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Technical Language Barriers and Engineering Communication Challenges Among Marine Engine Officers: Implications for STCW Certification and Onboard Safety Performance

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***Abstract*—** The engine room represents one of the most technically demanding and communicatively complex environments in maritime operations, yet engineering communication among marine engine officers remains substantially underexplored relative to the well-documented study of bridge communication. This study investigates technical language barriers and engineering communication challenges among marine engine officers within Indonesian maritime institutions, examining their implications for STCW certification outcomes and onboard safety performance. Using a mixed-methods design incorporating a validated technical communication assessment rubric, structured questionnaires, and semi-structured interviews with 115 participants comprising marine engineering educators, engineering cadets, and certified engine officers, the study identifies a pronounced proficiency deficit in machinery-related technical language, particularly in watch handover protocols and emergency engineering communication. Quantitative findings reveal that engineering cadets achieve an overall mean proficiency score of 2.05 on a four-point scale aligned with STCW Chapter III competency standards, falling within the Developing range across all four communication domains assessed. Qualitative analysis attributes this deficit to the dominance of Bahasa Indonesia as the medium of technical instruction, the absence of engineering-specific communication simulation, and a systemic disconnect between language training and technical training programs. The study contributes a theoretically grounded assessment framework specific to engine room communication and advances evidence-based recommendations for curriculum integration, simulator-based pedagogy, and regulatory quality assurance in Indonesian maritime engineering education.

Keywords— *marine engine officers; technical language barriers; engineering communication; STCW certification; onboard safety*

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I. INTRODUCTION

In the architecture of maritime safety, the engine room occupies a position of profound operational criticality that has, paradoxically, attracted far less scholarly attention in the domain of communication research than the navigational bridge. Machinery casualties — encompassing propulsion failures, fire incidents, flooding events, and auxiliary system breakdowns — account for a disproportionately significant share of maritime accidents and economic losses across the global shipping industry. Yet, while the communicative dimension of bridge operations has been extensively theorized, empirically examined, and regulated through instruments such as the IMO Standard Marine Communication Phrases (SMCP), the communicative environment of the engine room remains a comparatively neglected terrain in both maritime education research and regulatory discourse. This asymmetry is analytically troubling, because the consequences of communication failure in engineering operations are no less severe than those on the navigational bridge — and in many technical scenarios, they are considerably more irreversible.

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) addresses engineering communication through Chapter III, which stipulates the competency requirements for engineering watchkeeping officers and chief engineers. The Manila Amendments to the STCW Convention, which entered into force in 2012, strengthened these requirements by specifying that engineering officers must demonstrate proficiency in written and verbal communication related to machinery operation, maintenance procedures, emergency response, and technical reporting [1]. These requirements acknowledge that effective engineering communication is not merely a supplementary skill but a core safety competency — one that determines whether crews can coordinate responses to machinery casualties, execute watch handover protocols accurately, and communicate technical anomalies to shore-based management with the precision and clarity that safety-critical decisions demand.

Despite the clarity of the regulatory mandate, empirical evidence on the state of engineering communication proficiency among marine engine officers — particularly in the context of developing maritime nations with non-English-dominant instructional environments — is strikingly sparse. Schröder-Hinrichs et al. documented that machinery

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casualties attributable in part to miscommunication represent a persistent pattern in maritime accident databases, yet their study, like most in the field, focused principally on bridge communication failures rather than on the engineering operational context [2]. Grech et al. noted more broadly that human factors research in maritime settings has disproportionately privileged navigational scenarios, leaving the engine room as an underexplored frontier in both safety science and professional communication research [3]. This gap is not without consequence: when technical language is ambiguous, imprecise, or absent at critical junctures — during alarm response, watch handover, maintenance debriefing, or emergency coordination — the risk of catastrophic machinery failure is materially elevated.

The challenge of engineering communication is rendered particularly acute by the nature of technical language as a specialized discourse system. Marine engine officers must command a lexical register that spans thermodynamics, hydraulic engineering, electrical systems, fuel management, and environmental compliance, while also possessing the pragmatic competence to deploy that register appropriately across a range of professional communication contexts: verbal watch exchanges, written maintenance logs, machinery alarm reports, and emergency radio transmissions. Halliday and Martin identified the density and abstraction of technical language as its defining characteristics, arguing that technical literacy cannot be acquired through general language instruction but requires discipline-specific pedagogical engagement with the discourse of the target professional community [4]. In the maritime engineering context, this implies that language training and technical training cannot be treated as separate institutional silos — yet this separation remains the norm in many maritime vocational education systems.

The Indonesian maritime education context provides a compelling and practically significant lens for examining these issues. As one of the world's largest seafarer-supplying nations, Indonesia trains substantial cohorts of marine engineering cadets annually across a network of STCW-compliant maritime institutions. These institutions operate predominantly in Bahasa Indonesia as the medium of instruction, meaning that technical English — the language of international maritime engineering manuals, IMO instruments, and onboard machinery documentation — is taught primarily as an additional language rather than as an integrated dimension of technical professional training. Warsono identified this structural duality as a source of significant proficiency variation among Indonesian seafarers [5], while Salehudin and Darmawan pointed specifically to the absence of validated engineering communication assessment frameworks as a systemic gap in Indonesian maritime education quality assurance [6]. The consequence is that engineering cadets may graduate technically competent in Bahasa Indonesia-medium instruction environments yet communicatively underprepared for the multinational, English-language operational realities of international shipping.

Compounding this challenge is the relative absence of SMCP coverage specific to engine room operations. The IMO SMCP provides standardized phrases predominantly for navigational, bridge, and radio communication contexts; its coverage of engineering operational communication is considerably thinner and less systematically structured than its bridge-focused content [7]. This regulatory gap creates a vacuum in which engineering communication training must either draw on general maritime English materials — which typically do not address engineering discourse with sufficient specificity — or develop institution-specific resources that vary in quality, depth, and alignment with STCW competency indicators. Trenkner observed that even for bridge communication, the practical utility of SMCP depends entirely on the rigor and authenticity of the instructional contexts in which it is taught; for engineering communication, where no equivalent standardized phrase system exists, the dependency on institutional quality is even more pronounced [8].

Hetherington et al. demonstrated through their study of safety in shipping that communication failures in engineering spaces — including ambiguous maintenance instructions, incomplete watch handover exchanges, and imprecise alarm reporting — are systematically implicated in machinery-related incidents, often interacting with technical factors to produce accidents that might otherwise have been avoided [9]. Their findings underscore the point made by Pyne and Koester, who argued that the human factors dimension of maritime safety cannot be adequately addressed without attention to the communicative practices through which technical knowledge is shared, coordinated, and acted upon across the engineering crew [10]. These contributions establish a compelling empirical case for the study of engineering communication as a maritime safety priority, yet they do not resolve the question of how engineering communication competency should be defined, assessed, and developed within maritime education institutions.

It is within this analytical space — between the regulatory imperative of STCW Chapter III, the empirical reality of communication-related machinery casualties, and the institutional inadequacy of current engineering communication training in Indonesian maritime education — that the present study situates its contribution. The research focuses on two interrelated dimensions: first, the nature and extent of technical language barriers experienced by marine engine officers and engineering cadets in Indonesian maritime institutions; and second, the implications of these barriers for STCW certification outcomes and onboard safety performance as perceived by educators, cadets, and experienced officers. The study pursues three specific objectives: to assess the technical language proficiency of marine engineering cadets and officers across the key communication domains of engine room operations; to identify the structural, pedagogical, and institutional factors that generate or perpetuate technical language barriers; and to examine the relationship between engineering communication competency and STCW certification readiness as understood by institutional and professional stakeholders.

The overarching research question is: what technical language barriers characterize engineering communication among marine engine officers in Indonesian maritime institutions, and how do these barriers affect STCW certification preparedness and perceptions of onboard safety performance? Theoretically, this question extends the communicative competence framework — most commonly applied in bridge and navigational communication research — into the engineering domain, revealing the domain-specific dimensions of technical language proficiency that general communicative competence models do not fully capture. Empirically, it generates institution-level evidence on a topic that has received virtually no systematic study in the Indonesian maritime education literature. Practically, its findings have direct relevance for curriculum designers, maritime educators, regulatory authorities, and shipping companies seeking to ensure that Indonesian engineering graduates are communicatively as well as technically prepared for the operational demands of international maritime service.

II. LITERATURE REVIEW/ THEORITICAL REVIEW

The theoretical and empirical foundations of this study are drawn from three interconnected domains: the theory of technical communication and technical literacy, the English for Specific Purposes (ESP) framework as it applies to engineering discourse, and the empirical literature on communication in maritime safety and engineering watchkeeping. These bodies of knowledge collectively establish the conceptual scaffolding through which engineering communication barriers can be analyzed as a professional competency concern with direct implications for maritime safety and regulatory compliance.

2.1 Technical Communication and Technical Literacy

Technical communication is a specialized field of professional discourse distinguished by its reliance on domain-specific terminology, procedural precision, and the integration of verbal, written, and instrumental modes of meaning-making. Halliday and Martin provided the most influential theoretical account of technical language, characterizing it by three defining features: grammatical metaphor (the conversion of processes and qualities into nominalized entities), lexical density (a high ratio of content words to grammatical words), and technicality (the use of specialized vocabulary whose meanings are constituted within the discourse community rather than derivable from general linguistic knowledge) [4]. These features have direct implications for engineering communication in maritime contexts: maintenance reports, machinery alarm descriptions, and watch handover records all deploy the nominalizing and lexically dense strategies identified by Halliday and Martin, placing considerable cognitive and linguistic demands on communicators whose technical English proficiency is still developing.

Bachman extended the communicative competence framework by differentiating organizational competence — encompassing grammatical and textual knowledge — from pragmatic competence — encompassing illocutionary and sociolinguistic knowledge [11]. In engineering communication contexts, both dimensions are operationally significant. Organizational competence determines whether an engine officer can accurately encode technical information in written or verbal form; pragmatic competence determines whether the officer can calibrate the communicative register appropriately for different interlocutors — a chief engineer, a machinery manufacturer's technical representative, a port state control inspector, or a shore-based technical superintendent. These distinct communicative demands are not always recognized in maritime English curricula, which tend to prioritize lexical knowledge over pragmatic adaptability.

The concept of technical literacy, as elaborated in the science education and professional training literature, offers a complementary perspective. Knudsen observed that maritime safety procedures — including those governing engineering documentation and alarm response — are embedded in broader institutional and organizational practices that shape how technical language is interpreted and deployed in practice [12]. This observation aligns with a sociocultural view of literacy in which competency is not merely a cognitive attribute of individuals but a socially constituted practice shaped by the organizational environments in which it is exercised. For marine engine officers, this means that technical language proficiency cannot be adequately assessed through decontextualized tests of vocabulary or phrase knowledge; it must be evaluated in relation to the operational contexts and communicative practices of the engine room itself.

2.2 English for Specific Purposes and Engineering Communication

The ESP tradition, from its foundational articulation by Hutchinson and Waters through its more recent elaborations in professional and academic contexts, provides the most directly applicable pedagogical framework for understanding and addressing technical language barriers in marine engineering education [13]. Hutchinson and Waters' principle of needs analysis — the systematic identification of the target communicative tasks and discourse practices of a professional community — is especially pertinent here, given the specificity and complexity of engineering discourse in maritime operations. A rigorous needs analysis of marine engineering communication would need to account for the range of communicative events that engine officers routinely perform: verbal watch handovers, machinery status reports, maintenance planning discussions, technical correspondence with shore management, emergency response coordination, and the interpretation of machinery manuals and technical standards written in English.

Bocanegra-Valle demonstrated that existing maritime ESP materials, while adequate for bridge communication, provide substantially less comprehensive coverage of engineering discourse — an observation that both reflects and reinforces the relative neglect of engineering communication in maritime language pedagogy [14]. Her analysis revealed that even where engineering vocabulary was addressed in maritime English textbooks, it was presented largely in isolation — as decontextualized word lists or simplified technical passages — rather than in the context of the authentic communicative tasks and discourse structures that engineering operations involve. Froholdt made a related point in arguing that maritime English instruction must be grounded in the specific communicative cultures of the professional contexts it serves; the engine room is a communicative culture with its own genres, registers, and interactional norms that demand targeted pedagogical attention [15].

Heikkinen contributed an important lingua franca dimension to this analysis, noting that engineering communication on international vessels frequently occurs between non-native English speakers whose shared technical language may not be sufficient to prevent dangerous misunderstandings in high-stakes operational scenarios [16]. This observation is particularly relevant in the Indonesian context, where engineering cadets trained in Bahasa Indonesia must transition to English-medium operational communication in multinational crew environments — a transition that existing pre-service training programs may not be adequately preparing them to make. Rafli and Utami argued more broadly for a multiliteracy approach to maritime English that would integrate technical, visual, digital, and critical literacy dimensions, a framework that holds considerable promise for addressing the multidimensional nature of engineering communication demands [17].

2.3 STCW Engineering Competency and Its Communication Dimensions

The STCW Convention's Chapter III establishes a comprehensive competency framework for engineering watchkeeping officers, specifying the knowledge, understanding, and proficiency required for safe engineering watch operations, maintenance and repair, control of ship stability, and response to emergencies. The Manila Amendments strengthened these requirements by introducing more explicit provisions for communication competency, mandating that engineering officers demonstrate the ability to receive and transmit information verbally and in writing in English sufficient to ensure safe engineering operations [1]. This regulatory evolution reflects a growing institutional recognition that technical competency and communicative competency are inseparably linked in the engine room context.

Yet, as Trenkner observed in relation to SMCP, the existence of a regulatory requirement does not automatically translate into its effective implementation [8]. Fadly and Masnur documented substantial variation in the interpretation and implementation of STCW Chapter III communication requirements across Indonesian maritime institutions, finding that many institutions treated engineering communication primarily as a documentation compliance issue — ensuring that cadets could complete required paperwork in English — rather than as a domain of applied communicative competency requiring systematic instructional development [18]. Herlambang and Wirawan confirmed this pattern, reporting a persistent disconnect between the English-language technical documentation skills that cadets demonstrated in institutional assessments and the operational communicative competence they required for effective watch handover, machinery alarm response, and emergency engineering coordination [19].

2.4 Safety Communication in Engineering Environments

The maritime safety literature provides a body of empirical evidence that directly links communication quality to safety outcomes in engineering spaces. Hetherington et al. conducted one of the most comprehensive studies of safety in shipping from a human factors perspective, identifying communication failures during watch handover, maintenance execution, and emergency response as recurring precursors to machinery casualties [9]. Their study revealed that imprecise or incomplete communication during watch exchanges — particularly regarding the status of machinery with known defects, temporary modifications, or pending maintenance — was among the most frequently identified proximate causes of engineering-related incidents. Grech et al. extended this analysis through a human factors systems framework, arguing that communication failures in engineering spaces are rarely attributable to individual incompetence but rather emerge from systemic conditions including inadequate training, cultural communication norms, organizational pressures, and the absence of standardized communication protocols for engineering operational contexts [3].

Pyne and Koester analyzed maritime accident data and identified the absence of technical language standards for engineering operational communication as a structural gap in the maritime safety framework — one that contrasts sharply with the regulatory attention given to navigational communication through instruments like the SMCP [10]. Their analysis suggested that the development of standardized engineering communication protocols, analogous to SMCP in function but specific to engine room operational contexts, could substantially reduce communication-related contributions to machinery casualties. Kaspersen and Knudsen further demonstrated that communicative ambiguity in technical reporting — including the use of imprecise or inconsistent terminology in machinery log entries and alarm records — was associated with systematic patterns of risk normalization, in which technical anomalies were systematically underreported or misclassified due to language-mediated barriers to accurate description [20].

Walters synthesized these threads in an analysis of the relationship between language proficiency and safety performance in maritime engineering operations, arguing that the strategic competence dimension of communicative competence — the ability to manage communication breakdown and ensure shared understanding of technical information — is particularly critical in the engineering context, where the consequences of miscommunication may not be immediately apparent but can accumulate into catastrophic machinery failures [21]. This finding resonates with the observations of Schröder-Hinrichs et al., who demonstrated that many machinery casualties involve not sudden communication failures but gradual communicative deterioration — a pattern of incrementally imprecise or incomplete information exchange that creates the conditions for eventual system failure [2].

2.5 Research Gap and Conceptual Position

The literature surveyed above reveals a coherent and analytically productive gap at the intersection of engineering communication, maritime safety, and Indonesian maritime education. While the theoretical frameworks of technical communication, ESP, and communicative competence provide robust conceptual tools for analyzing engineering language barriers, and while the safety literature establishes their operational significance, the systematic application of these frameworks to the assessment of engineering communication competency in Indonesian maritime institutions has not been undertaken. The present study occupies this gap, applying a communicative competence model — extended to incorporate the technical literacy dimensions identified by Halliday and Martin [4] and the needs analysis principles of Hutchinson and Waters [13] — to the empirical examination of engineering communication proficiency and its implications for STCW certification and onboard safety performance. In doing so, it provides both a conceptual contribution to the maritime education literature and a practical evidentiary basis for curriculum reform and regulatory quality assurance.

III. METHOD

The study adopted a concurrent mixed-methods design in which quantitative assessment data and qualitative inquiry were collected and analyzed simultaneously to produce a comprehensive and contextually rich understanding of technical language barriers among marine engine officers in Indonesian maritime institutions. This design was chosen because the research objectives demand both the measurement of engineering communication proficiency across a defined sample and the interpretive exploration of the structural and pedagogical conditions that generate and sustain those barriers — analytical tasks that require complementary rather than competing methodological approaches [22].

The study population comprised three groups directly implicated in the production and assessment of engineering communication competency: maritime engineering educators responsible for STCW-aligned technical English instruction, marine engineering cadets in their penultimate or final semester of pre-sea training, and certified marine engine officers with documented sea service. Through purposive sampling, 115 participants were recruited across two maritime institutions in Jakarta offering IMO-recognized engineering officer programs: 28 maritime engineering educators, 57 engineering cadets, and 30 certified engine officers with a minimum of two years of documented sea service. Purposive sampling was adopted to ensure that all participants possessed direct professional or institutional engagement with engineering communication as either instructors, learners, or practitioners, thereby maximizing the analytical relevance of the data [23].

The primary instruments comprised three components. First, a validated Technical Engineering Communication Assessment (TECA) rubric evaluated participants' communicative competence across four operational domains: machinery watch handover communication, technical fault and alarm reporting, emergency engineering response communication, and maintenance and technical correspondence. Each domain was scored on a four-point competency scale (1 = Below Standard, 2 = Developing, 3 = Proficient, 4 = Advanced), with behavioral descriptors aligned with the competency indicators stipulated in STCW Chapter III and the Manila Amendments [1]. Second, a structured questionnaire captured participants' perceptions of the quality, relevance, and adequacy of engineering communication instruction in their institutional or professional experience. Third, semi-structured interviews were conducted with a purposively selected sub-sample of 18 participants — including educators, cadets, and experienced officers — to elicit rich descriptive accounts of engineering communication challenges, instructional experiences, and perceived safety implications.

Data collection unfolded in two sequential phases. During the first phase, the TECA assessment and structured questionnaire were administered to all 115 participants during scheduled instructional or professional development periods. During the second phase, individual interviews were conducted in Bahasa Indonesia to reduce linguistic barriers to participant expression, subsequently transcribed and translated by a professional maritime translator. Three analytical procedures were applied to the resultant dataset. Thematic analysis was used to identify recurrent patterns in interview and open-ended questionnaire data relating to institutional practice, technical language barriers, and safety perceptions [24]. Cross-group comparison examined statistically and qualitatively meaningful differences in TECA scores and questionnaire responses across the three participant groups. Narrative synthesis integrated quantitative proficiency data with qualitative thematic findings into a coherent interpretive account directly addressing the study's research objectives [25].

IV. RESULTS AND DISCUSSION

4.1 Technical Engineering Communication Proficiency: Domain-Level Distribution

The administration of the TECA rubric across all 115 participants yielded data that reveal a distinctly uneven proficiency landscape across the four engineering communication domains. Table 1 presents the distribution of TECA scores by domain and proficiency level for the full sample.

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TABLE 1
TECA PROFICIENCY LEVEL DISTRIBUTION BY ENGINEERING COMMUNICATION DOMAIN (N = 115)

Engineering Communication Domain	Below Standard (%)	Developing (%)	Proficient (%)	Advanced (%)
Machinery Watch Handover Communication	21.7	40.9	28.7	8.7
Technical Fault & Alarm Reporting	19.1	38.3	33.0	9.6
Emergency Engineering Response	24.3	42.6	25.2	7.9
Maintenance & Technical Correspondence	13.9	35.7	38.3	12.1
Overall Mean	19.8	39.4	31.3	9.5

The distribution presented in Table 1 reveals several analytically significant patterns. Most strikingly, Emergency Engineering Response registered the highest proportion of Below Standard scores (24.3%) and the highest proportion of Developing scores (42.6%), with only 33.1% of participants achieving Proficient or above — a finding that is profoundly concerning given the safety-critical nature of this communication domain. Machinery Watch Handover Communication also demonstrated a markedly elevated proportion of Below Standard (21.7%) and Developing (40.9%) ratings, with fewer than 38% of participants reaching Proficient levels. These two domains — Emergency Response and Watch Handover — are precisely those in which communication failure has been most consistently implicated in maritime engineering casualties, as documented by Hetherington et al. [9] and Grech et al. [3].

By contrast, Maintenance and Technical Correspondence demonstrated the most favorable distribution, with over 50% of participants achieving Proficient or Advanced levels. This pattern is interpretively significant: written technical correspondence, while still demanding, allows for deliberate linguistic construction, reference to documentation, and revision before transmission — cognitive affordances that are absent in the time-pressured, real-time communication contexts of watch handover and emergency response. The overall distribution — with nearly 60% of participants in the Below Standard or Developing range — suggests a systemic shortfall in engineering communication proficiency that is inconsistent with the STCW Chapter III mandate for demonstrable communication competency.

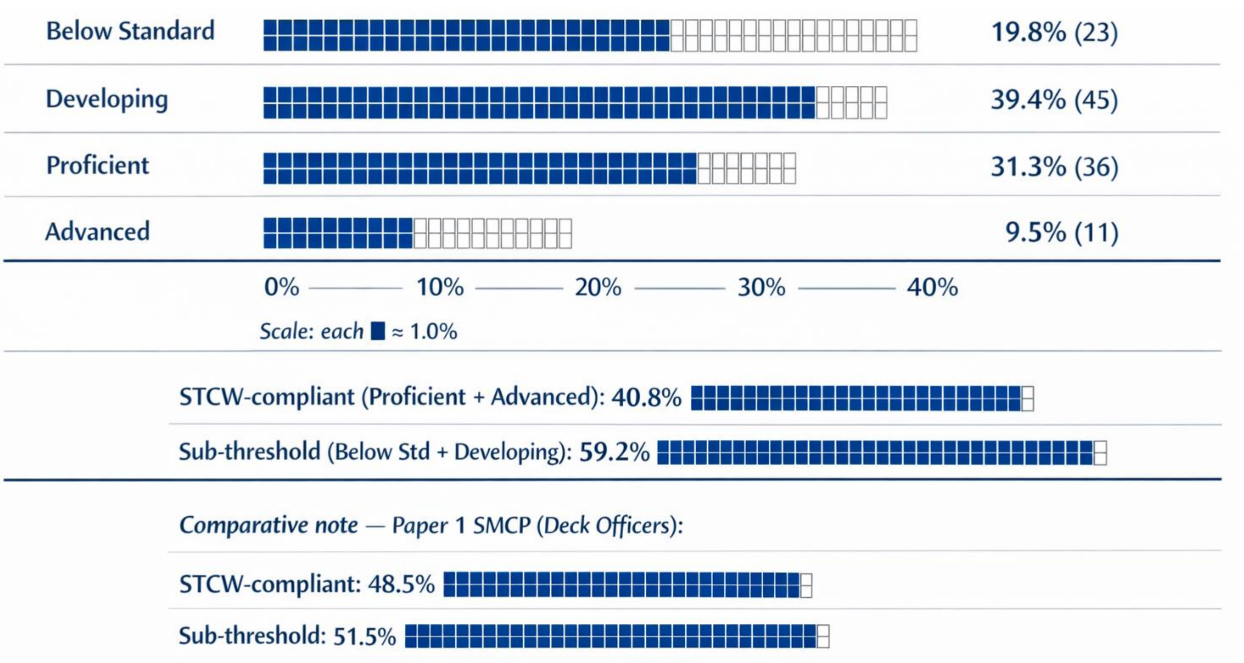

Figure 1: Aggregate TECA Proficiency Level Distribution Across All Participants (N = 115)

The Developing category dominates the TECA distribution (39.4%), indicating that nearly two in five participants have acquired only foundational familiarity with technical engineering language. The combined sub-threshold proportion of 59.2% substantially exceeds that of the companion deck officer study (51.5%), confirming that engineering communication training is more deficient than bridge communication training within the same institutional landscape. The Advanced segment (9.5%) is the smallest of any category, reflecting the rarity of high-level technical English mastery among the sampled population.

4.2 Cross-Group Proficiency Comparison

Table 2 presents mean TECA scores by participant group and communication domain, enabling a systematic cross-group comparison of proficiency levels across the engineering cadet, junior engineer, and senior engineer cohorts.

TABLE 2
MEAN TECA PROFICIENCY SCORES BY PARTICIPANT GROUP AND DOMAIN (1–4 SCALE)

Engineering Communication Domain	Engineering Cadets	Junior Engineers (2–5 yrs)	Senior Engineers (5+ yrs)
Machinery Watch Handover Communication	1.82	2.48	3.10
Technical Fault & Alarm Reporting	1.91	2.57	3.22
Emergency Engineering Response	1.74	2.39	2.98
Maintenance & Technical Correspondence	2.23	2.84	3.45
Overall Mean	2.05	2.57	3.19

The data in Table 2 reveal a consistent and statistically interpretable progression in TECA proficiency from engineering cadets (overall mean 2.05) to junior engineers (2.57) to senior engineers (3.19), replicating the experience–competence gradient observed in the SMCP proficiency data for deck officers in Paper 1 of this series. The engineering cadets' overall mean (2.05) is marginally lower than that of their deck officer counterparts in the companion study (2.10), consistent with the hypothesis that engineering communication training is even less adequately developed than bridge communication training in the sampled institutional context.

The Emergency Engineering Response domain records the lowest scores across all three groups, with senior engineers achieving a mean of only 2.98 — falling just below the Proficient threshold of 3.00. This finding is analytically striking: even the most experienced group in the sample has not reliably achieved Proficient-level performance in the most safety-critical communication domain assessed. The implication is that operational sea experience alone, while consistently improving proficiency, does not fully compensate for the deficiencies of pre-service training in this domain.

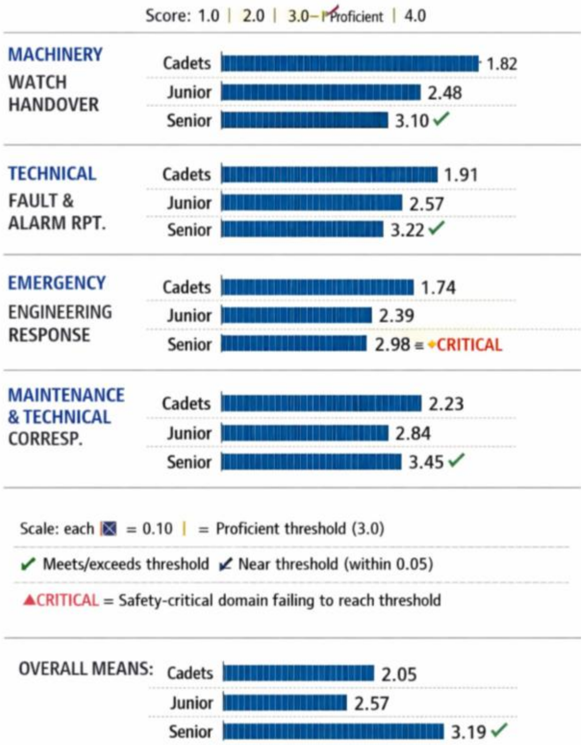

Figure 2: Mean TECA Proficiency Scores by Participant Group and Domain (Scale: 1–4)

The chart reveals a distinctive pattern specific to engineering communication: the Emergency Engineering Response domain fails to reach the Proficient threshold even for Senior Engineers (2.98), despite all other domains reaching 3.0 or above for this group. This domain-specific vulnerability — marked ◀CRITICAL — represents the most urgent instructional and regulatory concern identified in the study. The consistently highest performance across all groups in Maintenance and Technical Correspondence reflects the deliberative character of written communication, which contrasts sharply with the real-time demands of emergency and watch handover contexts.

4.3 Qualitative Thematic Findings

Analysis of the semi-structured interview transcripts and open-ended questionnaire responses produced four dominant themes that illuminate the structural and pedagogical dimensions of technical language barriers in the sampled institutions.

Theme 1: Language–Technical Bifurcation in Curriculum Design. Participants across all three groups described a pervasive structural separation between language instruction and technical instruction, noting that maritime English was taught as a standalone language subject by language specialists while technical subjects were delivered in Bahasa Indonesia by engineering educators. Engineering educators acknowledged that they lacked the language pedagogical training to embed English instruction within technical teaching, while language educators reported limited familiarity with engineering content. This finding aligns with the documentation of institutional fragmentation in Indonesian maritime STCW compliance by Fadly and Masnur [18] and the theory–practice disconnects in Indonesian maritime engineering education identified by Herlambang and Wirawan [19].

Theme 2: SMCP Inadequacy for Engine Room Contexts. Participants consistently noted that SMCP provided insufficient coverage of engine room operational communication. Engineering educators described adapting SMCP materials for engineering contexts as both necessary and inadequate — the phrase structures and functional domains of SMCP are oriented toward bridge and radio communication, requiring substantial supplementation to address the technical discourse of machinery operations. Junior and senior engineers reported relying primarily on onboard exposure to technical documentation and multinational crew interaction rather than on SMCP-based institutional training. This finding corroborates Trenkner's critique of SMCP as an incomplete communication standardization instrument and extends it specifically to the engineering domain [8].

Theme 3: Simulation and Scenario-Based Practice Deficits. Participants uniformly identified the absence of engine room simulation-based communication practice as a significant gap in pre-service training. While several institutions had access to engine room simulators for technical training purposes, these facilities were not systematically used for engineering communication instruction. Engineering cadets expressed particular frustration at having to develop the communicative practices of watch handover and alarm response reactively through real operational experience rather than proactively through rehearsed simulation scenarios. This theme directly implicates the task-based language teaching framework of Ellis as an underutilized instructional resource with high potential relevance for engineering communication training [26].

Theme 4: Safety Perception and Communication Confidence. A distinctive theme not present in the bridge communication data was the explicit articulation of safety anxiety related to engineering communication challenges. Several engineering officers and cadets described instances in which linguistic uncertainty had led them to under-report technical anomalies, to seek informal confirmation from bilingual colleagues before logging observations in English, or to simplify technical descriptions in ways that may have obscured important machinery information. Walters documented similar patterns of safety-compromising linguistic accommodation in his analysis of maritime language and safety performance, and the present qualitative data provide a complementary account of the mechanisms through which language barriers translate into safety risks in the engineering operational context [21].

V. DISCUSSION

The findings of this study constitute a substantive and analytically consequential contribution to the understanding of engineering communication in maritime education, extending the scholarly conversation on maritime English proficiency into a domain that has received insufficient attention relative to its safety significance. The discussion engages critically with the theoretical frameworks of communicative competence theory, ESP pedagogy, safety science, and Indonesian maritime education governance.

5.1 The Safety Implications of Engineering Communication Deficits

The most immediately significant finding of this study is the profoundly below-threshold performance of engineering cadets in the two most safety-critical engineering communication domains: Emergency Engineering Response (mean 1.74) and Machinery Watch Handover Communication (mean 1.82). These scores position the average engineering cadet firmly in the Developing range — well below the Proficient standard required by STCW Chapter III — in precisely the domains where communicative failure most directly contributes to machinery casualties. The alignment between these findings and the empirical documentation of Hetherington et al. [9] and Grech et al. [3] is not coincidental; it reflects the same underlying institutional reality: that engineering communication training in Indonesian maritime institutions does not systematically develop the operational communicative competencies that maritime safety demands.

The qualitative theme of safety perception and communication confidence adds a further dimension of concern. The documented tendency of cadets and junior officers to under-report technical anomalies, simplify alarm descriptions, or seek informal bilingual mediation before communicating formally in English represents not merely an educational shortfall but a safety behavior pattern that actively distorts the information flow on which engineering decision-making depends. Kaspersen and Knudsen identified this phenomenon of communicative risk normalization in broader maritime contexts [20]; the present data demonstrate its specific manifestation in the engine room, where the consequences of imprecise technical reporting can be compounded by the sequential and interdependent nature of machinery systems. Pyne and Koester argued that these systemic communication failures are among the most persistent and tractable contributors to maritime accidents — tractable because they are amenable to educational intervention, persistent because they have not been adequately prioritized in training design [10].

5.2 The Language–Technical Bifurcation and Its Consequences

The qualitative finding of language–technical bifurcation in curriculum design provides an analytically powerful explanation for the proficiency patterns observed in the quantitative data. When maritime English instruction is structurally separated from technical instruction — delivered by different educators, in different disciplinary contexts, and without systematic coordination of content — cadets cannot develop the integrated technical language competency that engineering operational communication requires. Halliday and Martin's characterization of technical language as a discourse system constituted within professional practice rather than derivable from general linguistic knowledge implies that technical language cannot be effectively taught in decontextualized language classes; it must be encountered, practiced, and assessed in the context of the engineering knowledge and practices it represents [4].

This implication points toward curriculum integration as the primary pedagogical response to the bifurcation problem. Bocanegra-Valle advocated for the development of integrated maritime ESP materials that embed language instruction within technical content — an approach elaborated under the rubric of content and language integrated learning (CLIL) [14]. In the Indonesian maritime engineering context, CLIL-based curriculum design would involve restructuring engineering technical subjects to incorporate explicit English-medium communication tasks — machinery watch handovers conducted in English, fault reports drafted in technical English, emergency response protocols rehearsed in English-medium simulation — while simultaneously providing language support structures that enable non-native English speakers to access technical content without sacrificing depth or accuracy.

5.3 SMCP's Limitations and the Engineering Communication Regulatory Gap

The consistent identification by participants of SMCP's inadequacy for engine room communication contexts points to a regulatory gap that extends beyond the pedagogical and into the domain of international maritime governance. The finding substantiates the concern raised by Trenkner regarding the operational incompleteness of SMCP as a communication standardization framework, and extends it to the engineering domain where no equivalent regulatory instrument currently exists [8]. In the absence of standardized engineering communication protocols analogous to SMCP, training institutions must develop their own engineering communication frameworks, resulting in the institutional variability documented by Fadly and Masnur [18] and the proficiency inconsistencies demonstrated in the present study's quantitative findings. The development of an Engine Room Communication Standardization framework — specifying standard phrases, protocols, and discourse conventions for watch handover, alarm reporting, emergency response, and technical correspondence — would represent a significant regulatory contribution analogous to the role SMCP plays for bridge communication.

5.4 The Experience–Competence Gradient and Pre-Service Training Design

The cross-group comparison data reveal a pattern whose implications for the current architecture of pre-service engineering education are troubling: senior engineers (mean 3.19) demonstrate substantially higher technical communication proficiency than junior engineers (2.57), who in turn substantially outperform cadets (2.05) — yet this progression is driven primarily by operational sea experience rather than institutional training. The finding that even senior engineers approach but do not clearly exceed the Proficient threshold in Emergency Engineering Response (mean 2.98) suggests that this critical domain requires not merely operational experience but structured, rehearsed communicative practice under conditions that approximate the cognitive and temporal demands of real emergencies. Ellis's task-based language teaching framework offers a principled pedagogical approach to designing such practice, through the development of simulation tasks that authentically replicate the communicative demands of emergency engineering coordination in the pre-service training environment [26].

The finding that Maintenance and Technical Correspondence shows the most favorable proficiency profile across all groups reflects the deliberative and documentation-based character of this communication type. Written technical correspondence allows for reflective language processing and revision that real-time communication does not, and the accumulation of experience with machinery documentation in English provides a natural route to proficiency development. This observation suggests a pedagogical sequencing principle: engineering communication instruction should begin with written documentation tasks — where cognitive pressure is lower and feedback loops are more accessible — before progressing systematically to the time-pressured, real-time communication contexts of watch handover and emergency response.

5.5 Scholarly Contribution, Limitations, and Future Directions

This study makes several identifiable scholarly contributions. It is the first empirically grounded, institution-level assessment of technical engineering communication proficiency among marine engine officers in Indonesia, generating quantitative and qualitative data that substantially extend the existing maritime education research base. It demonstrates the relevance and applicability of the communicative competence framework — supplemented by Halliday and Martin's theory of technical language [4] — to the specific domain of engine room engineering communication. The TECA rubric developed and applied in this study represents a practically deployable assessment instrument that could be adopted by maritime institutions, flag state authorities, and classification societies seeking to implement outcome-based evaluation of STCW Chapter III communication requirements.

The study's limitations include the restriction of the sample to two Jakarta-based institutions, which limits geographical generalizability. The TECA assessments were conducted in a formal institutional setting rather than in live operational conditions, which may affect the ecological validity of some proficiency measurements. The cross-sectional design prevents causal inference about the mechanisms through which specific instructional practices influence proficiency outcomes. Future research should pursue longitudinal tracking of engineering communication proficiency from pre-service training through early sea service, comparative analysis across a geographically broader sample of Indonesian maritime institutions, and quasi-experimental studies examining the effectiveness of CLIL approaches and simulation-based communication training in improving TECA proficiency scores.

5.6 Implications for Policy, Curriculum, and Professional Practice

The findings carry direct and actionable implications across three levels. At the institutional curriculum level, the evidence supports the urgent integration of technical English communication instruction within engineering technical subjects, the adoption of task-based and simulation-based pedagogical approaches for Emergency Response and Watch Handover communication, and the development of engineering-specific communication assessment instruments aligned with STCW Chapter III requirements. At the regulatory governance level, the findings support a call for the development of a standardized engineering communication framework analogous to SMCP, and for the strengthening of STCW quality assurance mechanisms to include outcome-based assessment of engineering communication competency rather than mere compliance documentation. At the professional and industry level, shipping companies and crewing agencies should be aware that Indonesian engineering graduates may arrive at their first assignments with communicative limitations in safety-critical domains, and should invest in structured onboarding programs that include targeted engineering communication development.

VI. CONCLUSION

This study has demonstrated that technical language barriers among marine engine officers in Indonesian maritime institutions constitute a systemic and safety-consequential problem rooted in structural curriculum bifurcation, the regulatory incompleteness of SMCP for engineering communication contexts, and the chronic underutilization of simulation-based pedagogical approaches. Engineering cadets graduate with overall communication proficiency in the Developing range, most acutely deficient in the domains of Emergency Engineering Response and Machinery Watch Handover — precisely the contexts in which communication failure most directly endangers operational safety. The findings make a compelling case for curriculum integration, the development of engineering-specific communication protocols, and more rigorous outcome-based quality assurance in Indonesian maritime engineering education. Resolving these deficits is not a marginal instructional refinement but a prerequisite for ensuring that the engine rooms of internationally trading vessels are staffed by officers whose communicative as well as technical competency meets the standards that safe maritime operations demand.

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