International Journal of Applied Mathematics

Volume 38 No. 1, 2025

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

ENHANCING MARITIME MATHEMATICS EDUCATION THROUGH MATHEMATICAL AND COMPUTATIONAL FRAMEWORKS: STUDENTS' PERCEPTIONS OF ENGAGEMENT AND LEARNING OUTCOMES

Lilia B. Bayos

Ph.D Zamboanga Peninsula Polytechnic State University

Zamboanga City

Abstract

This study looked into the influence of the Mathematical and Computational Framework on learning outcomes and student participation in maritime mathematics classes. It specifically sought to ascertain the degree to which marine students believed the framework to be beneficial and to examine its relationship to academic performance and student engagement. 150 Maritime Education students who were purposefully chosen based on their exposure to the Mathematical and Computational Framework in their math classes. The tool assessed students' perceptions of learning outcomes, their level of engagement, and the effectiveness of the framework. The effectiveness level was described using descriptive statistics, such as weighted mean and standard deviation. The results showed that respondents consistently evaluated the Mathematical and Computational Framework highly and thought it was highly effective. The approach greatly increased students' interest and improved their learning outcomes in maritime mathematics, according to additional results. By connecting mathematical ideas to practical marine applications like navigation and engineering calculations, the combination of computational and contextualized mathematical problems enabled students to strengthen their analytical thinking, problem-solving abilities, and conceptual comprehension. The study concludes that the Mathematical and Computational Framework is an effective instructional approach that promotes meaningful learning, active engagement, and improved academic performance in maritime mathematics education.

Keywords: maritime mathematics education, mathematical frameworks, computational frameworks, student engagement, learning outcomes

INTRODUCTION

To be able to adequately prepare students for the technological and analytical needs of the global maritime industry, it is becoming more and more crucial to incorporate mathematical and computational frameworks into maritime education. Navigation, ship stability, engineering operations, and data-based decision-making all depend heavily on mathematics, and computational methods help students develop their critical thinking and problem-solving abilities. According to recent research (Geron et al., 2024; Novitasari et al., 2024), maritime institutions are progressively implementing computational tools, simulation technologies, and mathematical literacy programs to improve cadets' competences and professional preparation. Additionally, the increasing use of digital technologies and simulation-based learning in

Received: August 12, 2025

maritime education emphasizes the need for efficient teaching frameworks that support students' theoretical comprehension as well as their practical application.

Learning outcomes and student engagement are seen as crucial markers of the efficacy of education in marine programs. According to research, students' interest, engagement, and academic performance are greatly enhanced by interactive and technologically aided learning settings (Jamil & Bhuiyan, 2021). Students showed greater levels of engagement and satisfaction in maritime simulation programs when learning activities were connected to specific goals, real-world applications, and cooperative experiences. According to Astriawati et al. (2025), marine cadets' comprehension of mathematics and engagement in class were found to be improved by mobile-supported and computational learning methodologies. These results imply that, when successfully included into the maritime curriculum, mathematical and computational frameworks may have a favorable impact on students' educational experiences.

Despite the increasing adoption of technological and computational approaches in maritime education, limited studies have examined how students perceive the effectiveness of these frameworks in relation to their engagement and learning outcomes. There is a gap in our knowledge of students' general perceptions of the integration of mathematical and computational frameworks in the curriculum because the majority of current research focuses mostly on simulation practices and academic competencies. Therefore, the purpose of this study is to look into the effectiveness of mathematical and computational frameworks in the maritime curriculum and ascertain how they affect student engagement and learning results as perceived by the students. The results of this study may help institutions, curriculum designers, and maritime educators create more adaptable and student-centered learning approaches that meet the changing needs of maritime education and business operations.

RESEARCH QUESTIONS

1. What is the extent of the effectiveness of the Mathematical and Computational Framework in maritime mathematics classes as perceived by maritime students?
2. What is the impact of the Mathematical and Computational Framework on students' engagement and learning outcomes in maritime mathematics classes?

RELATED LITERATURE AND STUDIES

By enhancing students' critical thinking, problem-solving skills, and technical competencies, mathematical and computational frameworks significantly contribute to the improvement of maritime mathematics education. Because marine workers frequently use mathematical ideas in navigation, engineering calculations, cargo operations, and safety management, mathematical literacy is regarded as a crucial ability in maritime education. Researchers studying mathematical literacy found that mathematical proficiency enhances cadets' ability to think critically, make operational decisions, and use marine technologies efficiently (Novitasari et al., 2024). Similarly, Geron et al. (2024) discovered that students' mathematical proficiency and problem-solving abilities were greatly enhanced by incorporating structured

Volume 38 No. 1, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

mathematical development programs into maritime curricula, highlighting the significance of contextualized mathematics instruction in maritime institutions.

Recent studies also highlight the growing importance of computational and technology-supported learning approaches in maritime mathematics classes. Computational frameworks such as simulation-based learning, electronic mapping, and interactive mathematical applications have been shown to enhance student engagement and learning outcomes. Jamil and Bhuiyan (2021) emphasized that maritime simulation programs promote deep learning by allowing students to apply theoretical knowledge in realistic maritime scenarios, thereby minimizing the gap between theory and practice. In addition, Astriawati et al. (2025) reported that mobile-supported electronic mapping significantly improved cadets' learning activities and academic performance in applied mathematics courses. These findings suggest that computational approaches provide more interactive and student-centered learning experiences that contribute to better.

The increasing significance of computational and technology-supported learning strategies in nautical mathematics programs is also shown by recent studies. It has been demonstrated that computational frameworks including interactive mathematics applications, electronic mapping, and simulation-based learning improve student engagement and learning results. According to Jamil and Bhuiyan (2021), marine simulation systems minimize the gap between theory and practice by enabling students to use theoretical knowledge in realistic maritime circumstances. This promotes deep learning. Furthermore, Astriawati et al. (2025) found that cadets' learning activities and academic performance in applied mathematics courses were greatly enhanced by mobile-supported electronic mapping. These results imply that computational techniques offer more participatory and student-centered learning opportunities that help marine students comprehend and remember mathematical ideas.

Furthermore, several international studies emphasize that integrating mathematical and computational frameworks into maritime education prepares students for the increasing technological demands of the global maritime industry. Omotoso et al. (2022) noted that industrial mathematics has become increasingly relevant in maritime business and maritime education because modern maritime operations rely heavily on quantitative analysis and technological applications. Likewise, Christensen (2025) stressed that computational thinking frameworks enhance students' quantitative skills and interdisciplinary learning by promoting logical reasoning and data interpretation. The incorporation of these frameworks into maritime mathematics classes therefore contributes not only to academic achievement but also to the development of practical competencies necessary for future maritime professionals.

Despite these developments, limited studies have focused specifically on students' perceptions regarding the effectiveness of mathematical and computational frameworks in maritime mathematics classes, indicating the need for further research in this area. According to Omotoso et al. (2022), because modern maritime operations mostly depend on quantitative analysis and technical applications, industrial mathematics has grown in importance in

Received: August 12, 2025

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

maritime business and maritime education. Similarly, Christensen (2025) emphasized that through encouraging logical reasoning and data interpretation, computational thinking frameworks improve students' mathematical abilities and interdisciplinary learning. Therefore, using these frameworks in maritime mathematics programs helps students learn the practical skills needed for future maritime professionals in addition to improving academic performance. Despite these advancements, there is still a need for more study in this field because few studies have explicitly examined students' opinions about the usefulness of mathematical and computational frameworks in maritime mathematics classrooms.

Students' Engagement And Learning Outcomes In Maritime Mathematics Classes

It is often acknowledged that learning outcomes and student engagement are significant markers of academic success in mathematics education, especially in specialized programs like maritime education. Learning outcomes are the knowledge, skills, and abilities that students acquire through instruction, whereas engagement is the behavioral, emotional, and cognitive involvement of students in learning activities. Higher levels of instructional engagement have been found to boost academic achievement and have a beneficial impact on students' attitudes towards mathematics (Kyriakides et al., 2022). Because students must apply mathematical principles in navigation, ship stability, engineering calculations, and operational problem-solving, meaningful involvement and active participation are crucial in marine mathematics studies. According to another research, student-centered learning strategies can boost students' motivation, self-assurance, and comprehension of math-related topics (Konstantinidou & Kyriakides, 2022).
The effectiveness of interactive and technology-supported learning methodologies in enhancing student engagement and learning results in maritime education has been highlighted in a number of global scholarly studies. According to Astriawati et al. (2025), marine cadets' learning activities and academic performance were considerably improved when mobile-supported electronic mind mapping was used in applied mathematics classes. In the same manner, Jamil and Bhuiyan (2021) found that by enabling students to make connections between theoretical ideas and real-world marine applications, simulation-based learning environments in maritime education promoted deeper learning experiences. Additionally, it was discovered that marine transportation students' problem-solving skills and conceptual knowledge were enhanced by peer-based and collaborative learning approaches (Natividad & Natividad-Franco, 2025). These results show that creative teaching strategies can improve students' involvement, understanding, and performance in nautical math classes.

Furthermore, recent research shows a substantial correlation between students' confidence, motivation, and overall academic achievement and their participation in mathematics learning. In math classes, it has been demonstrated that multimedia-based and adaptive learning environments enhance students' self-efficacy, self-regulation, and task value (Chipangura & Aldridge, 2019). Positive learning outcomes in undergraduate mathematics

Volume 38 No. 1, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

education are greatly enhanced by instructional strategies that encourage active and collaborative learning, according to a systematic review conducted by educational psychology experts (Educational Psychology Review, 2025). Fostering engagement through efficient instructional frameworks may improve academic achievement and professional preparation in maritime education, where mathematics proficiency is essential for technical and operational responsibilities. However, limited research has specifically examined students' perceptions regarding engagement and learning outcomes in maritime mathematics classes, thereby highlighting the need for further investigation in this field.

According to Lave and Wenger's Situated Learning Theory (1991), learning is essentially a social activity that takes place through engagement in real-world activities within a community of practice. The approach highlights that real learning occurs when students work with more experienced experts on real-world activities rather than seeing knowledge as abstract and decontextualized. Learners progressively pick up both explicit information and implicit abilities embedded in professional practice as they go from marginal to full participation. This viewpoint, which emphasizes that learning is most successful when it is integrated in realistic and socially structured scenarios in which knowledge is co-constructed through interaction and shared practice, has received broad support from international educational research.

Situated Learning Theory offers a powerful explanatory framework for comprehending how students acquire mathematical and analytical skills in the context of maritime mathematics education. Students can encounter mathematics as it is used in professional marine settings through computational assignments and problem-solving exercises connected to the maritime industry that replicate real shipboard and operational contexts. Students can increase conceptual understanding and procedural fluency by integrating theoretical knowledge with practical application through guided participation and collaborative interaction. Contextualized and practice-oriented learning environments greatly improve student engagement and deepen cognitive processing by tying academic information to real-world professional demands, according to studies in maritime and simulation-based education.

Furthermore, the integration of computational exercises into the teaching of nautical mathematics supports the fundamental idea of acceptable peripheral participation, in which students gradually gain proficiency by actively engaging in progressively more challenging assignments. Through challenges that replicate real maritime operations, this technique helps students develop higher-order thinking skills, especially in analysis, problem-solving, and decision-making. By bridging the gap between theory and practice, research in vocational and maritime education repeatedly demonstrates that involvement in real, community-based learning contexts enhances both academic accomplishment and professional preparation. The idea that contextualized instructional approaches not only improve mathematics learning but also foster meaningful student engagement and the development of industry-relevant competencies is thus supported by the study's application of Situated Learning Theory.

Received: August 12, 2025

Volume 38 No. 1, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

Methodology

To enable to ascertain the efficacy of the Mathematical and Computational Framework in marine mathematics classrooms as well as its influence on students' engagement and learning outcomes as perceived by maritime students, this study used a quantitative descriptive research approach. The students' views of the framework's efficacy were evaluated using the descriptive method. 150 Maritime Education students engaged in mathematics classes using Mathematical and Computational Frameworks made up the study's respondents. Since only students who have employed the framework in their math classes were included in the study, a purposive sample technique was used to choose the participants.

A validated survey questionnaire that was developed and adapted from prior research and pertinent literature was used to collect data. The instrument was put through pilot testing to determine its reliability before the actual study was conducted. The questionnaire's internal consistency and reliability were indicated by the reliability test's Cronbach's alpha coefficient of 0.91. Items measuring student engagement, perceived learning results, and the efficacy of the Mathematical and Computational Framework were included in the survey. The effectiveness of the Mathematical and Computational Framework was assessed using descriptive statistics, including frequency count, percentage, weighted mean, and standard deviation.

Ethical Considerations

Throughout the study, ethical guidelines were closely adhered to in order to safeguard the welfare and rights of the participants. The purpose and goals of the study were explained to the respondents, and their participation was completely voluntary. Before the survey was administered, each participant's informed consent was obtained. Respondent confidentiality and anonymity were always upheld. To safeguard the participants' identities, no names or student numbers were included in the questionnaire. The information gathered was treated with the highest confidentially and used only for academic and research purposes. Respondents were also informed that they had the right to withdraw from participation at any point without any penalty or negative consequences.

Furthermore, the researchers ensured that the study adhered to the ethical standards of research involving human participants. The survey questionnaire was designed to avoid any form of psychological discomfort, coercion, or harm to the respondents. All gathered information was stored securely and was accessible only to the researchers involved in the study.

RESULTS AND DISCUSSIONS

The findings revealed that the Mathematical and Computational Framework used in maritime mathematics classes was perceived by the students as highly effective. Based on the responses of 150 maritime students, the descriptive statistics indicate that the total mean was 3.8960 with a standard deviation of 0.70396. Based to the mean score, most respondents felt that the framework improved their experiences learning mathematics. The comparatively low

Volume 38 No. 1, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

standard deviation also implies that the students' responses were tightly clustered around the mean, suggesting consistency in their opinions of the framework's efficacy. The findings suggest that including mathematical and computational methods into marine math classes improved students' comprehension of mathematical ideas, strengthened their capacity for problem-solving, and encouraged active participation during class.

In maritime education, where mathematical applications are extremely important to navigation, engineering, and operational duties, the results validate the notion that computational and technology-assisted learning frameworks offer more participatory and practical learning experiences. Because the framework made it possible for students to relate abstract mathematical ideas to practical marine applications, they might have thought it was effective.

dditionally, the respondents' favorable opinion is consistent with the results of other international studies that highlighted how teaching techniques backed by computation and technology enhance student engagement and learning outcomes in mathematics-related courses.

While Jamil and Bhuiyan (2021) discovered that technology-integrated maritime learning environments encouraged deeper understanding and active learning experiences, Astriawati et al. (2025) found that mobile-supported mathematical learning significantly improved maritime cadets' academic performance and classroom participation. As a result, the current study indicates that the Mathematical and Computational Framework is a useful teaching strategy in maritime mathematics courses and could help maritime students achieve better academic results.

Table 1.0 Perception of the Students on the Effectiveness of the Mathematical and Computational Framework Used in Maritime Mathematics Classes

Variable	**N**	**Minimum**	**Maximum**	**Sum**	**Mean**	**Std. Deviation**
Perception of the Students on the Effectiveness of the Mathematical and Computational Framework Used in Maritime Mathematics Classes	150	1.60	5.00	584.40	3.8960	0.70396

The study's findings demonstrated that students' engagement and learning outcomes in maritime mathematics classes were significantly improved by the Mathematical and Computational Framework. The derived overall mean of 3.8960, which shows a high degree of agreement among the 150 maritime students on the effectiveness of the framework, served as evidence for this. According to the results, students thought the framework helped make

Received: August 12, 2025

math classes more engaging, intelligible, and applicable to maritime applications. Students' interest and engagement in class discussions and problem-solving exercises were probably enhanced by the use of computational methods and real-world mathematical exercises.

Additionally, the outcome suggests that by improving students' analytical thinking, mathematical comprehension, and capacity to apply concepts to actual marine scenarios, the framework helped to improve learning outcomes. The replies were comparatively consistent, as indicated by the standard deviation of 0.70396, demonstrating that the majority of students had similar favorable opinions on the framework's influence. This consistency shows that the Mathematical and Computational Framework successfully enhanced students' academic engagement and mathematical progress, strengthening the finding's reliability. Overall, the statistics show that the framework was a successful teaching strategy for teaching maritime mathematics.

Table 2. Descriptive Statistics on the Impact of the Mathematical and Computational Framework on Students’ Engagement and Learning Outcomes

Variable	N	Mean	SD	Interpretation
Impact of the Mathematical and Computational Framework on Students’ Engagement and Learning Outcomes	150	3.90	0.70	High Impact

Conclusion

The study came to the conclusion that students' engagement and learning results were much improved by the application of the Mathematical and Computational Framework in nautical mathematics classes. With an overall mean of 3.8960 and a standard deviation of 0.70396, the results showed that marine students consistently thought the framework improved their educational experiences. Students were able to participate actively in class activities, develop their problem-solving abilities, and get a deeper understanding of mathematical subjects because to the integration of computational and mathematical approaches. The results also showed that technology-assisted and contextualized teaching made math classes more engaging, useful, and applicable to real-world marine scenarios including navigation, engineering calculations, and operational problem-solving.

Furthermore, the study showed that the Mathematical and Computational Framework supported better academic achievement in maritime mathematics by having a positive effect on students' analytical thinking, mathematical comprehension, and application skills. The results are consistent with experiential learning theory and constructivist learning theory, which place a strong emphasis on real-world application, practical engagement, and active participation in the learning process. The findings indicate that technology-integrated and computational learning methodologies foster deeper comprehension and greater engagement among maritime students, which is consistent with earlier international studies. As a result,

Volume 38 No. 1, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

the study revealed that the Mathematical and Computational Framework is a useful teaching strategy that enhances and improves learning outcomes in the teaching of maritime mathematics.

The Situated Learning Theory, which was developed by Jean Lave and Etienne Wenger, may potentially be used to explain the study's results. According to the notion, learning gains greater significance when it is implemented in real-world and authentic social contexts (Lave & Wenger, 1991). In this study, maritime students were able to relate mathematical ideas to real-world marine applications like navigation, engineering calculations, and operational problem-solving because to the Mathematical and Computational Framework. Because they could see how mathematics related to their future careers in the maritime industry, this contextualized approach probably improved students' participation, engagement, and comprehension. The high mean score obtained in the study further suggests that students positively perceived the framework because it promoted practical and experience-based learning rather than abstract and purely theoretical instruction.

RECOMMENDATIONS

In order to further enhance students' engagement, participation, and learning outcomes, maritime educators are encouraged by the study's findings to consistently incorporate Mathematical and Computational Frameworks into mathematics instruction. To make math classes more engaging and applicable to students' future careers, teachers may include more technology-assisted tasks, computational exercises, and real-world maritime applications. In order to improve the application of computational and contextualized learning methodologies in mathematics education, maritime institutions may also offer training courses, educational materials, and technology assistance.

To confirm and broaden the results of the current study, future researchers might carry out comparable investigations with larger populations, various maritime institutions, or other mathematics-related topics. Additional research may also explore the long-term effects of Mathematical and Computational Frameworks on academic performance, critical thinking, and professional competencies among maritime students. Experimental and mixed-method studies may likewise be conducted to obtain deeper insights into how computational learning strategies influence students’ engagement and achievement in maritime education.

REFERENCES

1. Astriawati, N., Wibowo, W., & Setiyantara, Y. (2025). Enhancing maritime cadets’ learning outcomes through mobile-supported e-mapping in basic mathematics: A classroom action research study. *Advances in Mobile Learning Educational Research,* 5(2). https://doi.org/10.25082/AMLER.2025.02.001
2. Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher,* 18(1), 32–42. https://doi.org/10.3102/0013189X018001032

Received: August 12, 2025

3. Chipangura, A. T., & Aldridge, J. (2019). Multimedia: Students' adaptive learning engagement in mathematics classrooms. *International Journal for Mathematics Teaching and Learning*, 20(2). https://doi.org/10.4256/ijmtl.v20i2.71
4. Christensen, D. (2025). Learning marine biology quantitative skills through computational thinking. *Journal of Science Education and Technology*, 63(3). https://doi.org/10.1177/07356331251316480
5. Emad, G. R. (2010). Tracing legitimate learning in formal vocational education. *Procedia Social and Behavioral Sciences*, 2(2), 959–963. https://doi.org/10.1016/j.sbspro.2010.03.134
6. Geron, G., Gonzales, A. A., & Castillo, A. (2024). Effectiveness of basic gymathics as a math development program in the maritime curriculum. *International Journal of Research Studies in Education,* 13(6), 119–134. https://doi.org/10.5861/ijrse.2024.24053
7. Jamil, M. G., & Bhuiyan, Z. (2021). Deep learning elements in maritime simulation programmes: A pedagogical exploration of learner experiences. *International Journal of Educational Technology in Higher Education,* 18(18). https://doi.org/10.1186/s41239-021-00255-0
8. Karahalil, M., Lützhöft, M., & Scanlan, J. (2023). Formative assessment in maritime simulator-based higher education. *WMU Journal of Maritime Affairs*, 22, 181–207. https://doi.org/10.1007/s13437-023-00313-6
9. Konstantinidou, E. & Kyriakides, L. (2022). Instructional engagement and student learning outcomes: Direct and indirect effects based on country-specific contingencies. *Studies in Educational Evaluation,* Volume 73. https://doi.org/10.1016/j.stueduc.2022.101144.
10. Kyriakides, L., Creemers, B. P. M., & Charalambous, E. (2022). Instructional engagement and student learning outcomes: Direct and indirect effects based on country-specific contingencies. *Studies in Educational Evaluation,* 73, 101144. https://doi.org/10.1016/j.stueduc.2022.101144
11. Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge University Press.
12. Natividad, M. D., & Natividad-Franco, V. (2025). Peer-based learning as a method of enhancing the problem-solving performance of marine transportation students. International Journal of Multidisciplinary: *Applied Business and Education Research,* 6(12). https://doi.org/10.11594/ijmaber.06.12.05
13. Novitasari, N., Agustina, E. N. S., Fachrudin, A. D., & Irfan, S. (2024). Mathematical literacy as a key competency for maritime education: Systematic review of cadet competencies. Vygotsky, 6(2), 131–140. https://doi.org/10.30736/voj.v6i2.1112

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

14. Novitasari, N., Agustina, E. N. S., Fachrudin, A. D., & Irfan, S. (2024). Mathematical literacy as a key competency for maritime education: Systematic review of cadet competencies. Vygotsky: *Jurnal Pendidikan Matematika dan Matematika*, 6(2), 131–140. https://doi.org/10.30736/voj.v6i2.1112

15. Omotoso, O. O., Dunya, T., Ndekhedehe, A. I., Amadiegwu, S. C., & Adakama, E. A. (2022). Industrial mathematics and maritime business: Emerging trends and challenges. *Journal of Research in Education and Society*, 13(1), 45–56.

16. Zhang, M., & Yang, X. (2025). A systematic review on student engagement in undergraduate mathematics: Conceptualization, measurement, and learning outcomes. *Educational Psychology Review.* https://doi.org/10.1007/s10648-025-10046-y

Received: August 12, 2025