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Enhancing Maritime Vocational Education: A Qualitative Analysis of Curriculum Alignment, Technological Integration, and Sustainability Practices

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Abstract: Despite growing global recognition of the need to modernise maritime vocational education, there remains a significant research gap in understanding how curriculum, technological integration, and sustainability practices align with current industry demands in developing countries, particularly in Indonesian maritime institutions. This study addresses this gap by exploring the experiences and perceptions of three key stakeholder groups—maritime industry professionals (n = 5), lecturers (n = 5), and recent graduates (n = 5)—totalling 15 informants selected through purposive sampling. Using Braun and Clarke's (2006) six-phase thematic analysis, three major themes emerged: (1) partial curriculum–industry alignment, with curricula rooted in conventional seafaring competencies yet inadequately responsive to digital and autonomous shipping innovations; (2) a substantial technology integration deficit, whereby exposure to advanced digital systems such as electronic chart display and information systems (ECDIS) and integrated bridge systems remains superficial; and (3) a sustainability education gap, in which environmental and decarbonisation literacy is introduced theoretically but lacks applied, IMO-aligned practical training. These findings suggest the need for structured curriculum reform, industry co-design mechanisms, and investment in simulation-based and green-technology training infrastructure. This study contributes to the emerging literature on maritime education reform and offers actionable implications for institutions, policymakers, and the broader maritime training community.

Keywords: Maritime Education, Vocational Training, Curriculum Alignment, Sustainability Practices, Technological Integration, Qualitative Research

INTRODUCTION

The global maritime industry constitutes the backbone of international trade, facilitating the movement of approximately 90% of global goods and generating significant economic value across shipping, port management, logistics, and offshore operations (Notteboom et al., 2022). As the sector undergoes rapid and multidimensional transformation driven by digitalisation, automation, decarbonisation imperatives, and evolving regulatory frameworks, the competency requirements placed on maritime professionals have correspondingly intensified (Cicek et al., 2019; Kim & Mallam, 2020). Internationally, frameworks such as the International Maritime Organization's (IMO) STCW Convention and the 2023 IMO Strategy on reduction of greenhouse gas (GHG) emissions from ships mandate that maritime education and training (MET) systems continuously evolve to meet emerging global standards.

Despite this urgency, a persistent misalignment exists between the curricula of maritime vocational institutions and the practical realities of the contemporary maritime workforce. Previous research has documented this gap in European and East Asian contexts (Demirel, 2020; Tvedt et al., 2018), yet the specific dynamics within Indonesian maritime vocational education—where institutions such as Sekolah Tinggi Ilmu Pelayaran (STIP) Jakarta train thousands of future seafarers annually—remain insufficiently examined. Indonesian maritime education operates within a distinctive national regulatory framework and resource environment that shapes how institutions respond to international demands, making it a critical but underexplored context for applied educational research.

Qualitative studies to date have rarely centred the simultaneous perspectives of educators, industry professionals, and recent graduates in triangulated analyses of this misalignment (Albayrak & Ziarati, 2012; Nalupa, 2022). The dual gaps in technology education and sustainability training are particularly under-theorised, despite their growing strategic importance to both shipping companies and international regulators. State-of-the-art scholarship identifies three principal dimensions through which MET misalignment manifests: curriculum content obsolescence, technology training deficits, and sustainability literacy gaps (de la Peña Zarzuelo et al., 2020; Pappa, 2024). The present study directly addresses these dimensions through empirical qualitative inquiry.

This study is guided by the following research questions:

1. **RQ1:** How aligned is the maritime vocational curriculum at STIP Jakarta with current maritime industry needs?
2. **RQ2:** What specific gaps exist in the integration of technology and sustainability practices within maritime vocational training?

These questions frame the study's focus on providing theoretically grounded and practically actionable findings that can guide curriculum reform, institutional policy, and further scholarly inquiry into maritime education in developing maritime nations.

Literature Review

Curriculum Alignment in Maritime Vocational Education

Curriculum alignment—defined as the degree of coherence between educational objectives, instructional content, and the competency expectations of employers—is widely recognised as a foundational determinant of graduate employability and professional effectiveness (House & Saeed, 2016). In maritime education, this alignment is further complicated by the dual regulatory mandate of international standards (STCW, IMO) and national frameworks, requiring institutions to navigate both standardised certification requirements and the dynamic operational realities of shipping companies, ports, and offshore industries (Kim & Mallam, 2020).

Existing literature suggests that while maritime curricula have historically maintained reasonable alignment with conventional seafaring competencies—navigation, cargo operations,

safety management—they have struggled to incorporate emerging operational paradigms. Tvedt et al. (2018) found that on-board training frameworks in Norway, while formally compliant with STCW requirements, were insufficiently adapted to electronic navigation environments. Demirel (2020) similarly demonstrated that MET institutions across Europe faced structural inertia in updating course content to reflect digitalisation trends, attributing this partly to faculty knowledge gaps and partly to the slow pace of official curriculum revision cycles.

Technology Integration in Maritime Training

The maritime industry's technological transformation encompasses integrated bridge systems, ECDIS, dynamic positioning, autonomous vessel management, and AI-assisted decision support (Pappa, 2024). For MET institutions, the pedagogical challenge lies not merely in teaching specific tools but in cultivating adaptive technological literacy—the capacity to learn and apply emerging systems throughout a professional career. De la Peña Zarzuelo et al. (2020) document a growing Industry 4.0 divide in port and shipping education, where training content lags significantly behind operational technology deployment.

Simulation-based learning has emerged as a key pedagogical innovation for bridging this gap, enabling learners to engage with complex technological environments in controlled, low-risk settings (Nalupa, 2022). However, access to high-fidelity simulators and qualified technology instructors remains unevenly distributed, particularly in developing-country MET institutions. Cicek et al. (2019) project that by 2030, maritime operations will require competencies in data analytics, cybersecurity, and remote system monitoring—domains currently absent or marginal in most Indonesian maritime vocational programmes.

Sustainability Education in Maritime Vocational Programmes

International pressure on the shipping industry to decarbonise has intensified since the IMO's 2018 Initial GHG Strategy and its 2023 revision, which sets targets of net-zero emissions by or around 2050. This regulatory environment places new demands on maritime professionals to understand alternative fuels, energy efficiency management systems (EEMS), and environmental compliance protocols. However, Nguyen et al. (2023) note that MET responses to these demands remain nascent, with sustainability content often taught as peripheral supplementary modules rather than integrated core competencies.

Toriia et al. (2023) observe that maritime educators themselves frequently lack professional development opportunities in sustainability science, limiting their capacity to deliver applied environmental training. This creates a compounding deficit in which institutional capacity gaps and curriculum design weaknesses together undermine the production of environmentally literate graduates. The present study empirically investigates whether and how these documented dynamics manifest in the Indonesian maritime vocational education context.

METHOD

Research Design

This study adopts a qualitative research design grounded in interpretive inquiry, consistent with the epistemological aim of understanding the lived experiences, perspectives, and meanings that key stakeholders ascribe to maritime vocational education (Creswell & Clark, 2011; Padgett, 2016). Qualitative methodology was selected because the research questions require rich, contextualised insights into alignment, gap perception, and institutional experience that cannot be adequately captured through quantitative measurement alone.

Participants and Sampling

A total of 15 informants participated in this study, distributed across three purposively selected groups: (1) five maritime industry professionals with a minimum of ten years of active experience in shipping or port management; (2) five lecturers currently employed at STIP Jakarta in maritime-related disciplines; and (3) five recent graduates who had completed their maritime vocational programme within the preceding three years and were actively employed in the maritime sector. Purposive sampling was employed to ensure that participants possessed direct, relevant experience about the research questions (Darlington & Scott, 2020). The sample size was determined based on information sufficiency, with data collection continuing until thematic saturation was achieved.

Data Collection

Data were collected through semi-structured individual interviews conducted between [Month] and [Month] 2025. Each interview lasted between 45 and 75 minutes and was conducted in a setting chosen by the participant to promote comfort and candour. An interview guide was developed covering the core thematic areas of curriculum alignment, technology integration, and sustainability education. Questions were open-ended to allow participants to introduce perspectives beyond the anticipated thematic scope. All interviews were audio-recorded with participants' informed consent and subsequently transcribed verbatim. Field notes were maintained throughout to capture observational context.

Data Analysis

Thematic analysis was conducted following the six-phase framework proposed by Braun and Clarke (2006): (1) familiarisation with data through repeated reading of transcripts; (2) initial code generation applied systematically across the full data set; (3) theme searching through clustering of codes into candidate themes; (4) theme reviewing against the coded data and full data set; (5) theme defining and naming; and (6) report production. Coding proceeded in three stages: open coding to identify granular units of meaning, axial coding to establish relationships between categories, and selective coding to consolidate themes around the central research questions.

Trustworthiness and Validity

Several strategies were employed to ensure the trustworthiness of findings. Triangulation was achieved through the cross-group comparison of perspectives from industry professionals, lecturers, and graduates, enabling convergent and divergent insights to be identified. Member checking was conducted by sharing preliminary thematic summaries with a subset of participants from each group, who confirmed the accuracy and representativeness of the interpretations. Reflexivity was maintained through the researchers' documentation of positionality statements and regular analytical memos throughout the coding process.

RESULTS AND DISCUSSION

Thematic analysis of the 15 interview transcripts yielded three overarching themes, each supported by multiple sub-themes and direct participant testimony. The themes are presented in sequence, beginning with the most foundational (curriculum alignment) and progressing to the cross-cutting issues of technology integration and sustainability education.

Theme 1: Partial Curriculum–Industry Alignment

The majority of participants across all three groups acknowledged that the maritime vocational curriculum at STIP Jakarta covers foundational seafaring competencies adequately, but described a meaningful and widening divergence between curriculum content and current

industry operations. Industry professionals, who observed this misalignment most directly through their experience recruiting and supervising graduates, were particularly forthright:
"The curriculum does not reflect the digital systems we use today. When a graduate joins our vessel, they know the theory from STCW, but they have never seen an integrated bridge with the level of automation we operate. We spend months retraining them on basic digital navigation tools." (Industry Professional, IP-3)

Lecturers recognised the same structural tension but attributed it partly to the slow pace of official curriculum revision, which is subject to regulatory approval processes that can take several years to complete:
"We know the content needs updating. The problem is that changing an accredited curriculum is not something we can do quickly. We try to supplement with guest lectures from industry, but it is not a systematic solution." (Lecturer, L-2)

Recent graduates affirmed that while their training equipped them with the formal credentials required for employment, they frequently encountered a competency gap in practice, particularly in digital navigation and fleet management systems:
"In my first posting, I felt confident with the paperwork and the regulations. But when it came to the ship's electronic systems, I had to learn everything on the job. I had not seen anything like that in my training." (Graduate, G-1)

Sub-themes within this category included: the absence of industry co-design in curriculum development; the misalignment between assessment instruments and current operational competencies; and the inadequate incorporation of recent IMO regulatory changes into course syllabi.

Theme 2: Technology Integration Deficit

All 15 participants identified a significant gap between the technological content of the curriculum and the digital sophistication of contemporary maritime operations. This was the most consistently raised issue across all three groups, emerging with particular intensity in the accounts of industry professionals:
"ECDIS, voyage data recorders, integrated bridge systems—these are not optional anymore. They are the tools of the job. But when I ask graduates if they have used them in a real simulation environment, the answer is almost always no." (Industry Professional, IP-1)

Lecturers described the technology deficit as a consequence of both equipment limitations and faculty development gaps. Several noted that the institution lacked access to up-to-date simulators, and that faculty had not received systematic training in emerging maritime technologies:
"We want to teach ECDIS properly, but the simulators we have are outdated. The software versions do not match what is on modern vessels. It is very hard to give students realistic experience under these conditions." (Lecturer, L-4)

Graduates corroborated these observations, noting that their technology-related training felt theoretical rather than applied, and that they lacked confidence operating advanced bridge systems upon entering employment:
"We learned about AIS and radar in class, but we never really practised using them in realistic scenarios. I think the gap between what we learned and what we needed at work was biggest in the technology area." (Graduate, G-4)

Sub-themes included: absence of cybersecurity awareness in the curriculum; limited exposure to dynamic positioning systems; no formal instruction on AI-assisted navigation tools; and insufficient simulator fidelity.

Theme 3: Sustainability Education Gap

The third major theme concerns the integration of sustainability and environmental literacy into the curriculum. While all groups acknowledged that sustainability topics were

present in some form, the depth, relevance, and applied nature of this content were consistently criticised:

"The IMO is moving very fast on decarbonisation. But when I look at the graduates we hire, they have a very basic understanding of MARPOL and almost no knowledge of alternative fuels or energy efficiency management. This is becoming a serious problem for compliance." (Industry Professional, IP-5)

Lecturers attributed the sustainability content gap to the absence of specialised training materials and the lack of industry partnerships that could support experiential learning in green shipping contexts:

"We cover MARPOL in our Environmental Studies module, but it is mostly regulatory content. We do not have the resources to show students how an energy efficiency management plan actually works on a vessel. We teach the theory, not the practice." (Lecturer, L-5)

Graduates echoed this perspective, noting that their sustainability education had been primarily declarative rather than applied, and that they had limited capacity to implement environmental management protocols upon graduation:

"I knew the rules—the discharge regulations, the MARPOL annexes. But when my company asked me to help prepare an energy efficiency report, I had to look everything up from scratch. We were never taught how to actually do that." (Graduate, G-3)

Sub-themes in this area included: the absence of alternative fuels literacy (LNG, methanol, hydrogen); the lack of applied training in ship energy efficiency operations; and the absence of structured learning outcomes linked to IMO GHG reduction targets.

Summary of Themes

Table 1 provides a summary of the three themes, their sub-themes, and the stakeholder group from which each sub-theme received the strongest corroboration.

Table 1. Summary of Thematic Analysis Findings

Theme	Sub-themes	Primary Stakeholder Corroboration
Partial Curriculum–Industry Alignment	Absent industry co-design; outdated assessment; slow revision cycles; regulatory lag	Industry Professionals, Graduates
Technology Integration Deficit	Outdated simulators; no cybersecurity content; limited ECDIS/IBS exposure; no AI navigation training	All groups (strongest: Industry Professionals)
Sustainability Education Gap	Declarative MARPOL focus; no alternative fuels content; no EEMS application; no GHG strategy alignment	Industry Professionals, Lecturers

Discussion

Why Curriculum–Industry Misalignment Persists

The finding that maritime curricula at STIP Jakarta are only partially aligned with industry needs is consistent with broader patterns documented in MET literature (Demirel, 2020; Kim & Mallam, 2020), but the present study adds contextual specificity by identifying the institutional and structural mechanisms through which this misalignment is reproduced. Participants across all three groups pointed to the protracted formal curriculum revision process as a primary structural barrier. This is compounded by the limited institutionalisation of industry advisory mechanisms: unlike European MET systems where shipping companies are often formally embedded in curriculum governance structures (Tvedt et al., 2018), Indonesian maritime institutions have historically operated with relatively weak formal industry linkages.

From a theoretical perspective, this dynamic can be understood through the lens of institutional isomorphism (DiMaggio & Powell, 1983): institutions tend to conform to

established regulatory expectations (the STCW framework) rather than proactively adapting to emergent operational realities. The result is a curriculum that satisfies certification requirements while falling short of equipping graduates with the adaptive competencies demanded by a rapidly evolving industry—a distinction increasingly recognised in competency-based education theory (Albayrak & Ziarati, 2012). These findings extend the existing literature by demonstrating that in the Indonesian context, regulatory compliance and operational relevance are not synonymous, and that this distinction has significant implications for graduate performance.

The Technology Gap as a Structural and Pedagogical Problem

The technology integration deficit identified in this study cannot be reduced to a resource problem alone, though resource constraints are clearly significant. Rather, the data suggest that technology training deficits are simultaneously structural (outdated equipment, slow procurement cycles), pedagogical (lecturer technology proficiency gaps), and curricular (absence of competency outcomes linked to digital maritime operations). This multi-layered causation aligns with de la Peña Zarzuelo et al.'s (2020) analysis of Industry 4.0 integration challenges in maritime education, which similarly found that technology training deficits in MET institutions were overdetermined by intersecting institutional, human, and material constraints.

Compared to findings from East Asian MET systems—where government-funded simulator upgrade programmes have substantially reduced the technology training gap (Nalupa, 2022)—Indonesian maritime institutions appear to lack both the investment frameworks and the institutional capacity to achieve comparable outcomes without targeted policy intervention. The present study's findings thus add empirical weight to calls for state investment in maritime training infrastructure and for the establishment of formal industry–institution co-investment frameworks for simulation technology.

Sustainability Education: A Theoretical and Practical Contribution

The sustainability education gap documented here extends existing scholarship in important directions. Toriia et al. (2023) identified the absence of faculty sustainability expertise as a primary constraint on MET environmental education; the present study corroborates this but adds the finding that graduates experience this gap not merely as knowledge deficiency but as applied incapacity—an inability to perform environmental management tasks required in professional practice. This distinction between declarative knowledge and procedural competence is theoretically significant because it suggests that incremental content additions to existing syllabi are insufficient; what is required is a reconceptualisation of sustainability education as applied, competency-based, and linked to specific IMO regulatory performance standards.

The practical implication is that sustainability education in maritime vocational programmes should be redesigned around the IMO's GHG reduction strategy milestones, with mandatory applied components including vessel energy efficiency management plan development, alternative fuel scenario analysis, and environmental compliance simulation exercises.

CONCLUSION

Main Findings

This study examined curriculum–industry alignment, technology integration, and sustainability education in maritime vocational education through qualitative interviews with 15 stakeholders across three groups at STIP Jakarta. Three overarching themes emerged: partial curriculum–industry alignment driven by structural revision barriers and absent industry co-design; a technology integration deficit rooted in equipment obsolescence, faculty knowledge

gaps, and curriculum obsolescence; and a sustainability education gap characterised by declarative rather than applied environmental learning outcomes. These findings are consistent with and extend international MET literature while providing the first systematic qualitative evidence from an Indonesian maritime vocational context.

Theoretical Contributions

This study contributes to MET scholarship in three ways. First, it provides empirical evidence that in developing-country MET contexts, regulatory compliance and operational competence alignment are structurally decoupled, advancing the curriculum alignment literature beyond its predominantly European focus. Second, it demonstrates that technology integration deficits in maritime education are multi-causal and require systemic rather than additive solutions. Third, it theorises the sustainability education gap as a distinction between declarative and procedural competence, introducing an applied competency framework as the appropriate design response.

Practical Implications

For maritime vocational institutions, the findings recommend the establishment of formal industry advisory boards with curriculum co-design authority; the development of structured simulator upgrade and maintenance investment plans in partnership with shipping companies; the integration of sustainability modules as applied, competency-assessed components linked to IMO GHG milestones; and the provision of sustained faculty development programmes in digital maritime systems. For national policymakers, the findings support the case for ring-fenced funding for maritime training infrastructure modernisation and for regulatory incentives that encourage industry co-investment in MET technology provision.

Limitations and Directions for Further Research

This study is limited by its single-institution scope and the relatively small participant sample, which, while appropriate for qualitative inquiry, constrains the transferability of findings across the Indonesian MET system as a whole. Future research should extend this inquiry to a comparative multi-institutional study across Indonesian maritime academies, and should employ mixed-methods designs that combine the qualitative depth achieved here with quantitative measurement of competency outcomes. Longitudinal investigation of graduates' career trajectories in relation to curriculum characteristics would further strengthen the evidence base for reform recommendations.

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