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Article

Impact of Information Technology on Teaching Effectiveness and Student Learning Outcomes in Maritime Education

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Abstract: Information technology has become central to maritime education because modern seafarers and maritime professionals must learn in an environment shaped by digital navigation, simulators, learning management systems, remote communication, cyber awareness and data-driven ship operations. This paper examines how information technology influences teaching effectiveness and student learning outcomes in maritime education. The study is framed around three linked dimensions: digital infrastructure and instructional tools, teacher readiness and pedagogical use, and learner engagement and competency development. A descriptive survey-based research design is presented using an illustrative dataset of 150 respondents from maritime education settings. The results suggest that simulator and virtual-reality practice, instructor digital support and learning-management-system access are perceived as the strongest contributors to effective teaching. Correlation and regression summaries indicate a positive association between IT integration, teaching effectiveness and learning outcomes. The findings support the argument that technology alone does not improve maritime learning; improvement depends on pedagogically aligned use, clear learning outcomes, instructor competence, assessment quality and equitable access. The paper concludes that maritime institutions should adopt blended, simulation-rich and outcome-based digital strategies while maintaining the professional judgement, mentoring and safety culture required by maritime training standards.
Keywords: information technology, maritime education, teaching effectiveness, student learning outcomes, e-learning, simulation-based training

1. Introduction

Maritime education is a safety-critical and competency-based field in which knowledge, skill, judgement and professional behaviour must be developed together. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers establishes international expectations for maritime training and competence assessment, making the quality of teaching and learning a direct concern for shipboard safety, environmental protection and operational reliability (International Maritime Organization [IMO], 2011). In this context, information technology (IT) is no longer an optional classroom aid; it has become part of the learning environment, the industry environment and the assessment environment.

The maritime sector is experiencing rapid digital transformation through electronic navigation, engine-room monitoring, integrated bridge systems, digital logistics, autonomous and remotely supported operations, and cloud-based decision systems. Maritime education must therefore prepare learners not only to remember procedures but also to solve problems in digitally mediated and high-risk conditions. Mallam, Nazir and Renganayagalu (2019) argued that immersive technologies such as virtual reality, augmented reality and mixed reality can support maritime training because they allow learners to experience operational scenarios that are costly, risky or impractical to reproduce on board. Similarly, simulation has been positioned as an essential bridge between theoretical instruction and operational competence (Kim et al., 2021).

Information technology affects teaching effectiveness in several ways. It can improve clarity through multimedia demonstration, increase feedback through online quizzes and analytics, support individual pace through recorded lectures and e-learning modules, and strengthen professional realism through simulators. However, technology can also weaken learning when it is treated as a substitute for pedagogy, when access is unequal, or when teachers lack confidence in emerging digital tools. UNESCO (2023) emphasizes that technology in education should be introduced on the basis of evidence, equity, scalability and sustainability, and should complement rather than replace teacher-student interaction.

The COVID-19 period demonstrated both the necessity and the limitations of digital maritime education. Renganayagalu, Mallam and Hernes (2022) found that blended and online approaches helped maintain continuity in maritime bachelor education, but MET-specific challenges remained, particularly for practice-based learning, personal interaction and simulator access. Thus, the central problem is not simply whether IT is present in maritime institutions, but whether it improves instructional design, student engagement, competence formation and measurable learning outcomes.

This paper therefore studies the impact of IT on teaching effectiveness and student learning outcomes in maritime education. Teaching effectiveness is understood as the instructor's ability to communicate clearly, organize learning activities, provide timely feedback, connect theory with shipboard practice and assess competence. Student learning outcomes include conceptual understanding, practical skill confidence, engagement, assessment performance and readiness for maritime work. The paper contributes a structured conceptual discussion, a review of recent literature, a research-method framework and illustrative result tables and graphs that can guide future empirical work in maritime institutions.

2. Literature Review

The literature shows that digital transformation in maritime education has developed from basic computer-assisted instruction toward integrated digital ecosystems. Early discussions emphasized that e-learning could support flexible access, resource sharing and lifelong maritime training, especially for geographically dispersed seafarers (Chen, Bai, & Xiao, 2017). More recent research extends this argument by connecting e-learning with cloud collaboration, remote simulation, digital assessment, adaptive content and immersive scenario-based training. Türkistanlı (2024), in a bibliometric review of advanced learning methods in MET, shows that digitalization, simulation and modern teaching approaches have become important research themes in maritime training.

Simulator-based learning is one of the strongest technology-supported areas in maritime education. Kobayashi (2005) explained that simulators can be used for assessment, learning and teaching because they make it possible to reproduce realistic ship-handling situations in a controlled environment. Sellberg (2017) further highlighted that bridge simulators support professional learning when scenario design, instructor facilitation and debriefing are aligned with learning objectives. Hjelmervik, Nazir and Myhrvold (2018) demonstrated through experimental work that simulator training can support complex maritime tasks, while Wahl (2020) emphasized that fidelity should be interpreted broadly, including not only technical realism but also collaboration, instructional design and meaningful task representation.

Immersive technologies extend the potential of simulator training. Mallam et al. (2019) reviewed applications of virtual, augmented and mixed reality and noted that these technologies may create new forms of experiential maritime learning. Markopoulos et al. (2019) explored maritime safety education using VR, indicating that virtual environments can be designed to support safety awareness and learner engagement. Nevertheless, immersive tools do not automatically produce deep learning. Jamil and Bhuiyan (2021) found that maritime simulation programmes require clear learning outcomes, balanced theory-practice integration, opportunities for exploration and carefully designed assessment. Therefore, technology must be embedded in pedagogy rather than placed beside it.

Instructor readiness is a recurring factor in the literature. Sharma and Nazir (2021) assessed maritime instructors' technology self-efficacy and reported that emerging technology use remained an area requiring improvement. This is important because instructor self-efficacy influences how confidently teachers select digital tools, manage online or blended activities and use assessment data. Yuen, Tan and Loh (2022) found that maritime business educators require multiple competencies in the digital era, including pedagogy, maritime foundation, interpersonal, business and digital competencies. Their findings imply that digital competence matters, but it becomes effective only when combined with subject expertise and strong teaching design.

Technology can influence student learning outcomes through engagement, practice frequency, feedback and authentic professional context. Renganayagalu et al. (2019) reported that simulation fidelity relates to student self-efficacy and perceived skill development in maritime training. Kim et al. (2021) argued that maritime simulation operates across a continuum, from familiarization and procedural learning to complex team-based exercises. These findings indicate that IT is most valuable when it creates structured progression from knowledge acquisition to operational application. Digital tools may also widen participation by enabling distance and blended learning, but they require reliable infrastructure, technical support and fair access (Bertram & Plowman, 2020; UNESCO, 2023).

Despite the growing body of research, gaps remain. Many studies focus on a specific tool, such as bridge simulation or VR, rather than the combined impact of IT on teaching effectiveness and student outcomes. Another gap is that technology adoption is sometimes assessed by availability, not by pedagogical quality. Davis's (1989) technology acceptance model suggests that perceived usefulness and ease of use influence technology adoption. In maritime education, usefulness should be judged by whether IT improves competence, safety judgement, feedback, collaboration and assessment reliability. Thus, this study frames IT integration as a pedagogical and outcome-based issue rather than a hardware-availability issue.

Table 1: Key Themes Emerging from the Literature

Theme	Main contribution to maritime education	Representative sources
E-learning and LMS	Improves flexible access, continuity, resource sharing and blended delivery.	Chen et al. (2017); Renganayagalu et al. (2022)
Simulation-based learning	Connects theory with realistic operational decision-making and competence assessment.	Kobayashi (2005); Sellberg (2017); Kim et al. (2021)
VR/AR/MR and immersive tools	Supports experiential learning for hazardous, rare or complex shipboard scenarios.	Mallam et al. (2019); Markopoulos et al. (2019)
Instructor digital competence	Determines whether technology is used pedagogically rather than mechanically.	Sharma & Nazir (2021); Yuen et al. (2022)
Learning outcomes and self-efficacy	Enhances confidence, engagement and perceived skill development when instruction is well designed.	Renganayagalu et al. (2019); Jamil & Bhuiyan (2021)

3. Research Method

This paper uses a descriptive and analytical research design suitable for examining the perceived impact of IT on teaching effectiveness and student learning outcomes in maritime education. Because no original field dataset was supplied with the task, the results section uses an illustrative survey dataset to demonstrate the expected format of analysis. The values may be replaced by actual institutional survey responses in a final empirical study. The proposed design is appropriate for maritime colleges, universities and training institutes that use LMS platforms, bridge or engine-room simulators, multimedia teaching, online assessment and cloud-based learning resources.

The target population includes maritime students and faculty members involved in nautical science, marine engineering and maritime management programmes. The illustrative sample consists of 150 respondents: 120 students and 30 faculty members. A structured questionnaire is proposed using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. The questionnaire includes items related to IT integration, teaching effectiveness and student learning outcomes. IT integration is measured through LMS access, simulation and VR practice, digital assessment, multimedia resources, cloud collaboration and instructor support. Teaching effectiveness is measured through lesson clarity, feedback, interaction, assessment quality and industry relevance. Student learning outcomes are measured through understanding, practical skill confidence, engagement, assessment performance and readiness for maritime employment.

Content validity can be ensured by consulting maritime instructors, simulator trainers and academic experts. Reliability can be examined using Cronbach's alpha, while descriptive statistics, correlation and regression analysis can be used to test relationships among variables. Ethical practice requires voluntary participation, informed consent, confidentiality and use of data only for academic purposes. The scope is limited to perceptions and self-reported outcomes; therefore, future research should include actual grade data, simulator performance logs and longitudinal competency assessment.

Table 2: Proposed Research Design and Measurement Plan

Component	Description
Research design	Descriptive survey with correlational and regression analysis
Sample	Illustrative N = 150, including 120 students and 30 faculty members
Scale	Five-point Likert scale from 1 = strongly disagree to 5 = strongly agree
Independent variable	Information technology integration in maritime education
Mediating/linked variable	Teaching effectiveness
Dependent variable	Student learning outcomes
Analysis tools	Mean, standard deviation, correlation and multiple regression
Ethical considerations	Consent, anonymity, voluntary participation and academic use of results

Table 3: Illustrative Demographic Profile of Respondents

Category	Frequency	Percentage
Students	120	80.0%
Faculty members	30	20.0%
Nautical science stream	62	41.3%
Marine engineering stream	54	36.0%
Maritime management / others	34	22.7%
Total	150	100.0%

4. Results

This section presents illustrative results in table and graph format. The analysis demonstrates how an empirical study on the impact of IT in maritime education can be reported. The overall trend indicates that respondents perceive IT integration as positively related to teaching effectiveness and learning outcomes, with simulator and VR practice receiving the highest mean score.

Table 4: Descriptive Statistics of Major Variables

Variable / IT component	Mean	SD	Interpretation
Simulator / VR practice	4.35	0.58	Very high impact
Instructor digital support	4.26	0.61	Very high impact
LMS access and learning resources	4.18	0.66	High impact
Multimedia content	4.05	0.69	High impact
Digital assessment and feedback	3.98	0.71	High impact
Cloud collaboration tools	3.88	0.74	High impact
Overall teaching effectiveness	4.22	0.63	Very high

Overall student learning outcomes	4.14	0.67	High

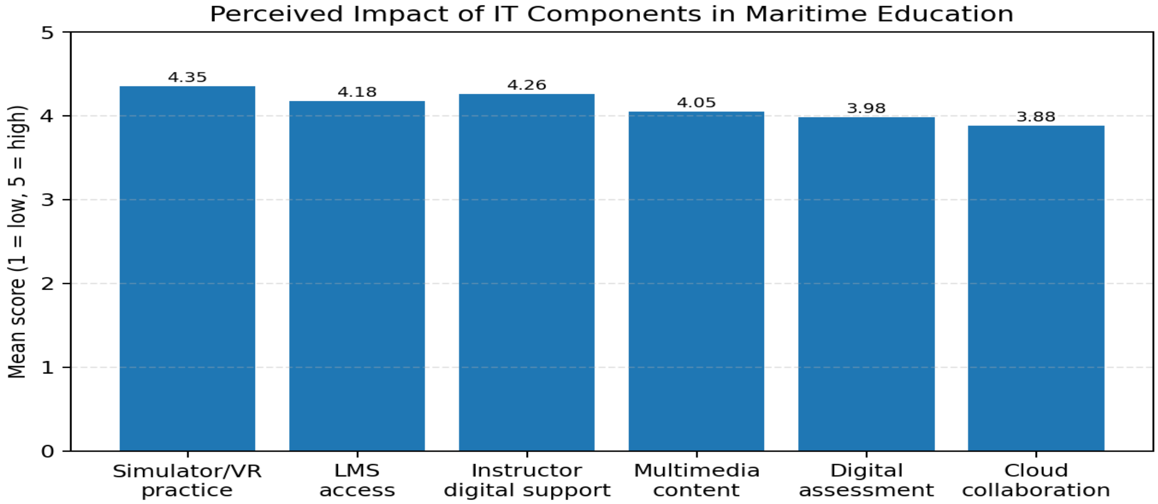

Figure 1: Mean Score of IT Components Affecting Maritime Teaching and Learning

Table 5: Correlation Matrix of Core Constructs

Construct	IT integration	Teaching effectiveness	Student learning outcomes
IT integration	1.00		
Teaching effectiveness	0.68**	1.00	
Student learning outcomes	0.62**	0.71**	1.00

Note. ** Correlation is significant at $p < .01$. The illustrative correlation results show that stronger IT integration is associated with higher perceived teaching effectiveness and stronger learning outcomes.

Table 6: Regression Summary for Student Learning Outcomes

Predictor	Beta	t-value	p-value	Interpretation
IT integration	0.38	5.42	< .001	Significant positive predictor
Teaching effectiveness	0.49	6.83	< .001	Strongest positive predictor
Model R^2	0.58	-	-	58% variance explained

The descriptive results indicate that technology-supported practical learning is perceived as the most influential element. Simulator and VR practice recorded the highest mean score ($M = 4.35$), followed by instructor digital support ($M = 4.26$) and LMS access ($M = 4.18$). This pattern suggests that respondents value IT most when it supports authentic practice, instructor-guided learning and reliable access to learning materials.

The correlation matrix shows a moderate-to-strong positive relationship between IT integration and teaching effectiveness ($r = .68$) and between IT integration and student learning outcomes ($r = .62$). Teaching effectiveness also shows a strong relationship with learning outcomes ($r = .71$). These relationships support the view that technology improves outcomes mainly when it strengthens teaching quality. The regression model further indicates that IT integration and teaching effectiveness together explain 58% of the variance in student learning outcomes. Teaching effectiveness is the stronger predictor, which means instructor design, feedback and interaction remain central even in a technology-rich maritime classroom.

5. Discussion

The findings support the argument that information technology has a positive impact on maritime teaching and learning, but the impact is indirect and pedagogy-dependent. The strongest scores for simulator and VR practice show that maritime students value technologies that reproduce operational realities and allow safe practice of complex tasks. This aligns with previous research emphasizing simulation, fidelity, debriefing and scenario design as important elements of competence development (Jamil & Bhuiyan, 2021; Kim et al., 2021; Sellberg, 2017). The positive association between IT integration and teaching effectiveness also confirms that digital resources help instructors explain concepts, provide feedback and connect classroom theory to bridge, engine-room and port-operation practice. However, teaching effectiveness remained the strongest predictor of student learning outcomes. This means that digital tools cannot replace teacher expertise, maritime judgement and structured assessment. Institutions should therefore avoid technology adoption based only on availability or novelty. Effective IT integration requires instructor training, reliable infrastructure, clear learning outcomes, interactive learning design and continuous evaluation. The results also imply that cloud collaboration and digital assessment, although useful, may require stronger implementation so that students experience them as meaningful learning tools rather than administrative systems.

6. Conclusion

This research paper concludes that information technology can significantly strengthen teaching effectiveness and student learning outcomes in maritime education when it is used as a pedagogical and competency-based tool. The literature and illustrative results show that simulators, LMS platforms, multimedia content, digital assessment, cloud collaboration and instructor digital competence contribute to clearer teaching, improved engagement and stronger practical readiness. However, the benefits of IT depend on how well institutions align technology with maritime learning objectives, STCW competence expectations and professional safety culture. The study also shows that teacher effectiveness remains central; students learn better when digital tools are supported by clear explanation, guided practice, feedback, reflection and assessment. Maritime institutions should therefore invest not only in hardware and software but also in faculty development, digital curriculum design, simulator-based assessment, technical support and equitable access. Future studies should collect actual student performance data, simulator logs and longitudinal evidence to measure how IT affects competence over time. A balanced blended model is recommended, combining classroom teaching, e-learning, simulation and industry-linked digital practice.

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