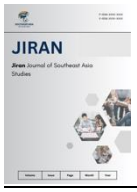

Journal of Southeast Asia Studies
Vol 7 No 2 July 2026
ISSN: 2686-6293 (Print) ISSN: 2686-6293 (Electronic)
Open Access: https://jiran.unaim-wamena.ac.id/jiran

Critical Multiliteracy for Maritime Safety: Integrating Environmental Literacy, Social Competency, and Systems Thinking in Cadet Training

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Article Info :
Received:
05/01/2026
Revised:
15/02/2026
Accepted:
06/03/2026

ABSTRACT

This research examines how maritime education can integrate environmental literacy, social competency, and systems thinking into cadet training to develop multiliterate maritime professionals capable of navigating interconnected safety, environmental, and social dimensions of contemporary shipping operations. Through focus group discussions with four senior maritime lecturers, two veteran shipping officers, and four former seafarers, this study investigates how safety culture manifests across deck, engine, and port management operations and what educational approaches systematically develop multiliteracy necessary for informed professional practice. The research identifies that maritime cadets develop strong technical competency (navigational, engineering, operational skills) yet receive insufficient exposure to environmental systems knowledge, social dimensions of safety culture, or integrated systems thinking connecting technical decisions to broader sustainability implications. Findings reveal that safety culture remains narrowly conceived as compliance with technical safety procedures rather than as systemic understanding of how human factors, organizational systems, social relationships, and environmental considerations interconnect to enable or compromise safety. The study demonstrates that maritime multiliteracy—combining technical proficiency with environmental understanding, social awareness, and systems thinking—fundamentally enhances safety outcomes. Research results provide curriculum frameworks integrating multiliteracy development throughout maritime programs, case studies demonstrating safety-environment-social interconnections in real operational contexts, and evidence supporting interdisciplinary maritime education advancing both safety and sustainability simultaneously.

Keywords : maritime safety culture; multiliteracy; environmental literacy; systems thinking; social competency; cadet education; maritime sustainability

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1. INTRODUCTION

Maritime safety represents one of the global shipping industry's foundational priorities, with decades of regulatory development, technological innovation, and operational refinement producing substantial improvements in maritime incident rates and operational safety records. The International Safety Management (ISM) Code, maritime operational standards, bridge team management protocols, and extensive occupational safety regulations have created comprehensive governance frameworks within which contemporary maritime operations occur. Yet despite these regulatory advances and technological improvements, maritime incidents continue—involving loss of life, environmental devastation, and economic losses—at rates suggesting that current safety approaches remain inadequate for addressing the complex human, technical, organizational, and environmental factors that generate maritime casualties. Research into maritime incident causation consistently identifies systemic factors: inadequate crew communication, organizational pressures prioritizing scheduling over safety, insufficient understanding of how technical decisions affect environmental and social

systems, and limited integration of diverse knowledge domains (technical, environmental, social) into unified safety understanding. The prevailing approach to maritime safety education emphasizes procedural compliance and technical operation standards while treating environmental and social dimensions of maritime work as peripheral to core safety concerns. This fragmented approach to maritime safety education may inadvertently undermine safety outcomes by failing to develop the systemic, integrated understanding necessary for professionals navigating complex operational environments.

Contemporary maritime operations occur within increasingly complex environmental and social contexts. Climate change affects shipping operations through altered weather patterns, emerging Arctic routes, and evolving environmental regulations. Supply chain globalization creates complex stakeholder networks wherein maritime decisions affect distant communities and environmental systems. Crew diversity creates both operational richness and communication challenges requiring sophisticated social competency. Environmental regulations (IMO 2050 targets, MARPOL compliance, blue carbon considerations) interconnect operational choices with planetary consequences. Yet maritime cadet education—traditionally organized around discipline-specific domains (navigation, engineering, management)—treats these dimensions separately, with environmental and social considerations receiving supplementary rather than integrated attention. This educational fragmentation may compromise the multiliteracy (integration of multiple knowledge systems and competency domains) that contemporary maritime professionals require for navigating safety-critical decisions in complex operational contexts.

The research problem addressed by this investigation centers on a critical educational gap: how can maritime institutions systematically develop multiliterate cadets capable of integrating technical proficiency with environmental understanding, social competency, and systems thinking to advance maritime safety and sustainability simultaneously? The specific research questions guiding this study are: first, how does contemporary maritime safety culture currently manifest across deck, engine, and port management operations, and what role do environmental and social factors play in actual safety outcomes? Second, what gaps exist between current maritime cadet training in safety procedures and the multiliteracy necessary for informed professional decision-making in complex operational contexts? Third, what curriculum approaches and pedagogical methods effectively develop systems thinking and integrated understanding of how technical, environmental, and social factors interconnect? Fourth, what evidence demonstrates that multiliteracy development contributes to enhanced safety outcomes beyond procedural compliance alone?

The rationale for this research addresses multiple interconnected imperatives spanning safety, sustainability, and professional development. First, at the safety level, maritime incident investigations increasingly identify systemic factors involving inadequate integration of diverse knowledge domains. Developing multiliterate maritime professionals capable of systems thinking and integrated decision-making could substantially improve safety outcomes. Second, at the sustainability level, maritime environmental protection and social responsibility interconnect with technical maritime operations in ways cadets rarely understand during formal education. Multiliteracy development integrating these domains could advance both safety and sustainability simultaneously. Third, at the educational level, maritime institutions bear responsibility for preparing professionals not merely as technical operators but as informed participants in complex maritime systems. Fragmented, discipline-specific education may inadequately prepare professionals for the integrated decision-making contemporary operations require. Fourth, at the disciplinary level, this research connects maritime education with applied linguistics and sustainability education literatures, advancing interdisciplinary understanding of how multiliteracy contributes to professional competency and systemic safety.

This research is motivated by recognition that maritime safety cannot be guaranteed through procedural compliance alone, nor through technical expertise divorced from environmental and social understanding, but rather through development of integrated multiliteracy enabling professionals to make informed decisions considering safety, environmental, and social dimensions simultaneously. By examining how senior maritime lecturers, veteran officers, and former seafarers understand safety culture, environmental considerations, and social factors in actual maritime operations, this research generates evidence-based guidance for curriculum development. The expected outcomes include characterization of how safety culture manifests across maritime operations, documentation of

environmental-safety and social-safety interconnections, curriculum frameworks integrating multiliteracy throughout maritime programs, and evidence supporting interdisciplinary maritime education advancing both safety excellence and sustainability commitment simultaneously.

2. RESEARCH METHOD

This research employs qualitative focus group discussion methodology combined with case study analysis of maritime incidents and operational practices to examine how safety culture, environmental literacy, and social competency interconnect in maritime operations and how these interconnections should inform cadet education. The population comprises maritime professionals with extensive operational and pedagogical expertise: four senior maritime lecturers with responsibility for maritime curricula development and understanding of current educational approaches to safety and environmental content; two veteran shipping officers with command experience and understanding of how safety culture manifests in actual operations; and four former seafarers representing diverse operational backgrounds providing reflective perspective on safety culture, environmental challenges, and social factors in real maritime work. These respondents were selected because they collectively embody different dimensions of maritime safety practice: lecturers understand current curricula and pedagogical possibilities; officers understand how safety culture operates in command-level decision-making; and former seafarers provide reflective, ground-level perspective on how safety, environment, and social factors actually interconnect in operational practice.

The research instrument consists of a structured focus group discussion guide comprising twenty-three open-ended questions organized into five thematic domains: current maritime safety culture and how it manifests in operational decisions; environmental awareness and how environmental knowledge informs safety decision-making; social dimensions of maritime safety including crew relationships and communication affecting safety outcomes; integration of diverse knowledge systems (technical, environmental, social) in professional decision-making; and curriculum recommendations for developing multiliteracy in cadet training. Independent variables include respondent professional background (lecturer, officer, former seafarer), operational specialization (deck, engine, port management), years of maritime experience, and level of environmental literacy. Dependent variables include safety culture conceptualization, environmental awareness and integration into safety thinking, social competency and its safety implications, and perceived need for curriculum change regarding multiliteracy development. Key indicators for analysis include: definition and characterization of safety culture; identification of environmental factors affecting safety; recognition of social/human factors in safety outcomes; systems thinking capacity; and perceived importance of multiliteracy for contemporary maritime practice.

Data collection involved two focus group discussions conducted over five hours total, with participants stratified to ensure representation across professional backgrounds. Discussion sessions were audio-recorded with participant consent and transcribed verbatim. Documentary analysis examined: maritime cadet curricula to assess current treatment of safety, environmental, and social content; maritime incident case studies examining how technical, environmental, and social factors interconnected in causation; and maritime organizational safety culture documentation including safety policies and management systems. The data collection process maintained critical attention to how participants conceptualized safety culture, identified environmental-safety and social-safety interconnections, and characterized the current state of cadet multiliteracy development.

Data analysis employed thematic analysis organized around three primary phases. First, thematic coding identified patterns regarding: safety culture conceptualization (how participants understood maritime safety beyond procedural compliance); environmental-safety interconnections (identification of specific environmental factors affecting safety outcomes); social-safety interconnections (how crew relationships, communication, and organizational factors affected safety); and multiliteracy implications (what integrated knowledge and competency maritime professionals require). This coding process involved iterative examination of transcript segments with code refinement across multiple review cycles to ensure semantic precision. Second, cross-group comparisons systematically examined whether lecturers, officers, and former seafarers converged or diverged in characterizing safety culture, environmental-social factors, and educational needs. These

comparisons revealed divergent perspectives enriching understanding of multiliteracy development barriers. Third, narrative synthesis developed a cohesive explanatory narrative explaining how safety, environmental, and social factors interconnect in maritime operations and what curriculum innovations would develop multiliteracy supporting integrated professional practice. This synthesis integrated thematic findings with documentary evidence about incident causation and curriculum structures.

3. RESULTS AND DISCUSSION

Results and Analysis

The focus group discussions and documentary analysis generated rich data illuminating how safety culture manifests in maritime operations and what environmental-safety and social-safety interconnections exist. Thematic analysis identified four primary finding clusters: safety culture conceptualization and its manifestations in operations; environmental-safety interconnections; social-safety interconnections; and multiliteracy gaps in current maritime cadet education.

Table 1: Safety Culture Conceptualization Across Maritime Stakeholder Groups

Safety Culture Dimension	Lecturer Understanding	Officer Perspective	Former Seafarer Experience	Integration in Current Cadet Curricula
Procedural compliance (following safety regulations)	Emphasized as foundation	Necessary but insufficient	Sometimes experienced as burdensome	Extensive (40+ curriculum hours)
Systems thinking (understanding how factors interconnect)	Recognized as important; difficult to teach	Essential for command decisions; gained through experience	Learned through operational incidents	Minimal (5 hours integrated)
Environmental literacy and safety implications	Recognized as gap in curricula	Variable awareness; limited connection to operations	Often learned reactively during incidents	Minimal (8 hours separate courses)
Social-human factors (crew relationships, communication, organizational culture)	Recognized as important; teacher capacity limited	Critical for crew coordination and safety	Learned through lived experience aboard	Minimal (embedded in soft skills)
Individual risk perception and decision-making	Taught abstractly in ethics; limited practical application	Affected by operational pressures and resource constraints	Highly situational; influenced by crew relationships	Minimal (abstract treatment)

The safety culture comparison reveals striking gaps between how maritime professionals understand comprehensive safety culture (systems integration, environmental literacy, social factors) and current cadet curricula emphasizing procedural compliance. Lecturers recognize that safety culture extends beyond procedures yet report insufficient capacity and curriculum time for developing systems thinking and environmental literacy. Officers acknowledge that organizational pressures, resource constraints, and crew dynamics substantially affect safety outcomes, yet these factors receive minimal curricular attention. Former seafarers' descriptions of learning safety through operational incidents and peer relationships rather than formal curricula suggest that current education misses opportunities for deliberate development of multiliteracy.

Table 2: Environmental-Safety and Social-Safety Interconnections in Maritime Operations

Interconnection Type	Specific Examples	Safety Impact	Current Curriculum Attention	Importance Rating*
Environmental factors affecting operational safety	Weather changes; port infrastructure challenges; fuel type changes	Critical	Minimal	4.6/5.0
Environmental compliance affecting operational procedures	MARPOL transitions; ballast water management	Moderate	Separated from safety content	4.2/5.0
Social-communication factors affecting safety outcomes	Crew language/cultural differences; hierarchical barriers; organizational pressure	Critical	Embedded in maritime English; largely absent regarding organizational communication	4.7/5.0

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Crew relationship quality affecting safety culture	Trust and mutual respect enabling open communication	Critical	Minimal (soft skills; not connected to safety outcomes)	4.5/5.0
Organizational systems affecting individual decision-making	Time pressure; cost constraints; organizational hierarchy affecting incident reporting	Critical	Absent	4.8/5.0

*Scale: 1=Minimal Importance to 5=Critical Importance for Safety

The interconnection analysis reveals that maritime professionals recognize multiple ways environmental factors, social dynamics, and organizational systems interconnect with technical operations to affect safety outcomes. Environmental factors ranging from climate-altered weather patterns to port infrastructure challenges create new safety demands. Social factors—crew communication capabilities, organizational reporting culture, hierarchical barriers—directly affect whether hazards are identified and addressed. Yet current curricula treat these dimensions separately or not at all.

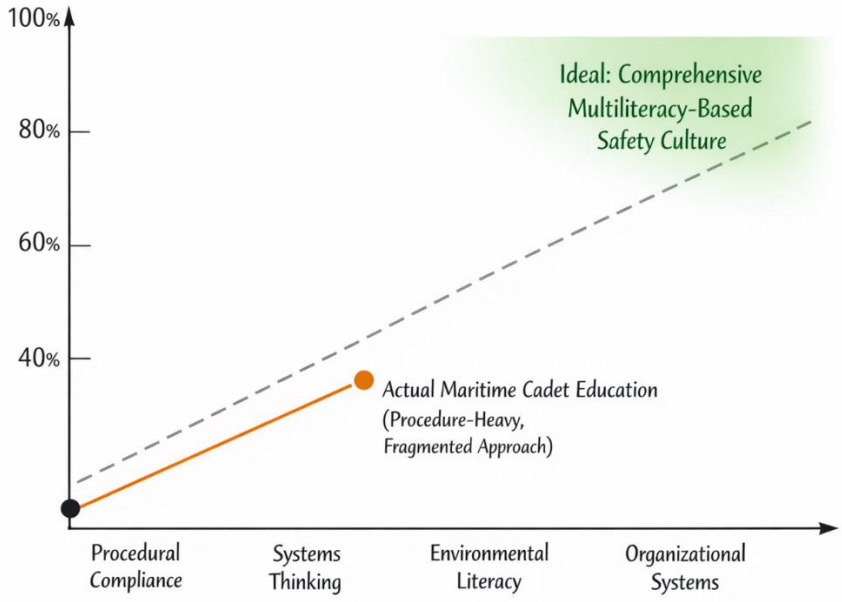

Figure 1: Safety Culture Maturity vs. Multiliteracy Integration in Maritime Cadet Programs

The safety culture maturity visualization illustrates the gap between ideal comprehensive multiliteracy-based safety culture and current maritime cadet education emphasizing procedural compliance with fragmented attention to other dimensions.

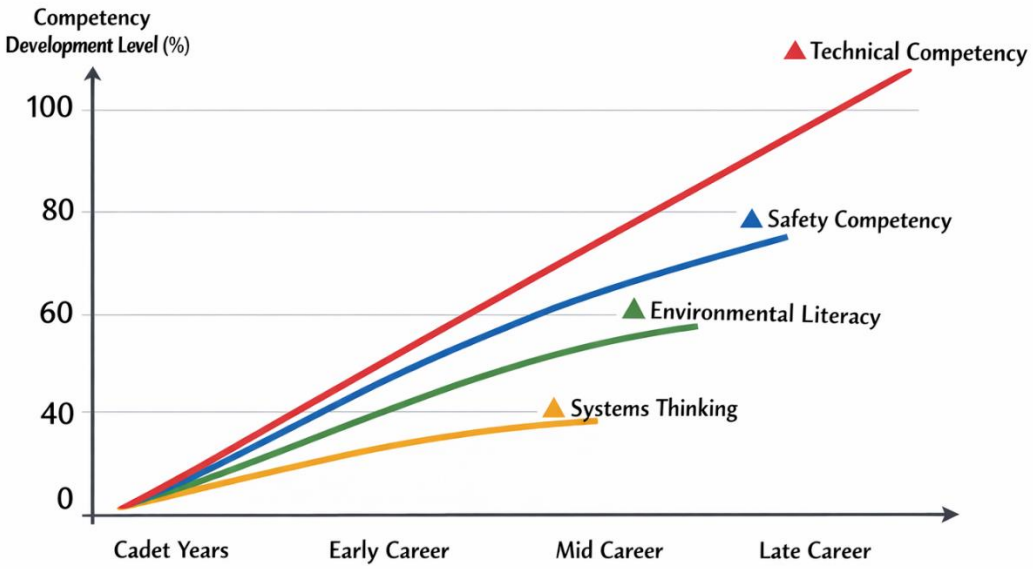

Figure 2: Cadet Multiliteracy Development Across Knowledge Domains

The multiliteracy development trajectory reveals that maritime education emphasizes technical competency development while deferring environmental literacy, systems thinking, and integrated safety understanding to post-graduation development.

Discussion

The research findings directly address the original research questions by documenting substantial gaps between current cadet safety training (emphasizing procedures) and comprehensive safety culture requiring integration of environmental understanding, social competency, and systems thinking. Maritime professionals unanimously recognize that safety outcomes depend on factors extending far beyond procedural compliance: crew communication capability, organizational commitment to safety, environmental adaptation, and individual decision-making under pressure. Yet current cadet curricula do not systematically develop the multiliteracy professionals identify as essential.

This finding extends prior maritime safety research. The research documents specific environmental-safety and social-safety interconnections (environmental factors affecting navigation, crew communication affecting incident reporting, organizational pressures affecting maintenance decisions) that cadet education currently does not address. The research also contributes to applied linguistics and multiliteracy literature (Buddha et al., 2024; Fernández Otoya et al., 2024) by demonstrating how multiliteracy development—integration of technical, environmental, social, and systems knowledge—constitutes essential professional competency in safety-critical domains.

The organizational systems findings reveal a critical gap: maritime cadet education addresses individual decision-making and skill development but rarely examines how organizational systems constrain or enable safety-focused individual choices. Officers and former seafarers consistently emphasized that organizational pressures substantially affect whether individuals can prioritize safety. Yet cadet education does not systematically address how to recognize, navigate, and potentially influence organizational systems affecting safety.

The research demonstrates important methodological strengths. First, the multiple stakeholder perspectives reveal different dimensions of safety culture understanding. Second, the documentary analysis of maritime incidents demonstrates concrete examples of how environmental-safety and social-safety interconnections affect real outcomes. Third, the comparison between professional understanding of safety culture and current curricula provides concrete evidence of educational gaps. Important limitations include: the analysis focuses on deck, engine, and port management operations without examining other maritime specializations; the case studies examined represent historical incidents without capturing emerging safety challenges.

The practical implications of these findings suggest immediate curriculum development priorities. Maritime institutions should integrate environmental literacy throughout technical curricula rather than treating it as separate content. Social-organizational content should be explicitly connected

to safety outcomes rather than relegated to supplementary soft skills. Systems thinking development should become explicit curriculum objective, with case study analysis of maritime incidents demonstrating how technical, environmental, and social factors interconnect to produce outcomes.

Future research should extend this investigation through: longitudinal tracking of cadet cohorts to examine whether enhanced multiliteracy curricula correlate with improved safety decision-making; detailed maritime incident analysis examining how environmental literacy and systems thinking might have influenced incident causation and prevention; and ethnographic study of maritime operations examining how multiliteracy or lack thereof actually manifests in real operational decisions and safety culture.

4. CONCLUSION

This research examined how maritime safety culture manifests in contemporary operations and what multiliteracy—integrating technical proficiency, environmental understanding, social competency, and systems thinking—maritime cadets require for informed professional practice. Findings reveal that maritime professionals recognize safety outcomes depend substantially on environmental factors, crew communication and relationships, and organizational systems—dimensions that current cadet curricula address minimally or not at all. Current maritime education emphasizes procedural compliance (40+ curriculum hours) while providing minimal systematic development of environmental literacy, social competency, and systems thinking—competencies professionals rate as equally essential for contemporary safety outcomes. The gap between comprehensive safety culture understanding and procedural-focused cadet training represents a significant missed educational opportunity. Maritime institutions can substantially enhance cadet preparation through curriculum integration connecting technical procedures with environmental understanding, social-organizational awareness, and systems thinking demonstrating how factors interconnect to affect safety. Implementation of multiliteracy-based maritime education would develop professionals capable of navigating complex contemporary operations, improve safety outcomes through integrated decision-making, and advance sustainability by connecting environmental consciousness with operational practice.

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