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MARITIME STUDENTS' PERCEPTIONS ON THE INTEGRATION OF COMPUTATIONAL INTELLIGENCE AND MATHEMATICS SKILLS IN THE MARITIME MANAGEMENT CURRICULUM

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Abstract

This study investigated maritime students' perceptions on the integration of computational intelligence and mathematics skills in the Maritime Management curriculum at Zamboanga Peninsula Polytechnic State University, Zamboanga City, Philippines. Using a quantitative descriptive design, data were collected from first-year to third-year Maritime Management students through a Likert-scale survey and analyzed using mean and standard deviation. Results showed that students perceived both computational intelligence and mathematics skills as very essential in their maritime education. They recognized computational intelligence as important for improving decision-making and operational efficiency, while mathematics was viewed as a foundational skill supporting data analysis, modeling, and optimization in maritime applications.The study concludes that maritime students strongly support the integration of computational intelligence and mathematics in the curriculum, highlighting their relevance to future maritime careers in a technology-driven industry.

Keywords*:* computational intelligence, mathematics skills, maritime management, curriculum integration, student perceptions

Introduction

As digital technologies, automation, and computational intelligence become essential components of maritime operations, the maritime industry is undergoing a significant shift. In order to enhance navigation, logistics, risk management, and operational efficiency in maritime environments, computational intelligence (CI), which encompasses artificial intelligence, machine learning, data analytics, and intelligent decision-support systems, has been used more and more (Zio, 2018; Munim et al., 2020). Maritime education institutions are required to provide future professionals with the information and skills needed to function in technologically advanced workplaces as shipping businesses and maritime organizations use cutting-edge technologies to improve sustainability and competitiveness. As a result, incorporating computational intelligence into maritime education has emerged as a strategic goal for equipping graduates to handle new difficulties in the maritime industry.

The increasing significance of computational intelligence in assisting maritime management operations and decision-making processes has been highlighted by academics worldwide. These days, intelligent systems are utilized extensively for safety monitoring, vessel traffic

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management, route optimization, and predictive maintenance, all of which need for strong analytical and computational skills (Munim et al., 2020). Because it supports the algorithms, statistical analysis, modeling, and optimization methods that power computational intelligence systems, mathematics plays a fundamental role in these applications (Bishop, 2006). According to educational scholars, mathematics is a crucial part of technology-oriented curricula because students with good mathematical abilities are better equipped to comprehend and use cutting-edge technical tools in professional contexts (National Research Council, 2001).

Maintaining the Philippines' status as one of the world's top providers of marine professionals depends heavily on maritime education. The worldwide Maritime Organization and the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers have created worldwide standards that the nation's maritime higher education institutions are constantly urged to conform to. The challenge for Philippine maritime colleges is to incorporate computational intelligence and related quantitative competencies into their curricula as the marine industry embraces digitalization and smart technologies. Despite the fact that mathematics has historically been taught in maritime education programs, little is known about how students view its value in assisting with computational intelligence applications in marine management. Understanding these perceptions is important because students' attitudes toward emerging technologies can influence their learning engagement, competency development, and readiness for future employment.

There are still a lot of unanswered questions despite the expanding corpus of work on artificial intelligence and maritime technology. Previous research has mostly concentrated on artificial intelligence applications in maritime industries, autonomous shipping systems, operational efficiency, and technological advancements (Zio, 2018; Munim et al., 2020). The educational aspect of computational intelligence, especially from the viewpoint of marine students, has, however, been the subject of comparatively few studies. Additionally, there is still a dearth of study on how mathematics proficiency is thought to support the use of computational intelligence in marine management courses. In the Philippine context, where there are few empirical studies examining students' preparedness for technologically driven marine employment, this disparity is particularly noticeable. To improve curricula and design educational policies, it is imperative to close this gap.

This study is important since it looks at how marine students view the curriculum's integration of mathematical and computational intelligence. For curriculum designers, teachers, academic administrators, and legislators looking to update maritime education in response to Industry 4.0 and digital transformation programs, the results may offer insightful information. Additionally, by examining a neglected topic at the nexus of mathematical proficiency, computational intelligence, and maritime education, the study adds to the body of existing work. The study may serve as a foundation for creating more adaptable courses that prepare future maritime professionals for an increasingly data-driven and technologically

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advanced maritime business by assessing students' perceptions and acknowledging the significance they attach to these competencies.

Research Questions

1. How do maritime students perceive the integration of computational intelligence concepts in the Maritime Management curriculum?
2. How do maritime students perceive the role of mathematics skills in supporting the application of computational intelligence in maritime management practices?

Scope and Delimitation of the Study

This study looked at how maritime students perceived about the curriculum's integration of math and computational intelligence. First-, second-, and third-year students studying maritime management at Zamboanga Peninsula Polytechnic State University in Zamboanga City, Philippines, made up the respondents.
Students' perceptions of the significance of computational intelligence ideas and the contribution of mathematical abilities to marine management techniques were the main focus of the study. A survey questionnaire was used to collect the data. Students' real competencies, academic performance, or the efficacy of particular teaching strategies were not evaluated in the study. Additionally, the results may not apply to other maritime programs or institutions because they were restricted to ZPPSU respondents.

Review of Related Literature

Maritime Curriculum in the Philippines

Maritime education in the Philippines has long been recognized as a major contributor to the global shipping workforce, supplying a significant proportion of officers and seafarers worldwide. Internationally aligned standards, particularly the Standards of Training, Certification and Watchkeeping for Seafarers (International Maritime Organization and International Convention on Standards of Training, Certification and Watchkeeping for Seafarers), have strongly influenced the design of maritime curricula in Philippine higher education institutions. Studies in international journals emphasize that compliance with STCW requirements has driven Philippine maritime schools to adopt competency-based training, simulator-based instruction, and outcome-based education to ensure global employability of graduates (Dimailig & Jeong, 2010; Bayotas, 2024).

Research indicates that Philippine maritime curricula are structured to meet both academic and technical competencies, including navigation, seamanship, marine engineering, and maritime management. However, literature also highlights persistent concerns regarding curriculum modernization and alignment with emerging maritime industry demands. A comparative study between Korea and the Philippines noted differences in curriculum delivery, with Philippine programs often criticized for being less integrated and more traditional in instructional design compared to other maritime nations (Dimailig & Jeong, 2010). More recent studies further emphasize that despite compliance with international

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standards, there remains a need to enhance curriculum responsiveness to technological advancements such as digital navigation systems, automation, and intelligent maritime operations (Pasigna, 2025).

In addition, internationally published studies on Philippine maritime education highlight the increasing importance of simulation-based training and digital learning technologies. Research shows that engine room simulators, learning management systems, and AI-assisted instruction are being gradually integrated into maritime institutions in the Philippines to improve competency development and operational readiness (Apor, 2025; Mobo, 2020). These innovations reflect a shift toward more experiential and technology-enhanced learning environments, consistent with global maritime education trends. However, the adoption of such technologies remains uneven across institutions due to limitations in infrastructure, faculty training, and resource availability.

Despite these developments, research consistently identifies gaps in the Philippine maritime curriculum, particularly in terms of curriculum modernization, digital integration, and alignment with Industry 4.0 requirements. Studies suggest that while the Philippines maintains strong compliance with international maritime standards, challenges persist in ensuring that graduates are fully prepared for data-driven and technologically advanced maritime environments (Pasigna, 2025; Bayotas, 2024). These gaps highlight the need for continuous curriculum review and enhancement, especially in integrating computational intelligence, mathematics applications, and advanced maritime technologies to sustain global competitiveness.

The Integration of Computational Intelligence Concepts in the Maritime Management Curriculum

As the marine sector depends more and more on automation, advanced analytics, and data-driven decision-making, computational intelligence (CI) has grown to be an important part of contemporary systems. International research has shown that CI methods such evolutionary algorithms, fuzzy logic systems, and artificial neural networks are frequently used in logistics optimization, maritime navigation, and vessel traffic management (Zio, 2018; Munim et al., 2020). By facilitating predictive skills and adaptive decision-making in challenging maritime conditions, these technologies improve operational efficiency. In order to prepare students for technologically sophisticated maritime operations, maritime education is progressively moving toward incorporating computational intelligence principles into its curriculum. In order to produce future-ready workers in engineering and transportation-related professions, it has been highlighted that computational intelligence must be incorporated into higher education curricula.

Bishop (2006) asserts that comprehending intelligent systems—which are becoming more and more prevalent in industrial applications—requires a solid grasp of statistical modeling and machine learning. Computational intelligence facilitates risk assessment, predictive maintenance of vessels, and intelligent routing in marine environments. These tasks

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necessitate interdisciplinary expertise combining computer science, mathematics, and maritime operations (Munim et al., 2020). This shows that in order to assure relevance to industry expectations, curriculum restructuring that incorporates CI concepts into marine management education is necessary.

The integration of developing technology into training and competency development is also supported by international frameworks for marine education. With regard to e-navigation and smart shipping efforts in particular, the International marine Organization (IMO) has acknowledged the significance of digital competences in marine safety and operational efficiency. Research indicates that incorporating computational intelligence into maritime education improves students' capacity for critical analysis, problem-solving, and technological innovation adaptation (Zio, 2018). Graduates will be able to fulfill international marine requirements and adapt to technology changes thanks to this congruence between academic instruction and industry practices.

Numerous studies show that, despite the acknowledged advantages of computational intelligence in marine applications, its incorporation into maritime education is still unequal across institutions. Many maritime schools still place a strong emphasis on traditional navigation and operational training, with little exposure to cutting-edge computational techniques, according to research published in international publications (Munim et al., 2020). This disparity emphasizes the necessity for additional curriculum development in order to methodically integrate CI ideas.

To close the gap between academic preparation and the changing needs of the global maritime industry, it is crucial to strengthen the integration of computational intelligence in maritime management education.

The research and implementation of computational intelligence (CI) heavily relies on mathematics, especially in fields that call for intricate modeling, prediction, and optimization. Studies that have been published internationally highlight how CI methods like machine learning, neural networks, and evolutionary algorithms have their roots in mathematical ideas like probability theory, calculus, linear algebra, and statistics (Bishop, 2006; Goodfellow et al., 2016). These mathematical structures allow algorithms to perform crucial tasks in intelligent maritime systems, including as learning from data, spotting trends, and producing predicting outputs. Without strong mathematical foundations, the interpretation and effective use of CI tools become significantly limited.

Mathematics is essential to data analysis, modeling, and decision-making procedures in maritime management methods that promote operational effectiveness and safety. According to studies, mathematical modeling is frequently employed in risk assessment, fuel consumption prediction, cargo optimization, and vessel routing (Munim et al., 2020). For precise forecasting and effective resource allocation, these applications mostly rely on quantitative reasoning and statistical analysis. The practical application of computational

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intelligence tools in real-world maritime contexts is made possible by mathematics, which acts as a bridge as maritime operations grow more data-driven.

Additionally, studies published in international publications demonstrate how the combination of computational intelligence and mathematics improves analytical and problem-solving skills in complicated systems. Goodfellow et al. (2016) state that deep learning models necessitate a solid grasp of matrix operations and gradient-based optimization, two crucial mathematical procedures. These skills enable professionals to test predictive models, evaluate algorithmic outputs, and make well-informed operational decisions in marine situations. Therefore, mathematics guarantees the correct implementation of CI in marine management techniques in addition to supporting its development. Despite the acknowledged value of mathematics, a number of studies show that students frequently find it difficult to apply mathematical ideas in technologically sophisticated settings. According to research, students may do well in procedural mathematics, but they might not have the conceptual knowledge needed for computational applications like modeling and algorithm interpretation (Bishop, 2006; Munim et al., 2020). This gap highlights the need to strengthen mathematical instruction within maritime education to better support computational intelligence integration. Enhancing mathematical competence is therefore essential to fully realize the benefits of CI in maritime management.

Theoretical Framework

Operations Research (OR) theory and stochastic decision theory, which offer a mathematical basis for examining intricate decision-making processes in uncertain situations, serve as the framework for this investigation. Operations research is a scientific method that uses quantitative analysis, optimization strategies, and mathematical modeling to facilitate effective decision-making in complex systems (Ahuja, Magnanti, & Orlin, 1993). OR is frequently used in marine management to address issues with scheduling, resource allocation, routing, and logistics optimization. These applications show how mathematical frameworks are crucial for enhancing strategic planning and operational effectiveness in maritime settings.

By addressing decision-making under uncertainty, a feature that distinguishes marine operations, stochastic decision theory enhances OR.

Unpredictable elements including weather, port traffic, changes in fuel prices, and navigational hazards all have an impact on maritime settings. When outcomes are unclear, stochastic models use statistical techniques and probability distributions to help make the best decisions (Powell, 2011). This study uses stochastic decision theory to describe how mathematical knowledge helps maritime students comprehend risk, uncertainty, and variability—all of which are essential to contemporary maritime management techniques backed by computer intelligence systems.

Because computational intelligence (CI) systems frequently rely on optimization algorithms, predictive analytics, and probabilistic modeling, the integration of CI into marine

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management is highly compatible with both OR and stochastic decision theory. These systems are made to process vast amounts of nautical data and produce judgments that are either optimal or nearly ideal in real time.

Psaraftis (2019) asserts that the development of intelligent maritime systems that improve operational safety, route planning, and fuel efficiency depends heavily on mathematical optimization and simulation models. Therefore, computational intelligence improves decision-making in marine management by acting as a sophisticated technical extension of conventional OR techniques. When combined, OR and stochastic decision theory offer a thorough framework for comprehending how mathematics supports computational intelligence in marine management procedures. In maritime systems, modeling, prediction, optimization, and risk analysis are all made possible by mathematics. Strong mathematical abilities are crucial for maritime students because they enable the efficient comprehension and use of computational intelligence tools in resolving actual maritime issues, according to this theoretical framework.

Methodology

This study employed a quantitative descriptive research design to examine maritime students' perceptions regarding the integration of computational intelligence and mathematics skills in the Maritime Management curriculum. The descriptive design was deemed appropriate as it allows for the systematic collection and analysis of data to describe existing conditions and perceptions without manipulating variables. This approach is commonly used in educational research where the objective is to assess attitudes, perceptions, and conceptual understanding of respondents.The respondents of the study were Maritime Management students from Zamboanga Peninsula Polytechnic State University, Zamboanga City, Philippines. The participants included first-year, second-year, and third-year students who were officially enrolled during the academic year of the study. A stratified sampling technique was used to ensure proportional representation across year levels, allowing for a more balanced and reliable interpretation of student perceptions across different stages of academic progression.

The primary research instrument used in the study was a structured survey questionnaire. The instrument was designed to measure two main variables: (1) students' perceptions of the integration of computational intelligence concepts in the Maritime Management curriculum, and (2) students' perceptions of the role of mathematics skills in supporting computational intelligence applications in maritime management practices. The questionnaire consisted of Likert-scale items ranging from 1 (Not Essential) to 5 (Very Essential). Prior to full data collection, the instrument was validated by experts in maritime education and educational research to ensure content validity and clarity of items.

Data collection was conducted after securing the necessary approvals from the relevant academic authorities. The questionnaires were distributed to the selected respondents, and participation was voluntary. Responses were collected, encoded, and statistically analyzed using descriptive statistics, specifically mean and standard deviation, to determine the level of

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perception of the respondents. The results were interpreted using a five-point Likert scale to classify responses from “Not Essential” to “Very Essential,” providing a clear basis for interpretation and discussion of findings.

Results and Discussions

Research Question 1: How do maritime students perceive the integration of computational intelligence concepts in the Maritime Management curriculum?

Table 1 shows that the respondents rated all indicators within the Very Essential category, with means ranging from 4.58 to 4.73. The highest-rated indicator was *"Computational intelligence helps students adapt to technological advancements in the maritime industry"* (M = 4.73, SD = 0.47), followed by *"Knowledge of artificial intelligence is relevant to future maritime careers"* (M = 4.71, SD = 0.49). The overall mean score of 4.66 indicates that maritime students strongly perceive the integration of computational intelligence concepts as highly important and beneficial to their academic preparation and future professional practice in the maritime sector. These findings suggest that students recognize the growing significance of intelligent technologies in maritime management and support their inclusion in the curriculum.

The findings revealed that maritime students perceived the integration of computational intelligence concepts in the Maritime Management curriculum as very essential. Students realized that computational intelligence improves their ability to think critically, make decisions, and solve problems—all of which are essential qualities for contemporary marine operations. They felt that understanding technology like automated systems, artificial intelligence, predictive analytics, and data-driven decision-making would better equip them to meet the changing needs of the maritime sector. Additionally, the students viewed computational intelligence as a useful tool for enhancing resource optimization, voyage planning, safety management, and operational efficiency. Overall, the respondents strongly supported the inclusion of computational intelligence principles in the curriculum since they saw it as pertinent to both the digital transformation of the marine industry and their future work responsibilities.

Table 1. Maritime Students' Perceptions on the Integration of Computational Intelligence Concepts in the Maritime Management Curriculum (n = 150)

Indicators	Mean	SD	Interpretation
Computational intelligence enhances maritime decision-making skills.	4.62	0.56	Very Essential
Computational intelligence improves problem-solving abilities in maritime operations.	4.58	0.61	Very Essential
Knowledge of artificial intelligence is relevant to future maritime careers.	4.71	0.49	Very Essential

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Computational intelligence supports efficient vessel and resource management.	4.65	0.54	Very Essential
The curriculum should include more computational intelligence-related topics.	4.69	0.52	Very Essential
Computational intelligence helps students adapt to technological advancements in the maritime industry.	4.73	0.47	Very Essential
Overall Mean	**4.66**	**0.53**	**Very Essential**

4.21 – 5.00 = Very Essential, 3.41 – 4.20 = Essential, 2.61 – 3.40 = Moderately Essential, 1.81 – 2.60 = Slightly Essential, 1.00 – 1.80 = Not Essential

Research Question 2: How do maritime students perceive the role of mathematics skills in supporting the application of computational intelligence in maritime management practices?

Table 2 reveals that all indicators received ratings within the Very Essential category, with mean scores ranging from 4.65 to 4.76. The highest-rated indicator was *"Mathematics is necessary for understanding algorithms used in computational intelligence"* (M = 4.76, SD = 0.44), followed by *"Mathematics provides the foundation for understanding computational intelligence concepts"* (M = 4.74, SD = 0.46). The overall mean of 4.70 demonstrates that maritime students strongly recognize the indispensable role of mathematics in facilitating the effective application of computational intelligence in maritime management. These findings suggest that students perceive mathematical competence as a key factor in preparing future maritime professionals to utilize emerging intelligent technologies, analyze complex data, and contribute to efficient and safe maritime operations.

The findings indicated that maritime students perceived mathematics skills as very essential in supporting the application of computational intelligence in maritime management practices. The respondents agreed that the fundamental knowledge required to comprehend algorithms, data analysis, predictive modeling, optimization approaches, and intelligent decision-support systems employed in contemporary marine operations is provided by mathematical competencies. Students claimed that being proficient in mathematics improved their capacity to assess risks, make evidence-based judgments, analyze complex operational data, and improve navigation planning. They also realized that mathematics is a crucial part of their professional education since computational intelligence is largely dependent on mathematical concepts. In general, the students believed that proficiency in mathematics was a necessary precondition for using computational intelligence technology in the maritime sector.

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Table 2. Maritime Students' Perceptions of the Role of Mathematics Skills in Supporting the Application of Computational Intelligence in Maritime Management Practices (n = 150)

Indicators	Mean	SD	Interpretation
Mathematics provides the foundation for understanding computational intelligence concepts.	4.74	0.46	Very Essential
Mathematical skills help in analyzing maritime operational data.	4.68	0.52	Very Essential
Mathematics enhances problem-solving abilities needed for intelligent maritime systems.	4.65	0.57	Very Essential
Mathematical knowledge supports predictive analysis and decision-making in maritime management.	4.71	0.49	Very Essential
Mathematics is necessary for understanding algorithms used in computational intelligence.	4.76	0.44	Very Essential
Strong mathematics skills improve the effective use of intelligent technologies in maritime operations.	4.69	0.50	Very Essential
Mathematics contributes to risk assessment and operational optimization in maritime management.	4.67	0.55	Very Essential
Overall Mean	**4.70**	**0.50**	**Very Essential**

4.21 – 5.00 = Very Essential; 3.41 – 4.20 = Essential; 2.61 – 3.40 = Moderately Essential; 1.81 – 2.60 = Slightly Essential; 1.00 – 1.80 = Not Essential

Conclusion

This study examined maritime students' perceptions on the integration of computational intelligence and mathematics skills in the Maritime Management curriculum at Zamboanga Peninsula Polytechnic State University. Based on the findings, maritime students perceived both computational intelligence concepts and mathematics skills as very essential in their academic preparation and future maritime careers. The findings show that students understand the value of computational intelligence in improving operational effectiveness, problem-solving skills, and decision-making in marine management. Similarly, mathematics was seen as a basic ability that facilitates the comprehension and use of computational intelligence, especially in the processes of data analysis, modeling, prediction, and optimization. The study's overall findings indicate that, in response to the growing technological needs of the marine sector, students significantly value the inclusion of mathematics and computational intelligence in their curricula.

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Recommendations

Based on the findings and conclusions of the study, the following recommendations are proposed:

1. Through specific courses, modules, or practical learning exercises like simulations and data-driven case studies, maritime education institutions, especially ZPPSU, may improve the incorporation of computational intelligence principles into the Maritime Management curriculum.
2. The practical applications of mathematics in computational intelligence, such as statistical analysis, optimization, and predictive modeling, should be highlighted in mathematics education in marine programs.
3. Teachers are encouraged to use technology-enhanced teaching methods that use computational intelligence technologies to relate mathematical ideas to actual nautical situations.
4. To guarantee that graduates have the necessary digital and analytical skills, curriculum designers and academic administrators should take into account ongoing curriculum revision and conformity with international marine and technical standards.
5. To confirm and broaden the results of this study and investigate additional variables affecting students' preparedness for computational intelligence integration, future researchers may carry out similar studies with larger populations or several maritime institutions.

References

[1] Ahuja, R. K., Magnanti, T. L., & Orlin, J. B. (1993). *Network Flows: Theory, Algorithms, and Applications*. Prentice Hall.

[2] Apor, M. D. (2025). The role of engine room simulators in strengthening applied maritime education. *International Journal of Applied Mathematics*.

[3] Bayotas, M. T. M. (2024). BoK-STCW-TRB Triumvirate course mapping for learning outcome matrix of BS Marine Engineering program. *International Association of Maritime Universities Conference Proceedings*.

[4] Bishop, C. M. (2006). *Pattern Recognition and Machine Learning*. New York: Springer.

[5] Dimailig, O., & Jeong, J.-Y. (2010). Comparative review of maritime transportation education between Korea and the Philippines. *Journal of the Korean Society of Marine Environment and Safety*.

[6] Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.

[7] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention). (2010 Manila Amendments).

[8] International Maritime Organization (IMO). (2017). *Guidelines on Maritime Cyber Risk Management*. London: IMO.

[9] Mobo, F. D. (2020). Readiness of maritime institution’s cadets and faculty towards learning management systems. *EJONS International Journal*.

Received: Aug 15, 2025

International Journal of Applied Mathematics

Volume 38 No. 2, 2025, 378-391

ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

[10] Munim, Z. H., Dushenko, M., Jimenez, V. J., Shakil, M. H., & Imset, M. (2020). Big data and artificial intelligence in the maritime industry: A bibliometric review and future research directions. *Maritime Policy & Management, 47*(5), 577–597.

[11] National Research Council. (2001). *Adding It Up: Helping Children Learn Mathematics*. Washington, DC: National Academy Press.

[12] Pasigna, B. T. (2025). Revitalizing Philippine maritime education: A comprehensive framework for reform. *Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields*.

[13] Powell, W. B. (2011). *Approximate Dynamic Programming: Solving the curses of dimensionality*. Wiley.

[14] Psaraftis, H. N. (2019). Green maritime transportation: Models and methods. *Transportation Research Part D: Transport and Environment*.

[15] Zio, E. (2018). Challenges in the vulnerability and risk analysis of critical infrastructures. *Reliability Engineering & System Safety, 152*, 137–150.

Received: Aug 15, 2025