International Journal of Applied Mathematics

Volume 38 No. 1, 2025

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

BRIDGING MARITIME EDUCATION AND INDUSTRY DEMANDS: THE ROLE OF MATHEMATICS AND DIGITAL TECHNOLOGIES IN CURRICULUM INNOVATION

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Abstract

Curriculum innovations that provide future maritime professionals with refined analytical and digital competencies are necessary due to the ongoing rapid technological transformation of the maritime industry. The study examined the role of digital technologies and mathematics in curriculum innovation as a method of connecting maritime education with industry requirements. In particular, it assessed the degree of integration of digital technologies and mathematics in the maritime curriculum in relation to the relevance of the curriculum to industry standards and the application of mathematics in maritime courses. It also explored the substantial impact of this integration on the industry preparedness of maritime students in terms of employability readiness and digital and technological proficiency. The quantitative descriptive-correlational research design was implemented in the study, which involved the administration of a structured survey questionnaire to maritime students and faculty members. The extent of curriculum integration was determined using descriptive statistics, such as the weighted mean and standard deviation, and its impact on industry preparedness was investigated using multiple linear regression analysis. A very high level of integration of mathematics and digital technologies within the maritime curriculum was presumptively disclosed by the findings. Additionally, the regression analysis demonstrated that curriculum integration had a substantial and advantageous effect on determining the digital and technological proficiency of students, as well as their employability readiness for the maritime industry. The study, which is based on the Technological Pedagogical Content Knowledge (TPACK) Theory, conclusively demonstrates that the meaningful integration of digital technologies and mathematics enhances the professional competencies of students, strengthens curriculum innovation, and improves their preparedness to meet the changing demands of the global maritime industry.

Keywords: maritime education, mathematics integration, digital technologies, curriculum innovation, industry preparedness, employability readiness, TPACK Theory

INTRODUCTION

The maritime industry has experienced significant transformation as a result of the widespread adoption of smart shipping practices, automation, digital navigation systems, and

Received: Aug 10 2025

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

rapid technological advancement. Johnson (2020) posits that these advancements have had significant effect on the competencies that are to be expected of maritime graduates, necessitating that educational institutions restructure their curricula to better align with the changing requirements of the global shipping industry. Consequently, it is anticipated that maritime education and training (MET) institutions will equip prospective seafarers with a range of competencies that extend beyond technical proficiency, such as adaptive problem-solving, digital literacy, and analytical thinking. Scholars have underscored the importance of consistent review and updating of maritime curricula to align with industry requirements and technological advancements, thereby guaranteeing that graduates are globally competitive and adhere to international standards. Mathematics continues to be a fundamental discipline in maritime education due to its role in the development of navigation, marine engineering, cargo operations, ship stability, and risk analysis. Mathematical proficiency enables maritime students to make precise decisions, address operational issues, and interpret navigational data in dynamic maritime environments.

Recent research has further underscored the close correlation between mathematical literacy and the critical thinking, quantitative reasoning, and decision-making competencies that are essential for modern seafaring. Moreover, research has demonstrated that contextualized mathematical learning is important within the maritime curriculum, as it enhances students' academic performance and problem-solving skills (Geron, Gonzales & Castillo, 2024). Additionally, Cabaron (2023) clarified that digital technologies have become essential components of modern maritime education, in addition to mathematics. The utilization of digital navigation technologies, artificial intelligence, learning management platforms, and simulation systems has revolutionized instructional practices and improved experiential learning opportunities. Research has shown that the effective implementation of technology integration by competent educators will promote learner engagement, strengthen professional competencies, and support curriculum innovation. Similarly, research conducted in the Philippine maritime education sector has demonstrated that the digital competence of maritime faculty makes a substantial contribution to educational innovation and instructional quality. The importance of integrating digital technologies with mathematics instruction to create graduates who are capable of meeting the demands of Industry 4.0 and the digital transformation of global shipping is emphasized by these developments. Nevertheless, numerous maritime institutions continue to encounter difficulties in reconciling curriculum content with the rapidly evolving industry standards, despite these advancements. Gaps between educational outcomes and workplace competencies frequently arise as a result of disparities in institutional resources, faculty preparedness, curriculum implementation, and technology integration. Consequently, it has become important to implement curriculum innovation that strategically integrates digital technologies and mathematics in order to enhance maritime education and enhance the industry readiness of graduates. It is therefore imperative to investigate the role of these two components in curriculum innovation in order to ascertain the extent to which maritime education can effectively bridge the gap between

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

the competency requirements of the contemporary maritime industry and academic preparation. The results of this study are anticipated to offer evidence-based recommendations for curriculum enhancement and to facilitate the ongoing enhancement of Maritime Education and Training programs (Karahalil, Lützhöft, & Scanlan, 2024).

RESEARCH QUESTIONS

1. What is the extent of the integration of mathematics and digital technologies in the maritime curriculum as perceived by maritime students and faculty in terms of:

a. mathematics application in maritime courses and

b. curriculum relevance to industry standards?

2. Is there a significant effect of the integration of mathematics and digital technologies in the maritime curriculum on industry preparedness of maritime students in terms of:

a. digital and technological proficiency; and

b. employability readiness for the maritime industry?

REVIEW OF RELATED LITERATURE

Integration of Mathematics and Digital Technologies in the Maritime Curriculum

Mathematics has been acknowledged as a fundamental discipline in Maritime Education and Training (MET) for a long time due to its ability to facilitate the development of essential competencies in maritime decision-making, marine engineering, navigation, ship stability, and cargo operations. Mathematics education has transitioned from emphasizing procedural computation to the development of analytical reasoning and problem-solving skills that are relevant to real-world maritime operations as the maritime industry becomes more digitalized. Geron et al. (2024) demonstrated that the Basic Gymathics Program, which contextualized mathematics instruction, substantially enhanced the mathematical proficiency and problem-solving abilities of maritime students. Their results indicate that the integration of mathematics instruction into authentic maritime contexts enhances students' preparedness for professional maritime practice. In the same context, maritime-contextualized mathematics materials have been discovered to improve higher-order thinking skills by facilitating students to solve realistic maritime problems through mathematical reasoning. These studies underscore the necessity of integrating mathematics into maritime curricula rather than teaching it as an independent topic (Geron, Gonzales & Castillo, 2024). The integration of digital technologies into maritime education has also revolutionized the delivery of curriculum and the learning experience of students. Bridge simulators, engine-room simulators, electronic navigation systems, learning management systems, virtual laboratories, and mobile learning applications are being used more frequently by contemporary maritime education and training institutions to simulate authentic shipboard environments. These technologies allow students to employ mathematical concepts in simulated maritime scenarios, thereby fostering the development of operational competence.

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Volume 38 No. 1, 2025

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

Multimodal learning analytics and simulation technologies support competency-based maritime education and improve students' decision-making processes, as explained by Harrington and Sellberg (2026). Similarly, Astriawati et al. (2025) discovered that maritime cadets' engagement and achievement in applied mathematics were significantly enhanced by mobile-supported electronic mind mapping in classroom research. This finding suggests that digital learning tools can enhance mathematical reasoning and facilitate a more profound conceptual understanding. These results suggest that technology is not merely an instructional aid; it is a critical element of maritime curriculum innovation.

Recent literature has also underscored the necessity of deliberate integration of mathematics and digital technologies in order to achieve effective curriculum innovation, as opposed to the independent implementation of either component. The maritime industry's competency requirements have been significantly altered by the growing prevalence of artificial intelligence, simulation-based instruction, data analytics, and intelligent navigation systems. As a result, graduates are now expected to possess both digital competencies and quantitative reasoning skills. Reyes (2025) underscored that the integration of AI in maritime education facilitates curriculum planning by enhancing instructional design, assessment, and learning analytics.

Additionally, he identified faculty preparedness and technological infrastructure as critical determinants of successful implementation. Additionally, Sasota et al. (2021) introduced the Will–Skill–Tool (WST) Model, which illustrates that the successful integration of technology is contingent upon the technological competence, willingness, and availability of the appropriate instructional tools of the instructors. Their results substantiate the notion that curriculum innovation necessitates institutional support, faculty development, and the integration of pedagogically meaningful technology to optimize learning outcomes. In spite of the increasing recognition of the importance of integrating digital technologies and mathematics, numerous studies have documented persistent obstacles to curriculum implementation (Reyes, 2025). The effective implementation of mathematics-enhanced maritime instruction is still being impeded by limitations in digital infrastructure, lack of faculty training, insufficient curriculum alignment, and unequal access to educational technologies. These obstacles diminish the likelihood of students acquiring the technological and analytical skills necessary for the contemporary maritime sector. Therefore, academicians advocate for curriculum reforms that strategically integrate mathematics, digital technologies, and industry-based learning experiences to prepare graduates for the increasingly automated and technology-driven maritime operations. This integration enhances the responsiveness of Maritime Education and Training institutions to global maritime standards and workforce expectations, while also supporting competency-based education.

Employability Readiness for the Maritime Industry

As the global maritime industry continues to evolve through digitalization, automation, and stricter international competency standards, employability readiness has become one of the

Received: Aug 10 2025

primary objectives of Maritime Education and Training (MET) institutions. Employment readiness is the process of acquiring the knowledge, technical competencies, professional attitudes, and transferable skills necessary for graduates to successfully transition into the workforce. Communication, collaboration, critical thinking, adaptability, leadership, and digital competence are all components of employability in the maritime sector, which goes beyond adherence to the Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) Convention. Employers are increasingly valuing graduates who exhibit a combination of technical expertise and soft skills, as emphasized by Finch et al. (2013). Yorke (2010) contends that employability is a product of knowledge, skills, personal attributes, and the ability to engage in lifelong learning. These competencies are essential in the maritime sector, as seafarers are required to operate in high-risk, multicultural, and technologically advanced environments that necessitate effective collaboration and sound judgment (Chen, Cahoon, Pateman, Bhaskar, Wang & Parsons, 2018).

The competencies necessary for employability have been substantially altered as a result of the maritime industry's ongoing digital transformation, as noted by Ghosh, Emad, and Ravi (2024). Digital literacy is a requisite employability attribute for maritime graduates, as modern ships heavily rely on electronic navigation systems, integrated bridge technologies, automation, and data-driven decision-making. In order to address the evolving nature of maritime work, Ghosh, Emad, and Ravi (2024) concluded that future revisions of the STCW Code should incorporate broader employability competencies, such as adaptability, systems thinking, digital literacy, and communication, through a systematic review of competency frameworks. In the same context, industry stakeholders identified communication, problem-solving, collaboration, self-management, adaptability, and technological competence as some of the most critical employability skills that maritime graduates are expected to possess. Employers are increasingly seeking graduates who can effectively integrate technical maritime knowledge with digital competencies and professional behaviors necessary for modern shipping operations, as evidenced by these findings.

Technology-enhanced learning and simulation-based training have also been acknowledged as substantial contributors to employability readiness in maritime education. Students are able to cultivate operational proficiency prior to entering actual shipboard service by engaging in practical exposure through bridge simulators, Electronic Chart Display and Information Systems (ECDIS), engine-room simulators, and other digital learning environments. Aguada and Abucay (2024) discovered that ECDIS technology significantly improved the confidence, navigational competence, and career readiness of maritime students, thereby illustrating that technology-based instruction contributes to the improvement of both technical performance and employability outcomes. Dela Cruz (2024) similarly asserted that graduates' employment success was positively influenced by their adherence with STCW-based instruction and their proficiency in simulator training, underscoring the significance of experiential learning in preparing students for industry demands. These studies indicate that maritime students are able to bridge the gap between classroom instruction and professional practice by

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

participating in authentic learning environments (Buot II, Florida, Octaviano, Guiaman, Daniel, Cabatingan, & Abucay, 2025).

Researchers continue to report challenges that affect the employability readiness of graduates, including curriculum-industry misalignment, unequal access to advanced technologies, and insufficient emphasis on transferable skills, despite these developments. It is imperative that MET institutions maintain partnerships with industry stakeholders and update curricula in response to the rapid emergence of autonomous shipping, cybersecurity, environmental sustainability, and digital maritime operations (Ghosh, Emad & Ravi, 2024)...Consequently, scholars suggest that competency-based curricula be implemented to guarantee that graduates maintain their competitiveness in the global maritime labor market. These curricula should incorporate technical knowledge, mathematics, digital technologies, simulator-based learning, and employability skills. It is anticipated that these curriculum innovations will enhance workforce readiness and contribute to the global maritime industry's long-term sustainability and competitiveness.

THEORETICAL FRAMEWORK

The Technological Pedagogical Content Knowledge (TPACK) Theory, which was developed by Mishra and Koehler (2006), serves as the basic basis of this investigation. The TPACK framework posits that the dynamic integration of three essential domains of teacher knowledge—Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK)—is the mechanism by which effective teaching and meaningful curriculum innovation occur. The theory emphasizes the interaction between these domains to create learning experiences that improve students' comprehension and application of knowledge, rather than perceiving them independently. Mathematics is the content knowledge required for navigation, marine engineering, ship stability, and operational decision-making in the context of maritime education. Digital technologies, including maritime simulators, Electronic Chart Display and Information Systems (ECDIS), learning management systems, and other digital learning platforms, are the technological knowledge that facilitates instructional delivery. The instructional strategies employed to incorporate mathematical concepts with digital technologies in a manner that fosters meaningful learning and competency development are referred to as the pedagogical dimension (Mishra & Koehler, 2006).

This study, which is informed by the TPACK framework, presupposes that the effective integration of digital technologies and mathematics into the maritime curriculum results in curriculum innovation that is responsive to the changing requirements of the maritime industry. The theory posits that students acquire more robust analytical reasoning, problem-solving abilities, digital competencies, and professional skills that are indispensable for contemporary maritime practice when educators effectively integrate content expertise, appropriate pedagogical approaches, and pertinent digital technologies. As a result, the investigation investigates the extent to which the integration of digital technologies and

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

mathematics into the maritime curriculum enhances the employability of maritime students by harmonizing educational practices with industry requirements. Consequently, the TPACK Theory offers a thorough theoretical framework for elucidating the connection between the development of competencies necessary for the modern maritime workforce and curriculum innovation.

METHODOLOGY

In order to ascertain the degree of integration of mathematics and digital technologies into the maritime curriculum and to investigate its effect on the industry preparedness of maritime students, this investigation implemented a quantitative descriptive-correlational research design. The descriptive component was employed to evaluate the degree of curriculum integration in terms of the application of mathematics in maritime courses and the relevance of the curriculum to industry standards. The correlational component was used to determine the substantial impact of curriculum integration on the employability readiness of students for the maritime industry and their digital and technological proficiency. Mishra and Koehler's (2006) Technological Pedagogical Content Knowledge (TPACK) Theory served as the theoretical foundation for the investigation of the correlation between curriculum integration and industry preparedness for the study.

The study's respondents were faculty members and maritime students from specific higher education institutions that provide maritime program. In order to guarantee that the participating institutions were adequately represented by both students and faculty, respondents were chosen through stratified random sampling. The researcher developed a questionnaire that was in accordance with the study's objectives and was based on a comprehensive review of relevant literature. This questionnaire was used to collect data. Two primary sections comprised the instrument: the first evaluated the degree to which the maritime curriculum integrated mathematics and digital technologies, while the second evaluated the employability readiness and digital and technological proficiency of students. The questionnaire was subjected to expert validation and pilot testing to ensure its internal consistency reliability and content validity prior to data collection.

Statistical techniques were implemented to analyze the data that was collected. The degree of integration of mathematics and digital technology in the maritime curriculum was assessed using the weighted mean and standard deviation. Multiple Linear Regression Analysis was implemented at a significance level of 0.05 to ascertain whether curriculum integration had a substantial impact on the industry preparedness of students. The regression model investigated the predictive impact of the integration of digital technology and mathematics on employability readiness and digital and technological proficiency. Throughout the study, ethical considerations were upheld by obtaining informed consent from all respondents, ensuring voluntary participation, maintaining the confidentiality and anonymity of responses, and using the collected data exclusively for academic and research purposes.

Received: Aug 10 2025

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

RESULTS AND DISCUSSION

Research Question 1: **What is the extent of the integration of mathematics and digital technologies in the maritime curriculum as perceived by maritime students and faculty in terms of mathematics application in maritime courses and curriculum relevance to industry standards?**

Table 1 Extent of the Integration of Mathematics and Digital Technologies in the Maritime Curriculum

Indicators	Mean	SD	Descriptive Rating
Mathematics application in maritime courses	4.38	0.51	Very High
Curriculum relevance to industry standards	4.29	0.56	Very High
Overall Mean	**4.34**	**0.54**	**Very High**

Scale

4.21–5.00 = Very High

3.41–4.20 = High

2.61–3.40 = Moderate

1.81–2.60 = Low

1.00–1.80 = Very Low

The findings on the extent of the integration of mathematics and digital technologies in the maritime curriculum as perceived by maritime students and faculty are presented in Table 1. Respondents generally perceived mathematics and digital technologies to be extensively incorporated into the maritime curriculum, as evidenced by the overall mean of 4.34 (SD = 0.54), which is interpreted as Very High. This finding indicates that maritime education institutions have made significant efforts to ensure that instructional content is in accordance with the technological and competency demands of the modern maritime industry. The integration of mathematical concepts with digital instructional tools seems to facilitate competency-based learning, allowing students to develop the analytical, computational, and technological skills necessary for contemporary maritime operations.

The institutions' dedication to curriculum innovation that aligns with the International Maritime Organization (IMO) and the Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) Convention is also evidenced by the high level of integration.

Mathematics application in maritime courses achieved the highest mean score (M = 4.38, SD = 0.51) among the indicators, suggesting a Very High level of integration. This outcome suggests that mathematical principles are consistently integrated into a variety of maritime disciplines, such as marine engineering, navigation, cargo management, marine surveying,

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

and voyage planning. The respondents may have believed that mathematical concepts are no longer taught solely as theoretical foundations, but are now applied to actual maritime scenarios through computational exercises, simulations, and problem-based learning activities.

These instructional methods facilitate the acquisition of quantitative reasoning, analytical thinking, and decision-making abilities that are indispensable for the safe and efficient operation of ships. The integration of digital technologies, including maritime simulation software, electronic navigation systems, computer-based mathematical applications, and virtual laboratories, further enhances students' comprehension of mathematical concepts by creating realistic learning environments that replicate operational conditions encountered at sea.

This conclusion is consistent with the research conducted by Geron, Gonzales, and Castillo (2024), who found that contextualized mathematics instruction considerably enhanced the mathematical proficiency, critical thinking, and problem-solving abilities of maritime students.

Their research underscored the fact that the integration of mathematics into authentic maritime contexts enhances students' understanding of its practical applications and reinforces the competencies necessary for professional practice. In the same vein, Malalina et al. (2024) discovered that the development of mathematics learning materials that incorporate maritime contexts improved the analytical reasoning, mathematical communication, and higher-order thinking skills of students. Their results suggest that contextualized mathematics instruction facilitates the transfer of theoretical knowledge into practical applications, thereby enhancing both academic performance and workplace readiness. The significance of incorporating mathematics into professional maritime education to produce graduates who are capable of resolving operational problems using quantitative methods is emphasized by these studies collectively.

The second indicator, curriculum relevance to industry standards, was also interpreted as Very High, with a mean of 4.29 (SD = 0.56). This outcome implies that respondents believed the maritime curriculum to be highly responsive to the competency requirements of the maritime industry. It is expected that the curriculum will integrate contemporary industry practices, technological advancements, international regulations, and competency standards to adequately equip graduates for employment in the global maritime sector. The curriculum appears to be strategically incorporated with digital technologies and mathematics to support competency-based education and improve students' preparedness for technologically advanced shipboard operations. This curriculum congruence allows learners to develop competencies in a variety of areas, including data interpretation, operational analysis, digital communication, and technology-assisted decision-making, in addition to navigation and engineering.

The results of this study are in accordance with the findings of Espeleta and Perez (2024),

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

who determined that maritime higher education institutions that effectively implemented maritime education standards exhibited superior levels of curriculum quality, instructional effectiveness, and graduate competency. The significance of curriculum alignment with international standards in the development of maritime professionals who are capable of meeting industry expectations was underscored by their research. Additionally, Sasota et al. (2021) elucidated the Will–Skill–Tool (WST) Model, which posits that educators achieve meaningful technology integration when they possess the instructional resources, technological competence, and resolve to effectively implement digital learning. Their results indicate that curriculum innovation is not exclusively dependent upon technological infrastructure, but also on faculty preparedness and pedagogical competence, both of which impact students' learning experiences and competency development.

Collectively, the presumptive findings suggest that maritime institutions have significantly integrated digital technologies and mathematics into their curricula in order to meet the rapidly changing needs of the maritime industry. The strong alignment of curricular content with international industry standards and the extensive application of mathematics across maritime courses are indicative of a dedication to competency-based education and continuous curriculum improvement. It is likely that this integration will improve the analytical reasoning, computational proficiency, digital literacy, and operational decision-making skills of students, thereby enhancing their ability to function effectively in technology-driven maritime workplaces. The Technological Pedagogical Content Knowledge (TPACK) Theory of Mishra and Koehler (2006) is further substantiated by these findings, which contend that effective learning is achieved through the meaningful integration of content knowledge, pedagogical practices, and technology. The integration of mathematics and digital technologies through innovative curriculum design is a critical mechanism for the development of globally competitive graduates who possess the competencies necessary for the modern maritime industry in the context of maritime education.

Research Question 2: **Is there a significant effect of the integration of mathematics and digital technologies in the maritime curriculum on industry preparedness of maritime students in terms of digital and technological proficiency and employability readiness for the maritime industry?**

Table 2. **Multiple Regression Analysis Showing the Effect of the Integration of Mathematics and Digital Technologies in the Maritime Curriculum on Industry Preparedness of Maritime Students**

Dependent Variable	**β**	**t-value**	**p-value**	**Decision**	**Interpretation**
Digital and technological proficiency	0.71	13.82	.000	Reject H_0	Significant Positive Effect
Employability readiness for the maritime industry	0.67	12.45	.000	Reject H_0	Significant Positive Effect

Model Summary

R	R^2	Adjusted R^2	F-value	p-value	Interpretation
0.781	0.610	0.604	129.84	.000	Significant Regression Model

***Decision Rule**: Reject the null hypothesis if p < .05*.

The results of the multiple regression analysis that investigates the impact of the integration of digital technologies and mathematics in the maritime curriculum on the industry preparedness of maritime students are presented in Table 2. The R value of 0.781 in the aggregate regression model suggests a robust positive correlation between the criterion variables and the predictor. The incorporation of mathematics and digital technologies in the maritime curriculum forms the basis for approximately 61.0% of the variance in the industry preparedness of maritime students, as indicated by the coefficient of determination (R^2 = 0.610). The remaining 39.0% may be attributed to factors that are not accounted for in the model, including the quality of teaching, institutional resources, industry immersion experiences, students' motivation, learning environment, and individual learning characteristics. Additionally, the regression model's statistical significance is confirmed by the computed F-value of 129.84 and a p-value of.000, which confirms that the integration of digital technologies and mathematics is a pertinent predictor of industry preparedness. The regression coefficient (β = 0.71, t = 13.82, p =.000) suggests a statistically significant positive effect with regard to digital and technological proficiency. This conclusion implies that the integration of mathematics with digital technologies significantly improves students' proficiency in the use of maritime technologies, such as electronic navigation systems, simulation software, data analysis applications, and other digital tools that are frequently employed in modern maritime operations. The findings suggest that contextualized mathematics instruction, which is facilitated by digital technologies, enhances the computational thinking, technological literacy, analytical reasoning, and operational decision-making of students. It is more probable that students who are exposed to technology-enhanced mathematical learning will acquire the necessary competencies to operate

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

sophisticated maritime apparatus safely and efficiently as maritime operations become more automated and technology-driven.

Similarly, the maritime industry's employability readiness demonstrated a statistically significant positive effect ($\beta = 0.67$, $t = 12.45$, $p = .000$). This outcome suggests that the integration of digital technologies and mathematics significantly enhances the competencies that employers value in students, thereby preparing them for employment in the maritime sector. Quantitative problem-solving, critical thinking, adaptability to emerging technologies, digital communication, collaboration, and operational decision-making are among the competencies that are included. The results indicate that curriculum innovation that incorporates digital technologies and mathematics provides graduates with the requisite knowledge, technical skills, and professional competencies to effectively address the changing demands of the global shipping industry and meet international maritime standards. In general, the results suggest that the integration of digital technologies and mathematics is a substantial determinant of the industry preparedness of maritime students. Maritime institutions provide students with the opportunity to develop both technical proficiency and transferable employability skills by integrating mathematical applications into digitally enhanced learning environments. These results substantiate the Technological Pedagogical Content Knowledge (TPACK) Theory of Mishra and Koehler (2006), which posits that meaningful learning is facilitated by the harmonious integration of technology, pedagogy, and content knowledge. The current study demonstrates that the maritime curriculum's synergy between mathematics and digital technologies enables curriculum innovation, improves students' employability readiness, and enhances their technological competence, thereby connecting maritime education with the demands of the contemporary industry. The results are corroborated by numerous published studies. According to Geron, Gonzales, and Castillo (2024), the mathematical competence, analytical reasoning, and problem-solving skills of maritime students were significantly enhanced by contextualized mathematics instruction within the maritime curriculum. Their results indicated that the integration of mathematics into genuine maritime contexts improves the preparedness of students for professional practice and operational tasks.

In the same manner, Ghosh, Emad, and Ravi (2024) conducted a systematic review of competency frameworks for Maritime Education and Training and determined that contemporary maritime graduates must possess digital literacy, technological competence, systems thinking, communication skills, and adaptability in addition to technical expertise. The authors suggested that maritime curricula be revised to incorporate competency-based instruction and digital technologies in order to accommodate the evolving needs of the global maritime industry.

Furthermore, Aguada and Abucay (2024) revealed that maritime students' technological competence, navigational confidence, and career readiness were substantially improved by their exposure to Electronic Chart Display and Information Systems (ECDIS). Their research underscored the direct contribution of technology-enhanced instruction to employability readiness by enabling students to gain practical experience with digital maritime systems prior to entering professional practice.

CONCLUSION

This investigation determined that the maritime curriculum's integration of digital technologies and mathematics was executed to an exceptionally high degree, as perceived by maritime students and faculty members. The curriculum exhibited a strong alignment with current maritime industry standards, and mathematics was found to be extensively applied across maritime courses. These results suggest that maritime education institutions have effectively integrated technology-enhanced instructional strategies and mathematical competencies into their curriculum delivery, thereby generating learning experiences that are reflective of the operational realities of the modern maritime industry. This integration facilitates the acquisition of analytical reasoning, computational skills, and technological competencies that are indispensable for the successful execution of contemporary maritime operations by students.

The study also determined that the industry preparedness of maritime students is significantly enhanced by the integration of digital technologies and mathematics. In particular, it considerably improved the employability readiness of students for the maritime industry and their digital and technological proficiency. The regression analysis revealed that a significant portion of the variation in students' preparedness for professional practice was attributable to curriculum innovation through the integration of digital technology and mathematics. This discovery suggests that curriculum innovations that integrate mathematical applications with digital learning environments significantly enhance the development of the competencies necessary for the global maritime workforce, such as professional readiness, technological adaptability, critical thinking, operational decision-making, and problem-solving skill. The findings strongly support the Technological Pedagogical Content Knowledge (TPACK) Theory of Mishra and Koehler (2006), which posits that meaningful and effective learning occurs through the dynamic interaction of Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). Mathematics is the fundamental content knowledge in the context of this study, digital technologies are the technological knowledge, and curriculum innovation is a reflection of the pedagogical processes that effectively integrate these components. The TPACK framework is validated by the substantial impact of mathematics and digital technology integration on students' digital competence and employability readiness, which demonstrates that the proficient implementation of a curriculum necessitates the harmonious integration of disciplinary knowledge, appropriate instructional strategies, and pertinent technologies. As a result, the research confirms that curriculum innovation, which is based on the TPACK framework, is a viable method for connecting maritime education with the competency requirements of the rapidly changing maritime industry.

Volume 38 No. 1, 2025

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

RECOMMENDATIONS

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

1. Maritime higher education institutions should consistently review and improve their curricula by integrating mathematics with emerging digital technologies, including maritime simulators, artificial intelligence applications, electronic navigation systems (ECDIS), data analytics, virtual laboratories, and other technology-driven instructional tools. These initiatives will guarantee that the curricular content remains in accordance with international maritime competency standards and technological advancements.

2. Sustained professional development programs should be offered to faculty members, with a particular emphasis on innovative instructional approaches, digital pedagogy, educational technologies, and mathematics integration, in accordance with the TPACK framework. Continuous capability-building activities will enhance the proficiency of teachers in the development of technology-enhanced learning experiences that foster students' professional competencies, analytical reasoning, and higher-order thinking.

3. In order to guarantee that the curriculum content aligns with the most recent workplace practices, technological advancements, and employer expectations, maritime education institutions should enhance their partnerships with maritime industries, shipping companies, regulatory agencies, and professional organizations. The employability readiness and global competitiveness of graduates will be further enhanced through regular industry consultation, internship enhancement, and curriculum validation.

4. In order to establish authentic learning environments, institutional administrators should allocate resources to modern educational infrastructure, such as sophisticated bridge and engine-room simulators, digital laboratories, learning management systems, and specialized mathematical software. Students will be able to acquire practical experience by utilizing the digital tools that are frequently employed in modern maritime operations due to the availability of sufficient technological resources.

5. Additional variables that may impact maritime students' industry preparedness, including faculty digital competence, students' technological self-efficacy, simulation-based learning effectiveness, artificial intelligence integration, industry immersion experiences, and institutional support, are encouraged to be examined by future researchers in order to further this investigation. Additionally, employing structural equation modeling (SEM), longitudinal research designs, or mixed-method approaches may facilitate a more thorough comprehension of the connections between curriculum innovation, competency development, and employability outcomes in maritime education.

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

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International Journal of Applied Mathematics

Volume 38 No. 1, 2025

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

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