. The hypothesis is that lifestyle distractions are positively correlated with psychological stress and negatively correlated with academic performance, and that the sociocultural factors will have positive correlations with psychological well-being and academic performance. In addition, the sociocultural variables will likely mediate between lifestyle distractions and psychological outcomes, and psychological well-being will be a significantly predictive variable of academic performance among maritime students.

The importance of this research is that it will contribute to the recent trend of a more holistic and humanistic approach towards MET. The recent studies show that psychological support systems, resilience-building programs, and sociocultural awareness should be included in MET programs to foster the well-being of students and their professional preparedness (Carras-Arce et al., 2025; Kamis et al., 2026). By providing empirical evidence of the inter-relationship of the key determinants of student experience, the study will contribute to the development of more comprehensive solutions to education, which is in line with the evolving requirements of the global maritime industry.

Lastly, the study has an essential literature gap, as it offers a multidimensional and integrated perspective on the well-being of students and their academic attainment at sea. It combines current theoretical and empirical studies to form a coherent perspective of the interaction between lifestyle decisions, sociocultural contexts, and mental conditions in the lives of maritime students, which may be useful in the further evolution of MET systems.

2. Methodology

2.1. Study design

This paper has utilized a quantitative and cross-sectional research design to investigate the sociocultural and psychological factors of well-being and academic performance of the maritime students in the MET environment. A survey-based method was chosen because it enables the systematic gathering of standardized data with a relatively large sample, which makes it easy to perform a statistical analysis and generalize research. This method is common in maritime education research as it is a valid way to assess psychological and behavioral constructs.

2.2. Research population and sample

The population under study was maritime students who were at their advanced levels of study. The sample size used in the study was 535 students (the cohort of third and fourth years). The balanced representation of the two levels of academics provided an implicitly stratified sampling methodology, as the sample consists of students who had a high level of academic and practical exposure. Demographic variables like academic Year, nationality, and gender were used as they give contextual information about the study population.

2.3. Data collection instrument

The data were gathered using a designed questionnaire, which was created in line with the available literature on student well-being, sociocultural factors, and academic achievement in the context of maritime and higher education. The instrument had 17 items that were categorized into three main constructs:

- Maritime Training Lifestyle and Distractions (4 items)
- Sociocultural Influences in Maritime (8 items)
- Psychological and Academic State in MET (5 items)

Attitudes and perceptions could be quantified by measuring all items on a five-point Likert scale (strongly disagree (1) to strongly agree (5).

2.4. Validity and Reliability

The content validity was maintained by conformity to prior empirical research and theoretical conceptualizations. To measure reliability, the Cronbach alpha coefficient, which is one of the most commonly accepted measures of internal consistency in social science research, was used. The outcomes showed that all constructs had high reliability (= 0.85 0.93), and this shows that the instrument is not only consistent but also appropriate in the measurement of the variables of the study. Another study of maritime-related studies using questionnaire-based methods has also claimed similar levels of reliability.

Table 1: Reliability analysis

Scale	Number of Items	Cronbach's Alpha
Lifestyle and distractions in maritime training	4	0.88
Sociocultural influences in maritime context	8	0.85
Psychological and academic state in MET	5	0.91
Overall Scale	17	0.93

2.5. Data analysis procedures

The analysis of the data was performed with the help of descriptive and inferential statistics. Student responses were summarized using descriptive statistics (means and standard deviations), and correlation analysis (Pearson r) was used to analyze the relationship between variables and multiple regression analysis.

2.6. Ethical considerations

The involvement was voluntary, and anonymity and confidentiality were guaranteed. Data were utilized purely in research, and ethical standards of research using human subjects were followed.

3. Results

Table 2: Academic year

Academic Year			
		Frequency	Percent
Valid	3rd	265	49.5
	4th	270	50.5
	Total	535	100.0

The sample can be considered well-balanced since the sample size of the students per academic year was nearly the same between students in the third year (49.5%) and the fourth year (50.5%). This proportional distribution is useful in terms of comparative purposes as it renders both categories equally contributing to the results. The students at these levels should have acquired a significant amount of academic and practical experience, and their feedback would be pertinent, particularly to the goals of the study.

Table 3: Nationality

Nationality			
		Frequency	Percent
Valid	Egyptian	508	95.0
	Non-Egyptian	27	5.0
	Total	535	100.0

The nationality sample indicates that the sample is very homogeneous as 95 percent of the sample are Egyptian and 5 percent are non-Egyptian. This lack of balance indicates that the results are probably influenced most by one cultural background, which would restrict the extrapolation of the results to a more diverse maritime education setting.

Table 4: Gender

Gender			
		Frequency	Percent
Valid	Male	519	97.0
	Female	16	3.0
	Total	535	100.0

The gender proportions of the sampling are highly skewed, whereby 97 percent of the participants are male, and 3 percent are female participants. Although such an imbalance may be regarded as a characteristic feature of the traditionally male-dominated concept of maritime education, it is a serious drawback in the context of representativeness and the depth of analysis. The limitation of the study is the very small sample of female respondents, since it does not contribute to the reflection of the gender-specific experiences and perspectives.

Table 5: Descriptive statistics

Descriptive Statistics				
	Items	Mean	Std. Deviation	
Lifestyle and distractions in maritime training context	1	3.4224	1.25460	Moderate
	2	3.4748	1.18938	Moderate
	3	3.4037	1.26224	Moderate
	4	3.5234	1.20350	High
Sociocultural context	1	3.3981	1.19784	Moderate
	2	3.5776	0.94862	High
	3	2.7383	1.05412	Low
	4	3.4879	1.20367	Moderate
	5	3.3084	1.19151	Moderate
	6	3.8187	0.797 25	High
	7	3.4019	1.13061	Moderate
	8	3.6860	0.72314	High
Psychological and academic state in MET	1	3.4430	1.26314	Moderate
	2	3.3720	1.20157	Moderate
	3	3.3944	1.21922	Moderate
	4	3.5103	1.27177	High
	5	3.4449	1.19935	Moderate

The descriptive statistics indicate a medium value of agreement with the majority of the items, and this indicates that maritime students are experiencing a balanced and important presence of lifestyle, sociocultural, and psychological variables in their educational environment. Social media usage and its perceived relationship to concentration are rated as moderate, which means that there is indeed a relationship, but it is not as disruptive. This is a general behavior trend of students in technologically integrated learning settings. The pattern of sociocultural variables, in turn, is more differentiated. It has a higher score in the effects of family traditions and cultural background on psychological health, indicating that the cultural background also plays a significant role in influencing the emotional and motivational state of students. In particular, the scores associated with the cultural influence on well-being are high, which indicates the strong presence of identity and tradition in the psychological experience of students. However, the perceived family pressure is not that high, which implies that the cultural influence is seen as a support, rather than a pressure. Psychological signs demonstrate moderate stress, anxiety, and isolation, which correspond to the strict and systematic MET. In the meantime, students are psychologically equipped at a medium level, and this is a sign of resiliency when confronting academic pressures.

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Table 6: Correlation Matrix

	Lifestyle and distractions in maritime training	Sociocultural influences in maritime context	Psycho logical and Academic State in MET
Lifestyle and distractions in maritime training	1	-0.42**	0.58**
Sig. (2-tailed)		0	0
Sociocultural influences in maritime context	-0.42**	1	0.51**
Sig. (2-tailed)	0		0
Psychological and academic state in MET	0.58**	0.51**	1
Sig. (2-tailed)	0	0	

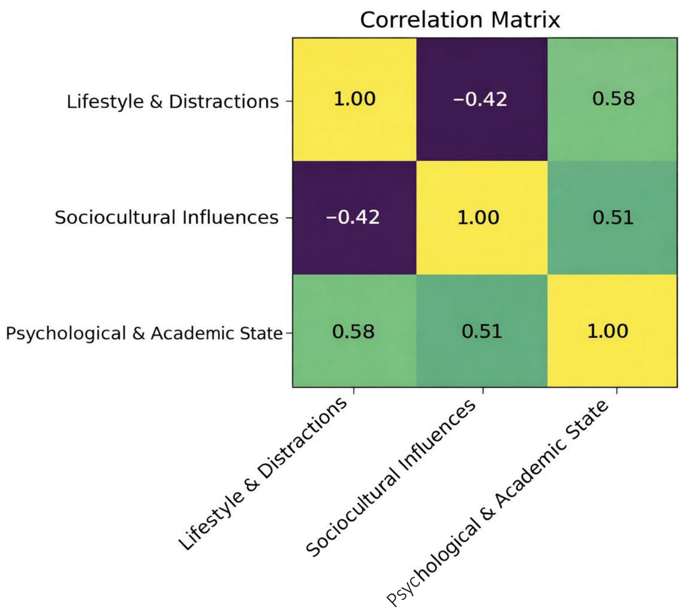

Figure 1: Correlation matrix

The correlation table demonstrates that the main variables in the study are interrelated statistically significantly and can be utilized to comprehend the interaction of the lifestyle habits, sociocultural factors, and mental states in the context of MET. The fact that positive correlations were found between lifestyle and distractions on one hand and psychological and academic state on the other hand, indicates that the greater the level of distraction, the greater the level of psychological strain and possibly reduced academic performance. This shows that uncontrolled distracters could have an adverse predictive relationship with mental health and academic results.

Table 7: Multiple regression analysis predicting psychological stress among

Maritime Students

Model Statistics	Value
R	0.615
R Square (R^2)	0.378
Adjusted R-Square	0.375
Std. Error of the Estimate	0.4821
F-value	134.25
Significance (p)	0

ANOVA Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	62.45	2	31.225	134.25	0
Residual	102.81	442	0.233		
Total	165.26	444			

Regression Coefficients

Predictor Variable	Unstandardized β	Std. Error	Standardized Beta (β)	t	Sig.
Constant	2.15	0.31		6.935	0
Lifestyle Distractions	0.45	0.072	0.41	6.25	0
Sociocultural Influencences	-0.35	0.068	-0.32	-5.147	0

- **Dependent Variable:** Psychological Stress among Maritime Students
- **Predictor Variables:** Lifestyle Distractions and Sociocultural Influences

The multiple regression analysis showed that the proposed model was statistically significant, $F(2, 442) = 134.25$, $p < .001$, with 37.8% of the variance in psychological stress among the maritime students accounted for. Psychological stress was positively predicted by lifestyle distractions ($\beta = 0.410$, $p < .001$) but negatively predicted by sociocultural influences ($\beta = -0.320$, $p < 0.001$). Based on these findings, it is suggested that sociocultural support mechanisms might help diminish negative psychological outcomes of lifestyle distractions in Maritime Education and Training (MET) settings.

4. Discussion

4.1. Strength of measurement and construct internal consistency

The current research is based on a solid methodological approach, which is reflected in the high reliability coefficients obtained in all measurement scales. The values of Alphaa (0.85-0.93) suggest that internal consistency is high, and the items in each construct are relevant and effectively measure the desired dimensions of lifestyle behaviors, sociocultural factors, and psychological conditions. Such reliabilities are regarded in modern social science research as a sign of well-developed scales, which increases credibility and reproducibility of results. This is specifically relevant when studying psychosocial variables, which are complex and whose measurement tools must be accurate and consistent (Cahyadi et al., 2025).

The fact that the psychological and academic state scale is highly reliable (α = 0.91) also contributes to the strength of the study because it shows that the perception of stress, anxiety, preparedness, and well-being of students, in turn, is consistently reflected in items. Instead of signifying a methodological shortcoming, this consistency implies the conciseness and applicability of the constructs in terms of their ability to represent the lived experiences of maritime students. According to recent literature, the use of highly reliable scales leads to higher predictive validity and stronger statistical correlations between variables (Jansone et al., 2026). Thus, the empirical base of the measurement design of this investigation offers a strong foundation for the analysis of the interaction between sociocultural and psychological aspects of the MET context.

Further, the scale reliability (0.93) in general highlights the consistency of the combined framework employed in this research. The study integrates lifestyle, sociocultural, and psychological aspects in a single model, which qualifies it as multidimensional in regard to student well-being, which has been promoted in recent scholarly literature. This methodology's strength builds confidence in the findings of the study and improves their use in the academic and practical environment.

4.2. Applicability of sample characteristics to advanced MET situations

This is because a very crucial area in justifying the relevance and applicability of study results is the sample demographics. The fact that the sample is virtually split into the third and fourth-year students also ensures that the results are reflective of the experiences of the people who are wholly engaged in the high levels of MET. The high level of academic intensity, real-world training requirements, and the willingness to become a professional seafarer are also characteristic features of these phases and, in particular, worth studying psychological and academic performance (Mapua, 2024). At these levels, students are usually subjected to simulator training, challenging tests, and real field of operation situations that assist in attaining professional competence. This means that their responses may be immensely valuable to the investigation of the influences of the sociocultural and mental processes under the circumstances of augmented academic and practical demands. This reduces the scope of the research by determining the most significant step in the maritime education process, since the well-being of students is the only factor that defines academic achievements and career readiness in the future.

In addition, the consistency of the answers of this sample is also indicative that the patterns are not a mere coincidence but are a feature of the consistent tendencies of the MET environment. This aligns with the previous research that shows that students with higher levels of their studies are better organized in their coping strategies and their vision of a professional identity as compared to students in lower stages of their studies (Hanik et al., 2025). The work, thus, gives a contextualized and practical perspective on the experiences of the maritime students at a critical stage of the educational experience.

4.3. Lifestyle behaviors and management related to digital interruptions

The findings regarding lifestyle habits, particularly the digital disruptions, provide a somewhat objective and evidence-based perspective on the experiences of students in the modern learning environment. The descriptive statistics indicate that social media use and its relation to concentration are moderate, i.e., although the use of digital media is popular among people, it does not have a significant negative impact on academic performance. This suggests that there exists a certain level of adaptive behavior with regard to maritime students, as it appears that they can manage their online interactions within the context of a systematic training environment.

The discovery is consistent with the more recent studies indicating that the influence of digital technologies on academic success is not always negative, but rather it depends on the ability of students to manage their consumption (Toriia et al., 2023). In cases of extremely structured schedules and within the context of maritime education, when the practical training requires long-term orientation, students are able to develop effective ways to balance digital use with studying.

In the meantime, the study also provides some useful data that even low percentages of distraction are strictly connected with psychological pressure. The fact that a positive relationship exists between lifestyle distractions and psychological and academic state (r = 0.58) implies that the greater the distractions, the higher the levels of stress and the lower the degree of academic performance. This discovery is supported by the fact that the published literature has strongly established distraction as a significant source of cognitive overload and emotional fatigue among university students (Mofatteh, 2020).

Notably, the findings do not imply that digital distractions are uncontrollable and harmful in every instance. On the contrary, they emphasize the role of awareness and self-control in controlling these influences. This interpretation is a strength of the study, as it gives a subtle understanding of lifestyle behaviors and highlights the difficulties that they come with, as well as the ability of the students to adjust well under the strenuous educational environments.

4.4. Sociocultural influences as drivers of motivation and psychological stability

The comprehensive discussion of sociocultural effects is one of the primary contributions of the study since it turned into one of the key factors of student well-being and academic motivation. The findings indicate that cultural practices, family experiences, and social identity play an important role in defining emotional and motivational experiences of maritime education students. The average scores of variables related to culture and psychological well-being are elevated, which indicates that the students have extensive Support in their sociocultural setting.

This observation is solidly connected with contemporary research that emphasizes the importance of cultural identity as a factor of resilience and psychological power. It has been shown that individuals with a positive attachment to their cultural values are better equipped to deal with stress and adapt to challenging environments (Russo et al., 2025). These cultural anchors provide a stable base where well-being can be supported in maritime settings, where learners are regularly exposed to rigorous programs and routines.

Interestingly, the study reveals that the family is considered to be supportive and not coercive. The perceived family pressure is also low, as indicated by the students, and simultaneously, they said that family expectations lead to their self-confidence and motivation. The discovery contributes to the literature by showing that the significance of the family involvement in collectivist cultural settings, in which the anticipation of the family is often thought of as Support rather than pressure (Dahalan et al., 2021).

The importance of sociocultural factors is also justified by the positive correlation between sociocultural influences on psychological well-being ($r = 0.51$). The higher the attachment of students to their cultural values and traditions, the higher the outcome of their mental health, which means that sociocultural support systems can be considered as protective mechanisms. This gives the study more strength as it demonstrates that cultural factors are not mere contextual variables but contributing factors to student success and resilience.

4.5. Psychological adaptation, stress management, and student resilience

The psychological findings of the study are very useful in comprehending the response of maritime students to the pressure of the learning environment. The stress and anxiety levels mentioned can be deemed as moderate, which is a sign of how difficult maritime education can be, and it also demonstrates that students can be effective in coping, in general. This is the same trend as the concept of optimal stress, where moderate levels of pressure are conducive to motivation and performance, rather than damaging it (Hanik et al., 2025).

Such an interpretation is also confirmed by moderate rates of psychological preparedness of students, as students learn adaptive coping strategies in the course of their training. This adaptive capacity is one of the main attributes of the maritime workers of the future, who are expected to be capable of operating under pressure.

These findings are consistent with those of other researchers who have demonstrated that resilience is one of the key success factors in maritime education and seafaring careers (Mapua, 2024).

The perceived isolation, because it is relatively high among the students, is a useful aspect of the analysis. Isolation is a bad thing, but in the education of the sea, it can also be a gauge of the stability and austerity of schooling scenes. The identical findings were achieved in the study of seafarers, where isolation is among the qualities of the occupation (Peplińska and Jeżewska, 2013).

4.6. Systemic support and the transformation of the role of maritime education systems

The findings of the research on institutional support provide useful data on the ways in which the maritime education systems can be used to support the well-being of students. The degrees of satisfaction with mental health support were moderate, and students observed that the mechanisms of mental health support are already present, but they might be enhanced. This observation marks a shift in the academic environment in which colleges are now taking more concern over the psychological well-being.

The new research has also emphasized the need to have systems of holistic Support in maritime education, including counseling programs, stress coping, and resilience training (Cahyadi et al., 2025). The middle score of the current study shows that such efforts are already being undertaken in one way or another, which is having a positive influence on the students.

It is important to note that the outcomes should be interpreted as the epistle of advancement and not deficiency. Even the presence of institutional Support, in the form of moderate levels, presupposes the growing extent of awareness concerning the needs and the desire to address them in students. This renders the study robust since it elicits the significance of schools as proactive agents in the health and academic performances of students.

4.7. Interactive relationships between lifestyle, sociocultural, and psychological factors

The correlation analysis provides a comprehensive understanding of the interrelation of the study variables. The close relations among lifestyle decisions, sociocultural variables, and psychological states testify that the well-being of students enrolled in maritime training can be identified by a number of interacting factors. This multidimensional approach is consistent with the recent theoretical viewpoint, such as the biopsychosocial model, which emphasizes the integration of behavioral, social, and psychological dimensions.

The positive correlation between lifestyle distractions and psychological strain highlights the importance of having control over external factors in the promotion of well-being. In the meantime, the negative correlation between lifestyle distractions and sociocultural effects suggests that cultural involvement leads to discipline and reduces vulnerability to distraction.

4.8. Future directions and implications

The findings of the study have immense implications for MET in the sense that the long-awaited emphasis on a holistic and student-centered approach, considering.

The psychological, sociocultural, and behavioral elements will be made. As the main associations between lifestyle distracters, the sociocultural factors, and psychological well-being have been identified, the maritime institutions must not only continue with the conventional technical training but also incorporate systematic mental health and resilience-building programs into their programs. Moderate stress and anxiety levels mean that stress is under control, but the most effective way to maximize student performance is to utilize active interventions (stress management training, counseling services, and psychological preparedness programs) (Cahyadi et al., 2025).

Furthermore, the influence of sociocultural variables is positive and significant enough, and therefore, there is a necessity to enhance the presence of a culturally inclusive setting that allows identity, motivation, and emotional stability. Peer collaboration, intercultural engagement, and culturally responsive teaching may enable the students to feel belonging and resilience, which are vital in the difficult maritime conditions (Russo et al., 2025). The specified relationship between psychological strain and lifestyle distractions also justifies the significance of developing the skill of digital self-regulation, which will enable students to become efficient in both controlling the use of technologies and staying concentrated on their studies.

Study-wise, future studies should expand on the sample diversity by expanding it to different nationalities, genders, and academic levels, since the maritime industry is global in nature. Longitudinal research designs are particularly recommended in the study of the evolution of the psychological and sociocultural factors over time and their influence on the long-term academic and professional outcomes. Furthermore, the use of more advanced methods of analysis, such as structural equation modeling, could provide more detailed data on the causal relationships and moderating effects among variables (Jansone et al., 2026).

4.9. Study limitations

There are several limitations of this study. First, there is a limitation of causal interpretation between variables in the cross-sectional design. Second, the sample was very homogeneous in terms of nationality and gender, thus limiting the generalizability of findings. Thirdly, the measures used were self-reported, and this can be associated with response bias. Future research needs to be conducted with longitudinal and multi-institutional designs with the use of more sophisticated analysis techniques like Structural Equation Modeling (SEM).

5. Conclusion

This study has established that the lifestyle, sociocultural, and psychological factors are interwoven in affecting the well-being and performance of the maritime students. The moderate stress level, anxiety, and distraction level show that students are not only exposed to high academic pressure, but they are also resistant in the MET environment. Family and cultural identity are the sociocultural factors that contribute to motivation and an increase in psychological stability. Additionally, the relationship to lifestyle distractions, especially digital use is objectively high in the context of concentration and academic achievements.

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Appendix
Questionnaire

Section A: Demographic information please select the most appropriate answer:

1. Academic year:

   ☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year

2. Nationality:

   ☐ Egyptian ☐ Non-Egyptian

3. Gender:

   ☐ Male ☐ Female

4. High school type:

   ☐ National ☐ International ☐ American ☐ Private ☐ Governmental

Section B: Lifestyle and distractions in maritime training

(1 = Strongly Disagree → 5 = Strongly Agree)

1. I spend a considerable amount of time on social media during my maritime studies or training periods.
2. Social media negatively affects my concentration during maritime education and training activities.
3. I am exposed to major distractions that interfere with my maritime studies or simulator training.
4. There are minor distractions that influence my academic performance in the maritime education environment.

Section C: Sociocultural influences in maritime context

1. I frequently adhere to customs and traditions in my daily life as a maritime student/trainee.
2. My family's traditions influence my personal and professional decisions related to maritime education.
3. I feel pressure from my family's expectations to succeed in my maritime career.
4. I actively interact with peers from diverse cultural backgrounds within the maritime education environment.
5. Customs and traditions influence my motivation to succeed in maritime studies and training.
6. Cultural traditions affect my psychological well-being during maritime education and training.
7. I feel proud of my cultural background, which motivates me to succeed in the maritime field.
8. My family's expectations influence my self-confidence in maritime training and performance.

Section D: Psychological and Academic State in MET

1. I experience a high level of stress due to the demands of maritime education and training (MET).
2. I feel psychologically prepared to meet the challenges of maritime studies and future seafaring duties.
3. I frequently experience anxiety before maritime exams, assessments, or simulator evaluations.
4. I feel isolated due to the structured and demanding nature of maritime education and training.
5. My mental health is adequately considered and supported within the Maritime Education and Training (MET) environment.

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Enhancing Dynamic Positioning Operator Performance through Integrated Training Methods: An Empirical Study in Offshore Maritime Operations

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Abstract

As the Dynamic Positioning (DP) systems of the offshore fleet become increasingly automated and integrated with sensors to enhance safety, Dynamic Positioning operators (DPOs) still play a critical role in accurately positioning vessels as safely and efficiently as possible, even under the harshest conditions. This study is framed in a quantitative context and examines the effects of different types of DPO training on training outcomes. Structured questionnaires were issued to certified operators to collect the data. This study found that this type of training has the greatest effect on training outcomes. Among the training types, the greatest training outcome is attributed to onboard or practical training on DP Vessels, compared with outcomes from simulator and computer training. Of the types of training mandated by the company, and the professional seminars or webinars attended, the majority of the training outcomes were intellectual, and in-the-field operational skills were minimally affected. This study found the remaining types of training on the spectrum of the theoretical portion of the training, practical, and in-the-field training to be balanced. This study provides the foundation for encouraging potential lines of sight for improving the development of training competencies. This study is intended to enhance industry safety.

Keywords:
Dynamic positioning, MET, DPO, Maritime Education & Training.

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1. Introduction

The last few decades have seen many shifts in the global maritime sector due to technological advances. One such development is the Dynamic Positioning (DP) system, which enables ships to maintain specific positions and orientations even in challenging situations (Kvaal et al., 2022). Dynamic Positioning (DP) technology is critical in subsea construction, the extraction of oil and gas, and the installation of wind farms. It notably enhances the range of offshore services while also safeguarding the environment (Masood, 2024).

The DP system relies heavily on automation; however, human input is still valued for safety reasons. Dynamic Positioning Operators (DPOs) monitor system data, analyze external variables, and make decisions in real time under challenging conditions. The stabilization of a ship is highly dependent on the decisions of a DPO. The system is likely to encounter unforeseen circumstances, such as the loss of a system unit, operation of a system unit during severe thunderstorms, or loss of system power (Øvergård et al., 2015).

Despite the risks of DP, human error is the cause of the majority of them, especially in DP risks known as the Loss of Position (LoP) risk. 61.2% of DP LoP cases have a human error component. There is a significant risk due to skill and supervisor-dependence errors. It is critical to efforts to reduce risks associated with the systems that end up improving DPO performance to put risks on the systems in the first place (Chae, 2017).

Many forms of effective training, such as onboard training on DP vessels, simulator exercises, company-mandated training, Computer-Based Training (CBT), and registered seminars or webinars, have been devised, but the effectiveness of each form has not been studied.

The disparity in knowledge may result in wasted training resources and unevenly skilled operators, raising concerns about safety in DP operations (Lundborg, 2014).

2. Research objectives and hypotheses

This research examines the impact of various DP training methods on DPO performance. The central question concerns the effect of the various training types on the improvement of DPOs' operational skills, the quality of their on-the-job decision making, and overall performance regarding safety. In light of this, the hypotheses have been constructed as follows:

- **H1:** DP training has a positive effect on DPO performance.
- **H1.1:** Simulator training significantly improves DPO performance.
- **H1.2:** Onboard training markedly boosts operational competence.
- **H1.3:** Company-required training produces a significant positive influence on performance results.
- **H1.4:** CBT significantly enhances DPO performance.
- **H1.5:** Webinars and seminars considerably improve professional performance.

From a methodological perspective, the research was designed as a quantitative study to collect data through a structured questionnaire administered to maritime-certified DPOs. This approach enabled statistical analysis of the relationship between the various DP training methods (the independent variables) and DPO performance (the dependent variable), thereby providing grounds for assessing training effectiveness and supporting the decision.

3. Human factors and competence

Although the DP system is largely automated, human factors remain crucial to maintaining optimal safety and operational efficiency. The DPO examines the overall operation and uses discretion to make critical, often urgent decisions about the operation of the system. The Senior DPO (SDPO) has complete responsibility for maintaining the position of the ship, ensuring navigation safety, and managing the DP activities related tasks (IMCA, 2025a).

A DPO's effectiveness and balance of key components, including technical knowledge and decision-making. Technical knowledge includes system construction, redundancy principles, and procedures for system operation. In contrast, situational awareness includes the flexibility of changing conditions, the behavior of the vessel, and the operational framework. The most proficient decision-making is crucial and provides a DPO with the tools required to contain risks, guide normal to abnormal situations, and manage the varied operational modes (NI, 2026).

To maintain and evaluate efficiency, formal training and certification courses are provided, for the most part, by the Nautical Institute (NI). This includes simulations and practical training, which is manufacturer-specific, continuous professional development (CPD) included, and is all related to the International Convention on the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) (NI, 2026). The DP Offshore Training Scheme offers a structured certification process that combines theoretical education with practical DP sea-time experience to ensure readiness for operations (see Fig.1).

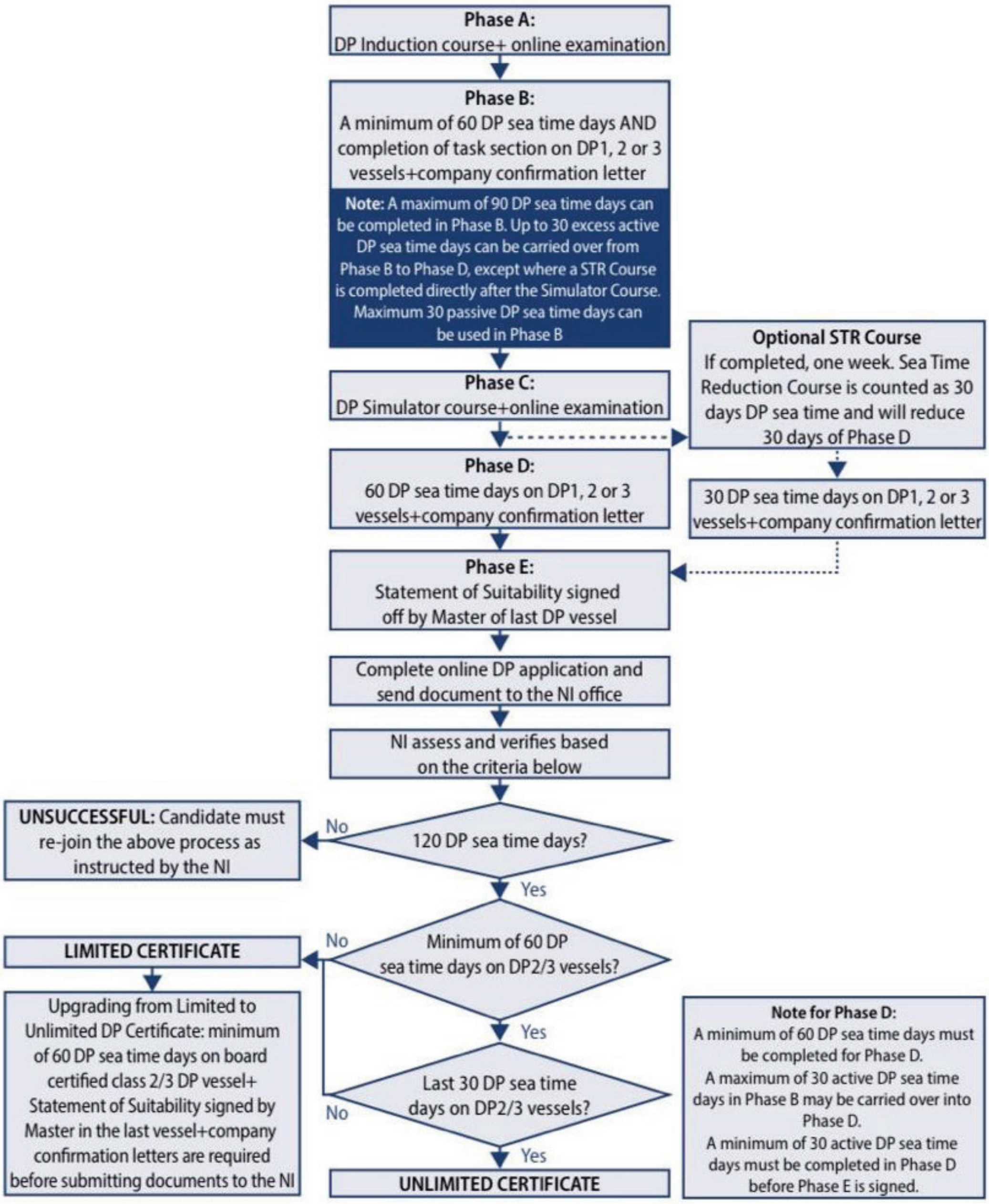

Figure 1: Offshore Limited/Unlimited DP Certificate flowchart (NI, 2026)

4. DP systems and technical framework

The DP system is designed as fluidly integrated hardware and software, allowing a ship to hold a specific position and heading in the absence of anchors while using active thrusters. Each subsystem in the system, position reference sensor, environment sensor, gyrocompasses, and a centralized control system, works in partnership to measure the disruption and establish a compensatory measure using active thrusters. (Duffield, 2024).

Central to DP is the concept of the six degrees of freedom. DP system defines parts of the system's movement in the horizontal direction as surge, sway, and yaw, and the parts of the movement in the vertical direction as heave, pitch, and roll (see Fig.2). DP systems can control horizontal movements, while vertical movements, although affected by various control systems, are largely left to the environment. This necessitates extensive system feedback and corrective measures to maintain stability (Masood, 2024).

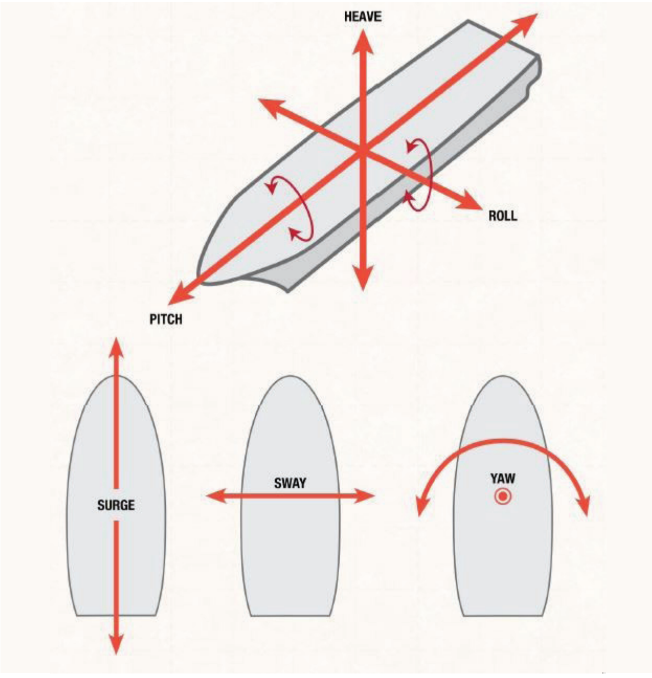

Figure 2: Six degrees of freedom (NI, 2024)

The critical components that integrate successfully to support effective station-keeping include a power supply, thrusters, environmental systems, Position Reference Systems (PRS), DP controllers, and Human-Machine Interfaces (HMIs) (see Fig.3). These components, within a cohesive architecture, enable accurate control and stability of the vessel. The system's reliability is further bolstered by redundant features across different DP classes (Duffield, 2024).

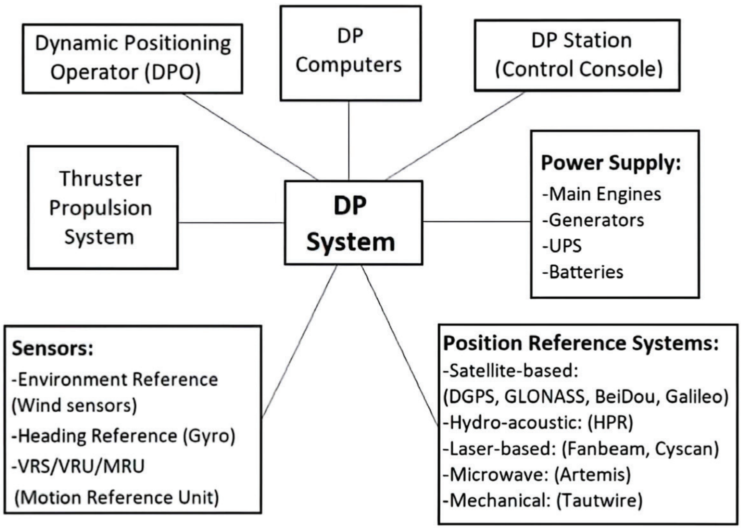

Figure 3: Components of a DP system (Duffield, 2024)

There are three types of DP Vessels, denoted as DP1, DP2, and DP3, and they are categorized based on their failure tolerance. Such analyses, such as failure mode and effects analysis (FMEA) and worst-case failure (WCF) analyses, delineate the failure that results in LoP for DP vessels. DP classes at a higher tier are preferable for high-risk offshore operations (IMO 2017), as they provide greater redundancy and fault tolerance.

From this perspective, operational planning dimensioned with the redundancy protocol and systems of defenses facilitates the protection offered. The frameworks for operational planning are dimensioned with the redundancy protocol and systems of defenses, Critical Activity Mode (CAM), and Task Appropriate Mode (TAM), as well as risk-specific Activity Specific Operating Guidelines (ASOG), which provide operational balance and the setting of redundancies. Prevention and response scheduling of maintenance activities and Hazard Identification (HAZID) activities sustain system integrity by addressing anticipated failures and ensuring that all system-perceived redundancies are available and operational (IMCA 2025b).

The complete crystallization of DP systems design is a robust, integrative approach to automation, redundancy, and operational structures. It ensures the safety of the vessel's systems and crew under harsh operational conditions.

5. Safety management in DP operations

There are three types of risk associated with DP operations: equipment failures, environmental risks, and human behavior risks. Because of the evident risk that human behavior poses to DP operations, continuing education, robust communication systems, and a cohesive safety culture are imperative for organizational success. From the IMCA (2023) publication, communication provides the basis for safety, and because people are a part of a system that should ensure safety, they should form the channels that combine controlled communication and regulated safety.

In addition, the safe management of DP operations, safety management systems such as the International Safety Management (ISM) Code, the International Maritime Organization (IMO), and the International Marine Contractors Association (IMCA) provide the foundation for safe practices, maintenance, and operational competency of the crew. The safety of operations that encourage constant improvements should also embrace blame-free reporting. This safety culture enables organizations to identify incidents and take measures to prevent them from recurring (IMO, 2017).

In conclusion, safety systems for DP operations should rely on people and technological systems that focus on risk management. Safety and effective operation of their radical system rely on the technological system, yet also on the capacity to operate the system, well-integrated supervisory systems, and holistic safety systems.

6. Research methodology

This research focuses on why people use different training methods. To collect data, a cohort of DPOs was sent a structured questionnaire in a bucket survey rather than a signpost survey to gain DPOs in offshore maritime jobs. The survey questions were mixed across both training and performance, and asked survey respondents to rate their responses to statements on a Likert scale.

The study population consisted of approximately 2,000 certified Dynamic Positioning Operators (DPOs) working in the offshore maritime sector (NI,2025). A sample of 100 certified DPOs was selected from this population. The majority of the participants were employed on supply ships, followed by diving support vessels and subsea construction vessels.

Statistical evaluation was obtained via the analysis. Descriptive statistics were used to summarize the retrieved evidence, while the relationship between training and performance variables was assessed using correlation analysis. This was also the case for regression analysis, which assessed the nature and degree of these variables.

This is a result of the best practices of research. Evidence found from a study that is both trustworthy and useful in answering the question of what the difference in training methods means for operational performance.

7. Results and Analysis

Analyzing the data illustrates the impact of various training methods, including simulator training, onboard training, company-required training, CBT, and webinars/seminars, on an operator's performance. It was apparent that the training conducted on-site and incorporated multiple training methods, like onboard training on DP vessels and Active Learning Principles, was the most beneficial for positive performance changes.

Conversely, simulation training allows operators to rehearse various scenarios, some of which may be rare in daily operations, as well as different emergency protocols. The use of CBT to consolidate operators' new knowledge and practice procedures and policies by using resources to guide them to the pertinent information was beneficial.

In addition to the use of different training methods, the facilitation of training in the form of one or two directed online courses is mandated more for policy compliance and procedural practice and is less beneficial to participants than the engaged learning of Facilitated training, Webinars, or Scheduled Professional Seminars in terms of the improvement of operational capability. The data illustrate that the most effective training of an operator, in terms of overall positive performance, centers on practical, active learning, rather than the less engaged type of training, which is more knowledge-centered.

8. Discussion

This research demonstrates the importance of integrated training systems for the maritime sector. Offshore activities often require operators to manage complicated technical systems and respond to rapidly changing environmental conditions. Therefore, effective training programs should address the requisite theoretical and practical components.

For that reason, the best training practices for an organization using DP systems integrate learning management systems, simulation training, and practical exercises on the vessels. Simulations allow learners to practice operating in and responding to difficult and dangerous operational environments. Practicing exercises on the vessel reinforces classroom concepts and hands-on training.

This research reinforces experiential learning theories that support learning through engagement with real-life activities. Actual engagement helps operators develop a better understanding of operational systems and, ultimately, better judgment through participation in real operational environments.

To conclude, maritime training programs that include an adequate amount of practical learning components as well as a strong theoretical component will best allow operators to cope with the inherent difficulties of offshore operations.

9. Conclusion

This research examines the influence of various training methods on DPOs' performance. The research study indicates that training is a core factor in improving the operational and safety skills of personnel involved in services in the maritime offshore environment. Among the evaluated training methods, Practical or onboard training has the most significant positive effect on operators' performance. This is followed by training using a simulator and training using a computer, in that order.

Contrary to the methods of training discussed in the previous paragraph, company-mandated safety training and participation in workshops, while they aid in the acquisition of knowledge, have a considerably smaller and indirect effect on enhancing operational skills. Based on the research, there is a need for comprehensive training programs for Operators that combine practical, simulation, and online training.

10. Recommendations

The present research offers several recommendations. Initially, it has been noted that maritime training involves much more theory than practice. Given the nature of the training, it is acceptable to conduct one or more training sessions at a company's training boards.

The second recommendation is much more focused on the Operators, and in fact, concerns the development and incorporation of more sophisticated training fitters into the training system.

The third, intricately connected to the development of simulators that will allow complex offshore situations to be worked on, is the development of Integrated Bridge System Simulators, which will be of significant importance.

The fourth recommendation is more directly aimed at the DPOs and their performance and concerns the development of standardized training frameworks. The last recommendation, of course, concerns the leap/leap of distance, as the introduction of distance learning systems contributes to training that is more than standard in the areas of further training, as noted. The improvement in offshore maritime activities can be conveniently monitored.

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