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KNOWLEDGE AND AWARENESS OF DECARBONIZATION PRACTICES IN THE SHIPPING INDUSTRY AMONG MARITIME STUDENTS: *BASES FOR INTERVENTION FOR CURRICULUM ENHANCEMENT AND SUSTAINABILITY INTEGRATION*

[1]Manuel Anthony B. Contreras

[1]John B. Lacson Foundation Maritime University, Iloilo City, Philippines

Abstract: The main purpose of this descriptive-correlational study was to determine the level of knowledge and awareness of third-year maritime students on decarbonization practices in the shipping industry at Mariners' Polytechnic Colleges Foundation of Canaman (MPCF–Canaman), Academic Year 2025–2026. Specifically, the study assessed the students' level of knowledge on decarbonization practices and their level of awareness in terms of global decarbonization efforts, environmental impact and sustainability goals, operational and institutional practices, and industry and employment trends. Likewise, the study ascertained the relationship between the students' level of knowledge and their level of awareness and identified suggested interventions to enhance their understanding of maritime decarbonization.

A descriptive and correlational research design was employed in the study. The respondents randomly selected third-year maritime students of the Bachelor of Science in Marine Transportation (BSMT) and Bachelor of Science in Marine Engineering (BSMARE) students. Data were gathered using a researcher-developed multiple-choice knowledge test and a Likert-scale awareness survey questionnaire, supplemented by an item on suggested interventions. The instruments were subjected to validation and reliability testing prior to administration. The statistical tools used included frequency, percentage, mean, and standard deviation for descriptive analysis, and Pearson's product-moment correlation coefficient and the independent samples z-test for inferential analysis, with the level of significance set at 0.1.

The findings of the study revealed that third-year maritime students demonstrated an overall poor level of knowledge but an overall "aware" level of awareness regarding decarbonization practices in the shipping industry. The study further showed significant low positive relationship between these two variables. The results also indicate that students tend to favor structured, visually supported and, and experiential learning approaches. These results served as the basis for formulating appropriate interventions and strategies aimed at strengthening maritime students' knowledge and awareness of decarbonization practices, thereby contributing to the development of environmentally responsible and competent future seafarers.

Key words: Decarbonization, Decarbonization practices, Knowledge, Awareness, Shipping Industry.

1. INTRODUCTION

Due to its significant role in transporting nearly all the world's necessities, including food, fuel, and consumer products, the marine sector has emerged as the hub of international trade, advancing nearly every nation on the planet. Consequently, it also shared a significant responsibility for maintaining a healthy environment. The shipping sector needs to function more sustainably because it is one of the main contributors to the rising greenhouse gas (GHG) emissions.

Because of this obligation, the International Maritime Organization (IMO) has established a new goal for its sector to ensure that the maritime industry fulfills its obligations while also considering environmental responsibility. By 2050, it seeks to reduce GHG emissions by half, necessitating the implementation of decarbonization strategies. Since ships typically utilize marine diesel or heavy fuel oils, this reduces carbon emissions, making ships cleaner. Better technologies, more effective operations, and the introduction of new fuels make this possible (IMO, 2023).

Moreover, IMO (2023) reported that the shipping sector is responsible for 3% of global carbon dioxide emissions, which could increase if nothing is done. This issue creates a bigger environmental conflict that could lead to ocean acidification, air pollution, and the spread of invasive marine species. The Philippines and other coastal and archipelagic nations may be more affected by this issue than other places. As a result, sustainable maritime practices can be viewed as a global challenge, but nations whose economies and populations rely significantly on a healthy marine ecosystem should give it more serious consideration.

Since the Philippines is the world's largest supplier of seafarers, it is crucial to ensure that the seafarers trained in the nation's maritime schools are competent and environmentally conscious. This is because, although shipping companies are working to reduce carbon dioxide emissions from ships by implementing decarbonization strategies such as using alternative fuels (such as LNG, methanol, and ammonia), the success of these initiatives is largely dependent on the skill and awareness of the seafarers they produce. To put such into practice, the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) emphasized that cadets should learn about sustainable marine practices in addition to deck and engine operations (Maritime Industry Authority [MARINA], 2024).

To address the issue, it is believed that the shipping industry must implement decarbonization. Maritime schools are responsible for preparing students, particularly future cadets, to develop solutions by continuously adopting the constantly evolving maritime standards and by practicing environmentally friendly shipboard operations. However, the current maritime curriculum does not yet fully incorporate decarbonization-related themes, raising questions regarding the students' level of knowledge and awareness. While shipping businesses, marine regulators, and seasoned seafarers are also discussing and researching decarbonization, it is indisputable that there is a dearth of research among maritime students, particularly those who are about to start working at sea. A deeper grasp of how the Filipino maritime students can satisfy the global sustainability standards expected of them can be achieved by incorporating them in the conversation and evaluating their knowledge and awareness of decarbonization.

At the institutional level, students pursuing a Bachelor of Science in Marine Transportation (BSMT) or Bachelor of Science in Marine Engineering (BSMARE) at Mariners' Polytechnic Colleges Foundation of Canaman (Cam. Sur), Inc. (MPCF-Canaman) have already been introduced to the implemented environmental initiatives that incorporate sustainable programs and environmental awareness. These programs are designed to assist students in adjusting to and improving their understanding of sustainable techniques used on a ship. Nevertheless, despite this, there is still a dearth of reliable information regarding students' awareness and knowledge of decarbonization.

To address this research gap, this study aims to evaluate the third-year maritime students at MPCF-Canaman, A/Y 2025-2026, regarding their knowledge and awareness of decarbonization strategies in the shipping industry. Given that these students are almost finished with their coursework, it is critical to determine whether they truly understand decarbonization.

2. Theoretical Framework

This study on the *Knowledge and Awareness of Decarbonization Practices in the Shipping Industry* is grounded in three interrelated theories: **Environmental Education Theory**, **Theory of Planned Behavior (TPB)**, and **Social Cognitive Theory (SCT)**. They collectively explain how knowledge and awareness influence environmentally responsible behavior.

a. Environmental Education Theory

According to Hungerford and Volk's (1990) Environmental Education Theory (EET), understanding and awareness of environmental problems are essential to taking responsible action to address them. According to their approach, people should be encouraged not only to identify environmental issues but also to find solutions. Because cognitive levels are insufficient, there should be progression to knowledge-awareness-action. According to Hungerford & Volk, "before an individual can intentionally act on a particular environmental problem... that individual must be cognizant of the existence of the issue" and "must also possess... knowledge of those courses of action which are available" (Hungerford & Volk, 1990, p. 11).

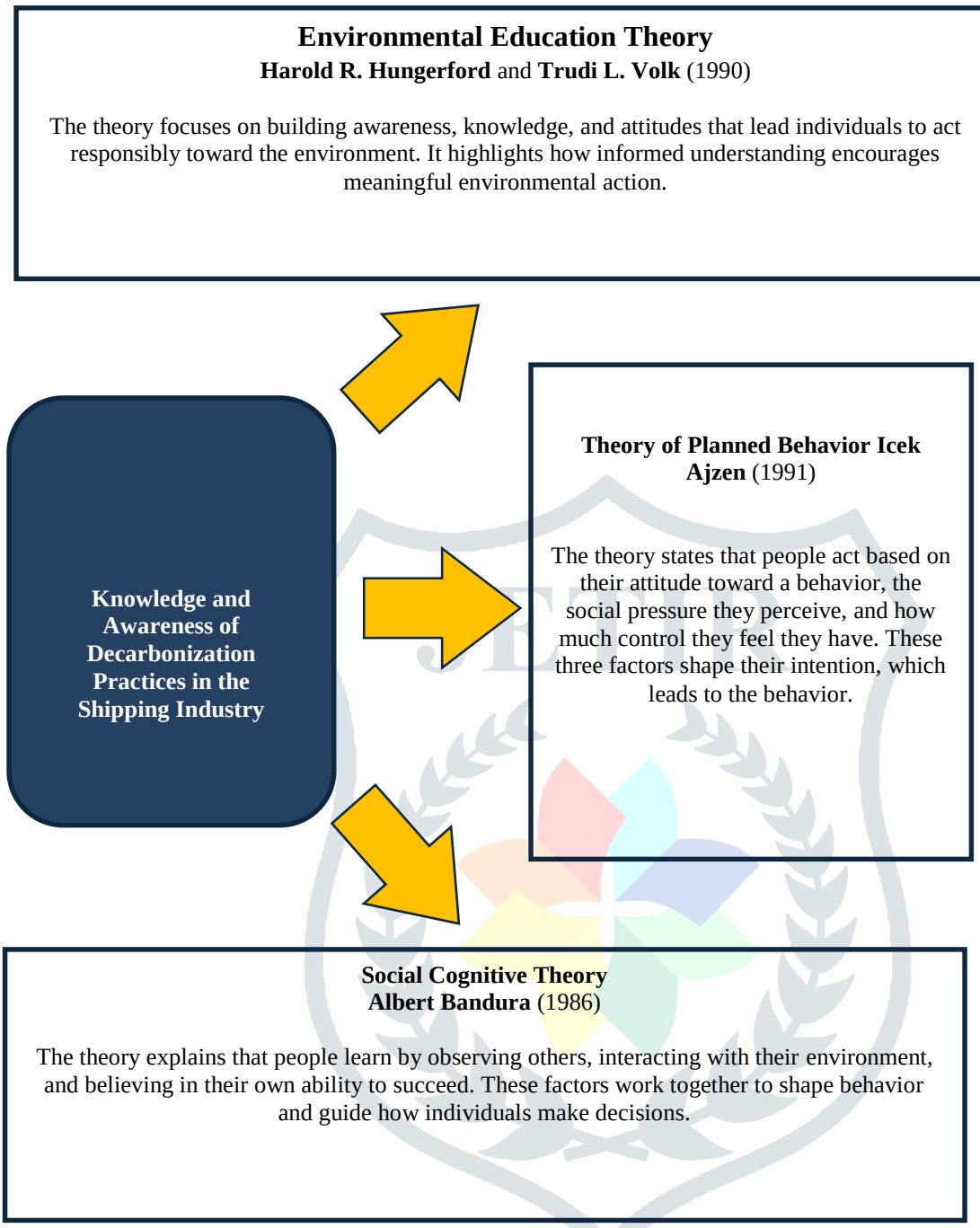
This theory offers a solid basis for evaluating the third-year maritime students' knowledge and understanding of decarbonization processes in the shipping sector when this framework is applied to the study. In this context, knowledge refers to understanding the ideas of decarbonization, whereas awareness refers to realizing the significance of sustainable maritime operations. By evaluating these two factors, the study hopes to learn more about the students' attitudes toward adopting greener practices after they are on board, as well as their cognitive abilities regarding decarbonization. As a result, the framework aids in the study's assessment of these students' readiness to engage in sustainable behaviors while onboard.

b. Theory of Planned Behavior (Ajzen, 1991)

According to Ajzen's (1991) Theory of Planned Behavior, a person's intentions—which are influenced by things like attitudes, subjective norms, and perceived behavioral control—have a significant impact on their conduct. According to his hypothesis, conduct, and their confidence in their ability to carry it out all influence whether or not they will actually follow through. It supports the idea that information alone is insufficient to motivate action, much as the preceding thesis. Additionally, attitudes and the environment should have an equally significant role in behavior.

The idea aids in explaining how the students' awareness and understanding of decarbonization affect their readiness to carry out sustainable operations on board. Students who understand the significance of decarbonization are more likely to develop a good attitude and readiness to use these methods. This demonstrates confidence in their ability to boost the likelihood of green practice, as well as the support of teachers, families, classmates, and the school environment.

Figure 1. Schematic Diagram of the Theoretical Framework



c. Social Cognitive Theory

Albert Bandura's Social Cognitive theory, which was put forth in 1986, emphasizes that social interactions, behavior modeling, and observation of others can all contribute to the acquisition of knowledge and skills, and not just direct experience. According to this theory, learning is influenced by both an individual's cognitive processes and their surroundings. This includes interpretation of information, decision-making, and application of what they have learned. Also, self-efficacy, which is necessary to carry out a certain action, can be built through interaction and observation.

When applied to the current study, this hypothesis implies that students' cognitive capacities and the learning environment have an impact on their knowledge and awareness of decarbonization. In order for students to readily model the behavior and take part in practical activities and simulation tasks that promote green practices, it is necessary for them to observe this from their instructors, peers, or the school environment.

3. Conceptual Framework

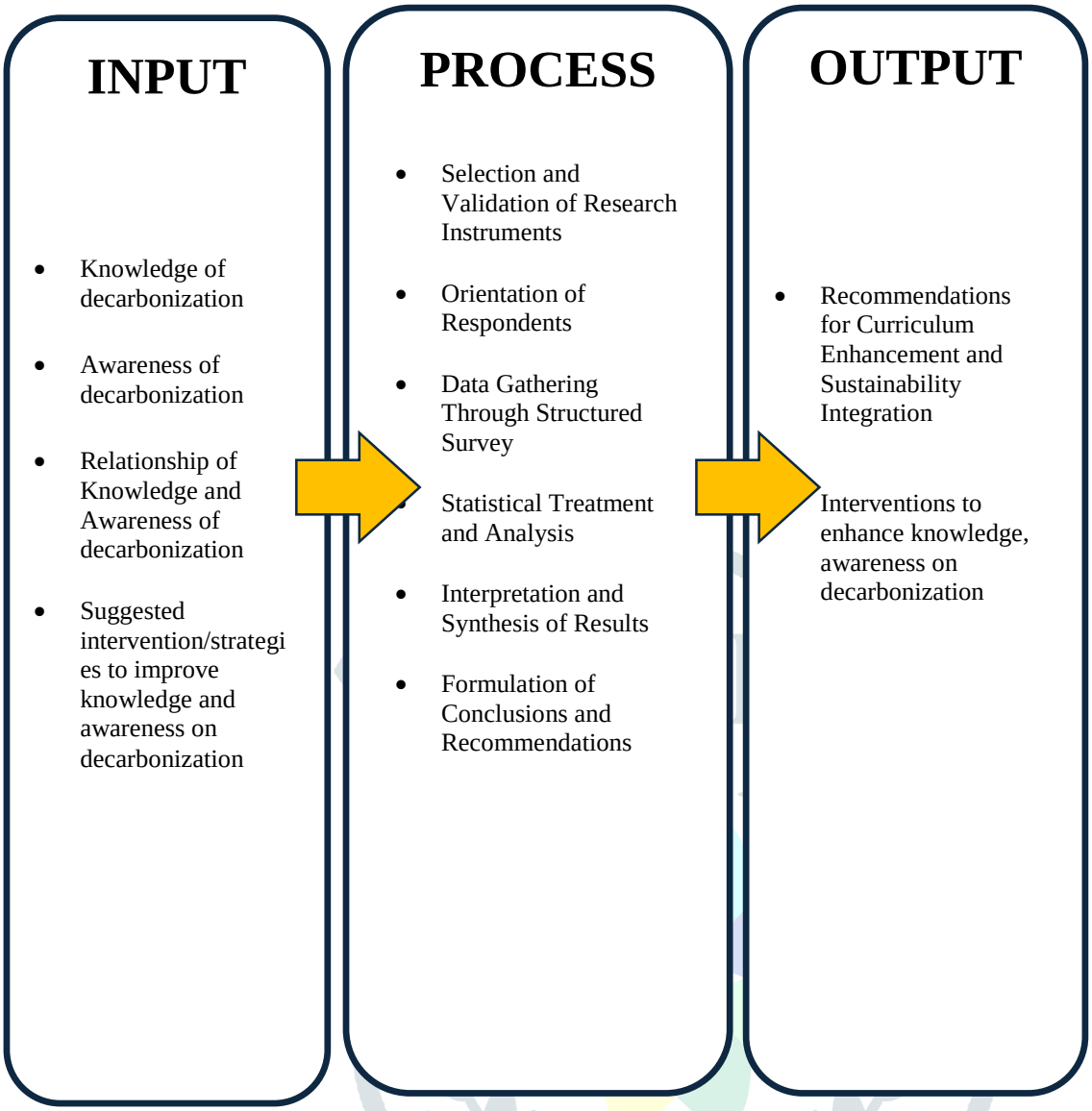
The conceptual framework of the study runs through the Input-Process-Output (IPO) Model to better understand how the study will be carried out.

The input includes the study's first variable, knowledge of decarbonization, which represents comprehension of the ideas, tenets, and real-world applications of decarbonization in the shipping sector, especially the methods to lower greenhouse gas emissions. This section also includes the study's second variable, awareness, which represents the understanding of the significance of sustainability and the environment in the maritime sector. In addition to evaluating these two distinct variables, this study includes a third variable which will look at how they relate to one another to see if having more knowledge about decarbonization equates to having a high awareness of decarbonization-related issues. The fourth variable is suggested interventions or strategies to improve knowledge and awareness of decarbonization**,** which includes proposed educational, institutional, and industry-based measures that may enhance understanding and awareness of decarbonization.

Meanwhile, the systematic process is shown in the next box to ensure the validity and reliability of the study. The first step involved choosing and validating research instruments to make sure the survey instruments are suitable and able to collect data on participants' awareness and knowledge of decarbonization. The goal, methods, and expectations of the study will then be explained to the respondents during orientation. After that, a structured survey will be used to collect data, which will make it possible to collect responses in an orderly and uniform manner. To find trends, connections, and patterns between the variables, the gathered data will be statistically processed and analyzed. To provide significant insights into the participants' knowledge, awareness, and preparedness for decarbonization techniques, the data will then be analyzed and combined. Ultimately, conclusions will be derived from the data, and suggestions will be developed to direct curricular improvements, encourage the integration of sustainability, and support efficient maritime management techniques.

The framework will finally result in the study's anticipated outputs, which include recommendations for curriculum enhancement and sustainability integration of sustainable practices in maritime education, as well as interventions, or methods to improve decarbonization knowledge and awareness, like focused learning modules, workshops, or even hands-on activities. By using these results, the study hopes to raise students' present level of decarbonization knowledge and awareness and enable them to successfully use these tactics in maritime operations by the time they enter the workforce.

Figure 2. Conceptual Framework of the Study



4. Methdology

This Chapter includes Research Design, Research Method, Participants/Respondents/Research Instruments, Data Gathering Procedure, and Statistical Treatment.

Research Design

The study utilized a descriptive and correlational design to assess the level of knowledge and awareness of third-year maritime students of MPCF-Canaman on decarbonization practices in the shipping industry. To address the research issues on the degree of knowledge and awareness, the study chose to employ a descriptive approach. This design is deemed suitable since it will attempt to quantify and describe methodically what the students already know and how aware they are of maritime decarbonization.

Additionally, a correlational design was used in the study to statistically ascertain whether the maritime students' knowledge and awareness of decarbonization are significantly correlated. This method is seen to be appropriate since the researcher wants to gauge how much one variable influence another without changing them or determining if they act independently.

The study is purely quantitative in nature; the findings generated from descriptive and correlational analyses aim to produce a strategy or intervention aimed at increasing the current level of knowledge and awareness among third-year maritime students of MPCF-Canaman regarding decarbonization practices. With this integrated approach, the study not only quantifies the two mentioned variables but rather it intends to result in recommendations that will help the students participate in more sustainable practices as professional and competent seafarers in the future.

Research Method

This study utilizes a quantitative research method to obtain objective, measurable, and statistically analyzable data. Quantitative methods are suitable for determining patterns, relationships, and levels of understanding among respondents.

By employing a Multiple-Choice Knowledge Test and a Likert-scale survey instrument, the researcher can quantify maritime students' knowledge and awareness regarding decarbonization practices involving methanol, ammonia, hydrogen, and LNG-powered ships. The method focuses on numerical data collection and analysis to identify trends, make comparisons between the two academic programs, and test the study's hypotheses using appropriate statistical tools.

Respondents

Slovin's formula is used to calculate the required sample size (n) given the population size (N = 683) and the margin of error (e = 0.1), as follows:

$$n = N/(1 + Ne^2)$$
$$= 683/ (1 + 683 \times 0.1^2)$$
$$n = 87 \text{ students}$$

The sample size was determined using Slovin's formula with a 10% margin of error, which is appropriate for descriptive and exploratory research designs that aim to identify general patterns and establish baseline information within the population. Considering practical constraints such as class schedules and voluntary participation, a total of 90 respondents was selected. To ensure balanced representation between academic programs, the respondents comprised of 45 Bachelor of Science in Marine Transportation (BSMT) students and 45 Bachelor of Science in Marine Engineering (BSMARE) students, all randomly selected. Although Slovin's formula yielded an estimated sample size of 87, the sample was adjusted to 90 to maintain feasibility while preserving descriptive validity. The respondents are third-year maritime students enrolled at Mariners' Polytechnic Colleges Foundation of Canaman, Camarines Sur, during the second semester of Academic Year 2025–2026.

These respondents were chosen as they are in their final academic semester before completing their classroom component instruction and prior to embarking as cadets for shipboard training. Their level of knowledge and awareness is therefore vital in assessing their readiness to apply decarbonization practices in actual maritime operations. Students from both programs have already taken the subject MARENV – Protection of the Marine Environment, which covers MARPOL Annex VI and is mandated under the current curriculum. Within this subject, decarbonization is partially discussed as part of the International Maritime Organization's efforts to reduce greenhouse gas emissions from ships.

Research Instruments

The initial tool, the Multiple-Choice Knowledge Test was used to identify the Level of Knowledge of the respondents on Decarbonization Practices. It is made up of 30 items within five key areas specifically: (a) the basics of maritime decarbonization, (b) methanol as an alternative fuel, (c) LNG as an alternative fuel, (d) ammonia as an alternative fuel, and (e) hydrogen as an alternative fuel. It is a tool that assessed the students in terms of skills and knowledge of technological data concerning international regulations, clean-fuel technologies, greenhouse gases reduction measures, and energy-efficiency mechanisms. The instrument allows giving a quantifiable and objective measure of the cognitive knowledge about decarbonization among the students as it uses structured, objectively scored items.

The second tool, the Likert-Scale Awareness Survey Questionnaire, is designed to determine the Level of Awareness on Decarbonization Practices among the respondents in the maritime operations. This instrument has statements that are spread over various specific areas of themes, such as the awareness of global decarbonization plans, environmental effects, and sustainability objectives, operational and institutional practices, and industry employment trends. The rating of the respondents takes a four-point Likert scale that starts with 1 (Not Aware) and ends with 4 (Strongly Aware). This scale is used to evaluate the level of awareness of the perceptual and attitudinal level of students regarding the importance, consequences, as well as relevance of decarbonization in the maritime industry.

The third tool solicited suggested interventions and/or strategies from third year maritime students that can be developed to improve the students' current level of knowledge and awareness on decarbonization.

Further on, the full questionnaire will start with a Respondents Profile section, which will collect demographic information, including program, age, gender, semester, and previous experience in seminars or training in the area of decarbonization. This fact allows putting the analysis into perspective, as it determines whether the level of awareness or knowledge is different based on individual or scholastic attributes.

To establish the validity of the survey instrument, three experts evaluated the instrument using the Survey Instrument Validation Rating Scale developed by Good and Scates (1972). The panel of validators consisted of one maritime subject-matter expert and two research experts from the general education field.

To determine the consistency of the test instrument, a pilot test to provide the reliability coefficient was conducted among 30 Third year maritime students to assess the reliability of the items using Cronbach's alpha coefficient. The results will establish whether the data collection instrument yields stable and reliable measurements. The 30 students in the pilot testing will not be part of the 87 students for the data gathering procedure involving the study sample.

The results of the pilot test indicate a reliability coefficient of 0.74 for the multiple-choice test, which is interpreted as acceptable. This suggests that the 30-item multiple-choice test is a dependable instrument for determining the level of knowledge.

Furthermore, the reliability analysis for the awareness scale yielded a coefficient of 0.836, which is interpreted as high internal consistency. This reflects strong consistency among the scale items and confirms that the instrument reliably measures the intended construct, particularly in determining the level of awareness.

Data Gathering Procedure

The data gathering process are presented in the following stages:

a. Preparation and Approval Phase

- A formal letter of request was submitted to the VPAA, the Dean of Maritime Studies, and the Program Chairs of Marine Engineering and Marine Transportation, and approval to conduct the study was subsequently secured.
- Once approved, coordination with faculty advisors and class instructors was made to schedule the administration of the questionnaire.

b. Instrument Preparation

- The survey questionnaire were prepared, validated, and reproduced for distribution.
- Respondents were informed about the purpose of the study and assured of confidentiality and voluntary participation.

c. Data Collection

- The questionnaires were administered personally by the researcher during class hours to ensure maximum response rate.
- Respondents were given ample time to complete the survey. Clarifications were allowed only for instructions, not for content.

d. Retrieval and Organization of Data

- Completed questionnaires were collected immediately after completion.
- The data were tallied, coded, and organized using spreadsheet software to prepare for statistical analysis.

e. Post-Collection Phase

- Data were checked for completeness and consistency.
- Statistical analyses were performed, and results were interpreted according to the research questions and hypotheses.

Data Analysis

To address the research questions stated in this study, the following statistical tools will be used:

a. Frequency, Percentage, Mean, and Standard Deviation were utilized to analyze data for Research Question 1, which seeks to determine the level of knowledge of third-year maritime students on decarbonization practices. These descriptive statistics summarizes students' responses and describe their overall knowledge level based on the results of the multiple-choice test.
b. Frequency, Percentage, Mean, and Standard Deviation were used for Research Question 2, which examined the students' level of awareness on decarbonization practices. These measures described the distribution of responses and determine their general level of awareness as indicated through the Likert-scale survey.
c. Pearson Product-Moment Correlation Coefficient (r) was used to analyze the research Question 3, which investigates the relationship between students' level of knowledge and their level of awareness. This correlation test determined whether increases or decreases in the student's level of knowledge is associated with changes in the student's level of awareness on decarbonization in the shipping industry.
d. The significance of the relationship was determined using the p-value associated with the computed Pearson correlation coefficient at the 0.05 level of significance. The research hypothesis stating that there is a significant relationship between students' level of knowledge and their level of awareness will be supported if the computed p-value is less than the set level of significance.
e. Frequency was also used for research question 4, which solicit suggested interventions and/or strategies from third year maritime students that can be developed to improve the students' current level of knowledge and awareness on decarbonization.

The results derived from these statistical treatments serves as the basis for formulating appropriate interventions aimed at improving the students' knowledge and awareness of decarbonization practices in the maritime industry.

5. Results and Discussions

This Chapter is a presentation of the descriptive and inferential data obtained for this research. Four parts make up the presentation: (1) Level of knowledge on Decarbonization Practices, (2) Level of awareness on Decarbonization Practices, (3) Relationship between Level of Knowledge and Level of Awareness, and (4) Suggested Interventions to improve Knowledge and Awareness.

Level of knowledge on Decarbonization Practices

This section presents the level of knowledge of third-year maritime students regarding decarbonization practices in the shipping industry, based on the Multiple-Choice Knowledge Test. The analysis covers the following areas: Fundamental concepts, Methanol as an alternative fuel, LNG as an alternative fuel, Ammonia as an alternative fuel, Hydrogen as an alternative fuel. The data results are shown in Table 1a.

Table 1a

Level of Knowledge of Maritime Students on Decarbonization Practices in the Shipping Industry

Domains	Items	Mean	SD	Knowledge Level (%)	Interpretation	Rank
Fundamental Concepts	10	7.26	1.86	72.56	Fair	1
Hydrogen as Alternative Fuel	5	3.36	0.98	67.11	Poor	2
Liquefied Natural Gas (LNG) as an Alternative Fuel	5	2.70	1.18	54.00	Poor	3

Note: SD refers to Standard Deviation, and Interpretation refers to the description of knowledge level which is based on the following: 96 to 100 is Excellent (E); (0 to 95 is Outstanding (O); 85 to 89 is Very Good (VG); 80 to 84 is Good (G); 70 to 79 is Fair (F); and 0 to 69 is Poor (P)

Methanol as Alternative Fuel	5	2.67	1.11	53.33	Poor	4
Ammonia as Alternative Fuel	5	2.63	0.95	52.67	Poor	5
Overall	**30**	**18.61**	**3.61**	**62.04**	**Poor**	

The overall results in Table 1a indicates an overall Poor level of knowledge on decarbonization practices among maritime students, with an overall mean of 18.61 corresponding to a knowledge level of 62.04%. A standard deviation of 3.61 describes that the responses of the maritime students were heterogeneously distributed, indicating variation in knowledge levels among respondents. This finding implies that while some students demonstrate moderate understanding of decarbonization concepts, a considerable number exhibit limited knowledge, reflecting an uneven grasp of the subject matter among students.

The fundamental concepts domain obtained the highest-level knowledge of 72.56%, with a mean score of 7.26 interpreted as Fair. This indicates that although they have better understanding on the fundamental concepts, the "Fair" interpretation suggests that knowledge remain limited and not yet comprehensive. For the Hydrogen as alternative fuel ranked second, this domain recorded a knowledge level of 67.11%**,** with a mean score of 3.36, interpreted as Poor**.** Although categorized as poor, hydrogen as alternative fuel shows a relatively higher understanding among students compared to other alternative fuel technologies. The Liquified Natural Gas (LNG) domain ranked third with a knowledge level of 54.00%**,** a mean score of 2.70, interpreted as Poor**.** The result suggests that despite its established use in the maritime industry as transitional fuel, the students still lack or have limited knowledge about LNG as an alternative fuel. Methanol ranked fourth with a knowledge level of 53.33%**,** a mean score of 2.67**,** interpreted as Poor. The results indicate the students are largely unfamiliar with methanol as an emerging alternative fuel in shipping. Ammonia is the lowest-ranked domain. It obtained a knowledge level of 52.67%**,** a mean score of 2.63, interpreted as Poor**.** This finding reveals that ammonia is the least understood among the alternative fuels considered, despite its potential significance as a zero-carbon fuel in future maritime applications.

The findings of the study indicate that maritime students possess an overall low level of knowledge on decarbonization practices, with relatively better performance in fundamental concepts and weaker knowledge in technical and operational domains. This pattern is consistent with existing literature, which reports that students generally understand the importance and general principles of decarbonization but lack deeper technical competence in emerging maritime technologies and regulatory mechanisms (IMO, 2023; ICS & DNV, 2022). Statistically, the higher mean score in the Fundamental Concepts domain suggests that students have greater familiarity with general environmental and decarbonization principles. This supports previous studies showing that maritime education effectively communicates high-level sustainability goals but provides limited exposure to applied and fuel-specific knowledge (DNV, 2022; UNCTAD, 2023). In contrast, lower mean scores in domains related to alternative fuels, regulatory frameworks, and technological applications indicate insufficient understanding of complex decarbonization systems, aligning with findings that students struggle with technical aspects such as EEXI, CII, SEEMP, and emerging fuel technologies (Zhang et al., 2025; Machaj et al., 2022).

The standard deviations further describe the variability of students' responses across domains. The fundamental concepts domain recorded the highest standard deviation of 1.86, indicating a wider spread of scores and considerable variation in knowledge. In contrast, hydrogen as an alternative fuel showed a lower standard deviation of 0.98, reflecting more consistent responses despite generally low knowledge levels. The Liquefied Natural Gas (LNG) domain had a standard deviation of 1.18, indicating moderate variability, while methanol showed a similar pattern with a standard deviation of 1.11, suggesting fairly consistent yet varied understanding. Ammonia obtained the lowest standard deviation of 0.95, indicating relatively homogeneous responses, albeit consistently low, reinforcing its position as the least understood domain. The observed variability suggests heterogeneous knowledge levels among students, supporting the findings of Dewan et al.

(2024), who identified gaps between perceived and actual knowledge; this variation may be attributed to differences in curriculum coverage, institutional resources, and access to practical training.

Overall, the results empirically validate prior research indicating a persistent gap between conceptual understanding and technical competence in maritime decarbonization. The findings reinforce the need for curriculum enhancement, integration of emerging fuel technologies, and increased experiential learning to strengthen students' preparedness for the evolving demands of a decarbonized shipping industry.

Level of awareness on Decarbonization Practices

This section presents the level of awareness of the respondents regarding decarbonization practices based on the 4-point Likert-scale survey instrument. The results, including the overall level of awareness and the different aspects of awareness are presented in the following tables: Table 2a Global decarbonization efforts; Table 2b Environmental impact and sustainability goals; Table 2c Operational and Institutional practices; Table 2d Industry and employment trends; and, Table 2e summary of Level of Awareness of Maritime Students on Decarbonization Practices in the Shipping Industry.

Awareness of Global Decarbonization Practices
Table 2a

Level of Awareness of Maritime Students on Decarbonization Practices in the Shipping Industry in terms of Global Decarbonization Efforts

Indicators	WM	Interpretation	Rank
Decarbonization has become a major concern in shipping operations.	2.89	Aware	1
Global shipping is transitioning to green technologies.	2.76	Aware	2
Global shipping companies are investing in research and development for low-carbon technologies.	2.74	Aware	3
International collaborations promote zero-emission ships.	2.59	Aware	4
Ongoing projects are developing methanol- and LNG-powered ships.	2.46	Slightly Aware	5
Average WM	**2.69**	**Aware**	

Note: The WM refers to Weighted Mean and Interpretation refers to the description of weighted mean based on 1.00 to 1.75 as Not Aware, 1.76 to 2.50 as Slightly Aware, 2.51 to 3.25 as Aware, and 3.26 to 4.00 as Highly Aware.

The findings indicate that third-year maritime students generally demonstrate awareness of global decarbonization efforts, as reflected by an overall weighted mean of 2.69. Awareness that decarbonization has become a major concern in shipping operations is particularly strong, with a weighted mean of 2.89, highlighting students' recognition of the issue's significance within the industry. Recognition of the global shipping sector's transition to green technologies is evident, with a weighted mean of 2.76, suggesting students acknowledge the move toward environmentally friendly innovations. Students also show awareness that international shipping companies invest in research and development for low-carbon technologies, as indicated by a weighted mean of 2.74. Moderate recognition is observed regarding international collaborations promoting zero-emission ships, with a weighted mean of 2.59. Awareness of ongoing projects developing methanol- and LNG-powered ships is lower, with weighted means of 2.46, interpreted as Slightly Aware, reflecting comparatively limited familiarity with specific alternative fuel vessel developments.

Overall, these results show that while students possess general knowledge of broad global decarbonization initiatives, their awareness varies across specific aspects, with stronger understanding of the sector's environmental and operational concerns than of particular technological developments in alternative fuel vessels.

Awareness of Environmental Impact and Sustainability Goals
Table 2b

Level of Awareness of Maritime Students on Decarbonization Practices in the Shipping Industry in terms of Environmental Impact and Sustainability Goals

Indicators	WM	Interpretation	Rank
Reducing ship emissions minimizes the maritime industry's contribution to global warming.	3.11	Aware	1
Research and innovation are important for maritime sustainability.	3.04	Aware	2
Shipowners are adopting eco-friendly designs to comply with MARPOL 73/78.	3.03	Aware	3
Decarbonization contributes to sustainable marine ecosystems.	2.86	Aware	4
Decarbonization helps achieve the Paris Agreement targets.	2.44	Slightly Aware	5
Average WM	**2.90**	**Aware**	

Note: The WM refers to Weighted Mean and Interpretation refers to the description of the weighted mean based on 1.00 to 1.75 as Not Aware, 1.76 to 2.50 as Slightly Aware, 2.51 to 3.25 as Aware, and 3.26 to 4.00 as Highly Aware.

The findings indicate that third-year maritime students demonstrate strong awareness of the environmental impact and sustainability goals associated with decarbonization, as reflected by an overall weighted mean of 2.90. The highest-rated item shows that reducing ship emissions minimizes the maritime industry's contribution to global warming, with a weighted mean of 3.11 and an interpretation of Aware, highlighting students' recognition of the connection between emission reduction and climate change mitigation.

Students also show awareness of the role of research and innovation in promoting maritime sustainability, with a weighted mean of 3.04 and an Aware interpretation, suggesting recognition of technological progress as a factor in environmental performance. Awareness extends to regulatory practices, as seen in the adoption of eco-friendly ship designs to comply with MARPOL 73/78, which yielded a weighted mean of 3.03 and an Aware interpretation, indicating familiarity with industry standards and compliance requirements. The ecological benefits of decarbonization are also acknowledged, with a weighted mean of 2.86 and an Aware interpretation, reflecting understanding of decarbonization's contributions to marine ecosystems.

However, awareness of the link between decarbonization efforts and international climate commitments is comparatively lower, with a weighted mean of 2.44 and a Slightly Aware interpretation. Overall, the results suggest that while students have strong awareness of operational and environmental aspects of decarbonization, their understanding of global policy frameworks is less pronounced.

Awareness on Operational and Institutional Practices

Table 2c

Level of Awareness of Maritime Students on Decarbonization Practices in the Shipping Industry in terms of Operational and Institutional Practices

Indicators	WM	Interpretation	Rank
Environmental policies implemented by maritime schools are in place.	2.93	Aware	1
Cadets must understand green ship operations before deployment.	2.90	Aware	2
Shipboard procedures to reduce carbon emissions are implemented.	2.88	Aware	3
Training centers conduct courses related to alternative fuels.	2.86	Aware	4
The maritime curriculum includes topics related to decarbonization.	2.70	Aware	5
Average WM	**2.85**	**Aware**	

Note: The WM refers to Weighted Mean and Interpretation refers to the description of the weighted mean based on 1.00 to 1.75 as Not Aware, 1.76 to 2.50 as Slightly Aware, 2.51 to 3.25 as Aware, and 3.26 to 4.00 as Highly Aware.

The results indicate that third-year maritime students demonstrate a broad level of awareness of operational and institutional practices related to decarbonization, with an overall weighted mean of 2.85. The highest awareness is observed in the recognition of environmental policies in maritime schools (WM = 2.93), suggesting that institutional sustainability efforts are visible and acknowledged. Awareness that cadets must understand green ship operations prior to deployment is also strong (WM = 2.90), reflecting students' recognition of emerging industry expectations and the need for continued pre-deployment preparation.

Students likewise acknowledge shipboard procedures aimed at reducing carbon emissions (WM = 2.88), indicating familiarity with operational sustainability measures. Awareness of the availability of training centers offering alternative fuel courses (WM = 2.86) further suggests that students recognize opportunities for specialized competency development. However, awareness of the formal inclusion of decarbonization topics within the maritime curriculum is comparatively lower (WM = 2.70), implying that curricular integration may not be as explicit or consistently emphasized.

While students show strong awareness of institutional policies and operational expectations, the relatively lower perception of curricular integration highlights the need for clearer alignment between sustainability initiatives and academic instruction.

Awareness on Industry and Employment Trends

Table 2d

Level of Awareness of Maritime Students on Decarbonization Practices in the Shipping Industry in terms of Industry and Employment Trends

Indicators	WM	Interpretation	Rank
Decarbonization influences promotion and career advancement opportunities in shipping companies.	2.89	Aware	1
Maritime employers are investing in upskilling the workforce for energy-efficient vessel operations.	2.87	Aware	2
Knowledge of green shipping practices is becoming an advantage in maritime employment.	2.82	Aware	3
Future seafarers are expected to handle low-carbon and alternative-fuel technologies on board.	2.79	Aware	4
Global shipping companies hire personnel trained in decarbonization.	2.66	Aware	5
Average WM	**2.80**	**Aware**	

Note: The WM refers to. Weighted Mean and and Interpretation refers to the description of the weighted mean based on 1.00 to 1.75 as Not Aware, 1.76 to 2.50 as Slightly Aware, 2.51 to 3.25 as Aware, and 3.26 to 4.00 as Highly Aware.

The results indicate that third-year maritime students demonstrate an overall awareness of industry and employment trends related to decarbonization, as reflected by an average weighted mean of 2.80, interpreted as *Aware*. This suggests that students generally recognize the evolving demands of the shipping industry in response to sustainability initiatives.

The highest-rated indicator shows that students are aware that decarbonization influences promotion and career advancement opportunities in shipping companies (WM = 2.89). This implies that students understand the professional value of sustainability competence, which may encourage greater motivation to acquire green skills and certifications.

Awareness that maritime employers are investing in upskilling the workforce for energy-efficient vessel operations (WM = 2.87) further indicates recognition of industry-wide efforts to adapt to environmental standards. Students also acknowledge that knowledge of green shipping practices is becoming an advantage in maritime employment (WM = 2.82), suggesting that sustainability literacy is increasingly perceived as a competitive asset.

The expectation that future seafarers must handle low-carbon and alternative-fuel technologies onboard (WM = 2.79) reflects awareness of emerging operational responsibilities. Continued inclusion of alternative fuel systems and emissions-reduction technologies in coursework and simulations may further enhance readiness.

The lowest-rated indicator, though still within the “Aware” range, relates to the hiring of personnel trained in decarbonization by global shipping companies (WM = 2.66). This comparatively lower perception may indicate limited exposure to actual industry hiring trends, highlighting the value of industry briefings, labor market discussions, and collaboration with shipping companies to provide clearer insights into recruitment practices.

The findings suggest that while students are aware of the growing importance of decarbonization in shaping employment and career trajectories, sustained industry-academe linkage and clearer integration of labor market realities into instruction may further strengthen this awareness.

Summary of Level of Awareness

Table 2e

Summary of Level of Awareness of Maritime Students on Decarbonization Practices in the Shipping Industry

Aspects	Average WM	Interpretation	Rank
Environmental Impact and Sustainability Goals	2.90	Aware	1
Operational and Institutional Practices	2.85	Aware	2
Industry and Employment Trends	2.80	Aware	3
Global Decarbonization Efforts	2.69	Aware	4
`Overall Level	**2.81**	**Aware**	

Note: The WM refers to Weighted Mean and Interpretation refers to the description of the weighted mean based on 1.00 to 1.75 as Not Aware, 1.76 to 2.50 as Slightly Aware, 2.51 to 3.25 as Aware, and 3.26 to 4.00 as Highly Aware.

Overall, all aspects fall within the descriptive range of 2.51–3.25 and were interpreted as "Aware." These results show that while students generally possess a positive and adequate level of awareness of decarbonization practices, the depth of their awareness varies across different dimensions, with stronger emphasis on environmental and operational aspects than on global policy and industry-wide initiatives.

The results indicate that maritime students exhibit an overall level of awareness of decarbonization practices, with an overall weighted mean of 2.81, interpreted as "Aware." This finding is consistent with prior studies reporting that maritime students generally demonstrate moderate awareness of sustainability and environmental issues, though such awareness is often conceptual rather than technical (IMO, 2023; UNCTAD, 2023; DNV, 2022).

Among the domains, Environmental Impact and Sustainability Goals obtained the highest mean (WM = 2.90), followed by Operational and Institutional Practices (WM = 2.85) and Industry and Employment Trends (WM = 2.80). These results support the literature indicating that students are more aware of environmental implications and institutional expectations than of technical or regulatory aspects of decarbonization. In contrast, Global Decarbonization Efforts registered the lowest mean (WM = 2.69), suggesting comparatively limited awareness of global initiatives and emerging fuel technologies, which aligns with previous findings that students have weaker awareness of specific international strategies and technological developments (ICS & DNV, 2022; Global Maritime Forum, 2023).

Overall, the pattern of results confirms the literature's assertion that maritime students' awareness is uneven—stronger in environmental and conceptual domains and weaker in global, technical, and technological dimensions. These findings highlight the need for educational interventions that strengthen students' awareness of international policies and emerging maritime technologies to complement their existing environmental awareness.

Relationship between Level of Knowledge and Level of Awareness

To determine the relationship between the level of knowledge and level of awareness of maritime students regarding decarbonization practices in the shipping industry, the Pearson Product–Moment Correlation Coefficient (Pearson's r) was employed. This statistical test was used to measure the strength and direction of the linear relationship between the two continuous variables. The level of significance was set at 0.05.

Table 3 presents the computed correlation coefficient on the relationship between level of knowledge and level of awareness of the maritime students, and its interpretation

Table 3

Relationship between Level of Knowledge and Level of Awareness of the Maritime Students on Decarbonization Practices in Shipping Industry

Knowledge Domains	Awareness Aspects	r-value	Interpretation	p-value
Fundamental Concepts	Global Decarbonization Efforts	0.805*	HC	0.006
	Environmental Impact and Sustainability Goals	0.189*	VLC	0.004
	Operational and Institutional Practices	0.508*	MC	0.005
	Industry and Employment Trends	0.520*	MC	0.026
Methanol as Alternative Fuel	Global Decarbonization Efforts	0.304*	LC	0.005
	Environmental Impact and Sustainability Goals	0.601*	MC	0.007
	Operational and Institutional Practices	0.147*	VLC	0.016
	Industry and Employment Trends	0.460*	LC	0.006
Liquefied Natural Gas (LNG) as an Alternative Fuel	Global Decarbonization Efforts	0.130*	VLC	0.022
	Environmental Impact and Sustainability Goals	0.140*	VLC	0.006
	Operational and Institutional Practices	0.517*	MC	0.009
	Industry and Employment Trends	0.819*	HC	0.001
Ammonia as Alternative Fuel	Global Decarbonization Efforts	0.121*	VLC	0.026
	Environmental Impact and Sustainability Goals	0.210*	VLC	0.043
	Operational and Institutional Practices	0.820*	HC	0.044
	Industry and Employment Trends	-0.110*	VLC	0.021
Hydrogen as Alternative Fuel	Global Decarbonization Efforts	0.310*	LC	<.001
	Environmental Impact and Sustainability Goals	0.660*	MC	0.037
	Operational and Institutional Practices	0.120*	VLC	0.010
	Industry and Employment Trends	-0.240*	VLC	0.020
	Overall	**0.415**	**Low Correlation**	**0.012**

Note. The r-value interpretation is based on the following 0.90 to 0.99 as Very High Correlation (VHC); 0.70 to 0.89 as High Correlation (HC); 0.50 to 0.69 as Moderate Correlation (MC); 0.30 to 0.49 as Low Correlation (LC); and 0.01 to 0.29 as Very Low Correlation (VLC). While the p-value is interpreted as Significant when < 0.05. An asterisk (*) on the r-value is interpreted as significant.

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Fundamental Concepts and Awareness Aspects

For Fundamental Concepts, a High Correlation (HC) was found with Global Decarbonization Efforts ($r = 0.805$, $p = 0.006$), indicating that stronger foundational knowledge is strongly associated with greater awareness of global maritime decarbonization initiatives.

Moderate correlations (MC) were observed with Operational and Institutional Practices ($r = 0.508$, $p = 0.005$) and Industry and Employment Trends ($r = 0.520$, $p = 0.026$), suggesting that a solid grasp of basic principles contributes meaningfully to awareness of operational policies and career-related developments in the industry.

However, only a Very Low Correlation (VLC) was found with Environmental Impact and Sustainability Goals ($r = 0.189$, $p = 0.004$). This implies that awareness of sustainability goals may not rely heavily on technical fundamentals alone and could be influenced by broader environmental exposure or general information sources.

Strengthening fundamental concepts significantly enhances awareness, particularly regarding global initiatives and institutional practices.

Methanol as an Alternative Fuel and Awareness Aspects

For Methanol as an Alternative Fuel, a Moderate Correlation (MC) was found with Environmental Impact and Sustainability Goals ($r = 0.601$, $p = 0.007$), indicating that increased knowledge of methanol technology is meaningfully associated with sustainability awareness.

Low Correlations (LC) were observed with Global Decarbonization Efforts ($r = 0.304$, $p = 0.005$) and Industry and Employment Trends ($r = 0.460$, $p = 0.006$), suggesting that methanol knowledge contributes modestly to broader industry awareness.

A Very Low Correlation (VLC) with Operational and Institutional Practices ($r = 0.147$, $p = 0.016$) indicates limited alignment between technical knowledge of methanol and awareness of regulatory or institutional frameworks.

Knowledge of methanol is more closely linked to environmental sustainability awareness than to institutional or policy-related awareness.

Liquefied Natural Gas (LNG) as an Alternative Fuel and Awareness Aspects

For Liquefied Natural Gas (LNG), a High Correlation (HC) was found with Industry and Employment Trends ($r = 0.819$, $p = 0.001$), suggesting that students who understand LNG technology are strongly aware of its impact on maritime career opportunities and industry shifts.

A Moderate Correlation (MC) was observed with Operational and Institutional Practices ($r = 0.517$, $p = 0.009$), indicating a meaningful association between LNG knowledge and awareness of operational frameworks.

However, Very Low Correlations (VLC) were found with Global Decarbonization Efforts ($r = 0.130$, $p = 0.022$) and Environmental Impact and Sustainability Goals ($r = 0.140$, $p = 0.006$), suggesting limited integration of LNG knowledge with broader environmental awareness. LNG knowledge is strongly associated with industry and employment awareness but less connected to global environmental perspectives.

Ammonia as an Alternative Fuel and Awareness Aspects

For Ammonia as an Alternative Fuel, a High Correlation (HC) was found with Operational and Institutional Practices ($r = 0.820$, $p = 0.044$), indicating that understanding ammonia technology strongly relates to awareness of regulatory and operational considerations.

Very Low Correlations (VLC) were observed with Global Decarbonization Efforts (r = 0.121, p = 0.026) and Environmental Impact and Sustainability Goals (r = 0.210, p = 0.043), showing minimal association between ammonia knowledge and environmental awareness dimensions. A Very Low negative correlation (r = -0.110, p = 0.021) was found with Industry and Employment Trends, suggesting a slight inverse but weak relationship. Knowledge of ammonia appears strongly connected to operational awareness but only weakly related to environmental and employment awareness.

Hydrogen as an Alternative Fuel and Awareness Aspects

For Hydrogen as an Alternative Fuel, a Moderate Correlation (MC) was found with Environmental Impact and Sustainability Goals (r = 0.660, p = 0.037), indicating that hydrogen knowledge is meaningfully associated with sustainability awareness.

A Low Correlation (LC) with Global Decarbonization Efforts (r = 0.310, p < 0.001) suggests modest alignment with global initiatives.

Very Low Correlations (VLC) were observed with Operational and Institutional Practices (r = 0.120, p = 0.010) and Industry and Employment Trends (r = -0.240, p = 0.020), indicating limited linkage in these areas. Hydrogen knowledge is more closely tied to environmental sustainability awareness than to institutional or employment-related awareness.

Overall, The Pearson Product–Moment Correlation revealed a low positive correlation between the level of knowledge and the level of awareness of third-year maritime students on decarbonization practices (r = 0.415). The computed p-value (p = 0.012) is less than the 0.05 level of significance, indicating a statistically significant relationship between the two variables. This indicates that knowledge and awareness are positively associated, with stronger conceptual understanding corresponding to greater recognition of related practices and developments in the maritime sector.

The study revealed a low positive correlation between third-year maritime students' level of knowledge and their level of awareness of decarbonization practices (r = 0.415, p = 0.012), indicating a statistically significant relationship. This suggests that students with higher knowledge of decarbonization concepts tend to have greater awareness of global efforts, industry trends, and related career opportunities.

These findings are consistent with the literature, which shows that while students generally understand high-level decarbonization goals and environmental imperatives (IMO, 2023; UNCTAD, 2023), their technical and operational knowledge—such as fuel handling, energy efficiency measures, and alternative fuel technologies—is often incomplete (DNV, 2022; Machaj et al., 2022; Zhang et al., 2025). The positive relationship observed in this study supports prior research highlighting that knowledge enhances awareness, particularly when students are exposed to both theoretical concepts and practical applications (Nyári et al., 2024; ICS & DNV, 2022).

Overall, the results confirm that improving students' understanding of decarbonization practices can strengthen their awareness, reinforcing the need for curriculum updates, experiential learning, and competency-based assessments to prepare maritime students for a decarbonized shipping industry.

Suggested Interventions to improve Knowledge and Awareness

Table 4

Suggestions to Improve Knowledge and Awareness of Maritime Students on Decarbonization Practices

Intervention/Strategies	Frequency	Percentage	Rank
Seminars or lectures on maritime decarbonization	75	83.33	1
Educational videos or documentaries on climate change and shipping	58	64.44	2
Shipboard exposure or industry immersion on green technologies	49	54.44	3

Case studies on IMO, MARPOL, and GHG strategies	40	44.44	4
Use of simulation software for emissions reduction	37	41.11	5
Research projects or papers on decarbonization	36	40.00	6
Guest speakers from shipping companies	35	38.89	7
Webinars or online courses on green shipping	29	32.22	8
Inter-school forums or conferences on sustainable shipping	26	28.89	9
Posters, infographics, or IEC materials on campus	25	27.78	10

The results reveal a clear hierarchy in the strategies preferred by maritime students to enhance their knowledge and awareness of decarbonization practices. Structured and instructor-led learning emerges as the most favored approach, with seminars and lectures on maritime decarbonization receiving the highest level of support (f = 75; 83.33%). This strong preference suggests that students value organized, formal instruction delivered by knowledgeable facilitators, indicating the importance of systematically integrating decarbonization topics into core maritime courses. Educational videos and documentaries ranked second (f = 58; 64.44%), reflecting students' appreciation for visual and illustrative materials that help clarify complex environmental and technical concepts. The inclusion of multimedia resources in classroom instruction may therefore enhance comprehension and engagement.

Shipboard exposure or industry immersion (f = 49; 54.44%) ranked third, demonstrating students' recognition of the value of experiential learning. Exposure to real-world vessel operations and emerging green technologies may strengthen practical understanding and bridge the gap between theoretical knowledge and industry application. Case studies on IMO, MARPOL, and GHG strategies (f = 40; 44.44%) also received substantial support, highlighting students' awareness of the importance of regulatory compliance and international environmental standards. Integrating regulatory analysis and problem-based discussions into relevant subjects may further reinforce this understanding.

Simulation software for emissions reduction (f = 37; 41.11%) and research projects on decarbonization (f = 36; 40.00%) show moderate preference, suggesting that students recognize the value of technology-based and academic approaches, particularly when guided effectively. Meanwhile, guest speakers (f = 35; 38.89%) and webinars (f = 29; 32.22%) are considered relevant but less preferred, possibly indicating a need for greater interactivity in such activities. Inter-school forums (f = 26; 28.89%) and IEC materials on campus (f = 25; 27.78%) ranked lowest, implying that passive dissemination strategies alone may not sufficiently enhance technical knowledge.

Overall, the findings indicate that maritime students tend to favor structured, visually supported, and experiential learning approaches. These preferences provide a clear direction for designing targeted academic and training initiatives aimed at strengthening students' knowledge and awareness of decarbonization practices within maritime education.

The study shows that maritime students prefer structured, instructor-led learning such as seminars and lectures, followed by visual materials and shipboard exposure, to enhance their knowledge and awareness of decarbonization practices. These preferences align with literature emphasizing that effective learning requires a combination of curriculum integration, competency-based instruction, simulation tools, and experiential industry engagement (DNV, 2022; Gan et al., 2022; UNCTAD, 2023). Awareness-building activities, including case studies, documentaries, and sustainability forums, are particularly effective when structured and interactive, reflecting the students' expressed priorities (ICS & DNV, 2022; Nyári et al., 2024). Overall, the findings support the literature's call for a multi-level, integrated approach to equip maritime students with both the knowledge and practical awareness needed for decarbonized shipping operations.

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