

Comprehension and Application of Collision Regulation (COLREGs) among Second Year Maritime Students in Simulated Navigational Scenario

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ABSTRACT

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Correctly comprehending and applying the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs) remains genuinely difficult for maritime professionals worldwide, yet no published study has evaluated how second-year students' profile, study habits, and instructor qualifications relate to COLREGs comprehension and application within simulated navigational training. This study determined the extent of COLREGs comprehension and application among second-year Bachelor of Science in Marine Transportation students at the Merchant Marine

Academy of Caraga, Incorporated (MMACI), and established whether student profile, study habits, and student-instructor perceptual alignment related meaningfully to these outcomes. The study employed a quantitative descriptive-correlational design. Respondents were 71 participants (70 students, proportionally sampled from 139 across four sections, and one instructor), surveyed using a three-part questionnaire adapted from validated instruments and analyzed using frequency and percentage distributions, weighted means, chi-square, and one-way analysis of variance. Students strongly agreed that instruction supported COLREGs

comprehension (weighted mean = 3.53) and application (3.51), rating simulated exercises highest but allotted practice time and anchorage-area scenarios lowest. Student profile (sex, academic performance) showed no significant relationship with study habits (all $p > 0.05$), and no significant difference emerged between students' and their instructor's perceived comprehension and application ($F = 1.020$, $p = 0.316$). These findings indicate that MMACI's simulation-based COLREGs training is generally effective and consistently calibrated between students and instructor, but that practice time and less commonly rehearsed scenarios represent specific, actionable targets for a proposed sustainability program to reinforce experiential learning.

INTRODUCTION

Maritime sector human resources must be well versed in international navigational regulations, particularly the 1972 Convention on the International Regulations for Preventing Collisions at Sea (COLREGs), to avoid collisions and keep vessels sailing safely, an imperative that grows more pressing as globalization intensifies competence demands across the industry (International Maritime Organization, 1972/2018; Kurniadi, Mu'tamar, Santoso, & Harianto, 2024). Robles (2022) traced the COLREGs' origins to eighteenth-century United Kingdom seafaring practice, noting that the regulations gained international acceptance specifically because their rules are simple, technology-independent, and require minimal disruption to navigational practice, qualities that have allowed near-universal state adoption since the convention's entry into force in 1977. Despite this apparent simplicity, correctly applying COLREGs in complex, real-time navigational situations remains genuinely difficult: an international survey of marine professionals found that Rule 14 (head-on situations) and Rule 15 (crossing situations) are among the regulations most frequently violated and misunderstood in practice (Rudan et al., 2024), a concern consistent with a much earlier large-scale industry survey of over 450 maritime professionals across 31 countries, which similarly found widespread misunderstanding and disregard of COLREGs and traced much of this gap to insufficient training and overreliance on technology rather than to the rules' inherent complexity (Syms, 2002). Pietrzykowski and Malujda (2012) further argued that many COLREGs provisions are inherently imprecise for the range of sea conditions they must cover, prompting research into fuzzy-logic-based decision-support systems to reduce this ambiguity in navigational judgment.

Simulator-based training has become a central strategy worldwide for closing the gap between COLREGs theory and shipboard practice. Suhrab, Islam, Shamsuri, Hamid, Fuad, and Said (2023) found that nautical science students trained with simulators demonstrated deeper COLREGs understanding, stronger situational awareness, and greater confidence in critical scenarios than students trained through conventional classroom methods alone. Similarly, Karahalil, Lützhöft, and Scanlan (2023) found that maritime simulator-based education has traditionally relied on

informal, instructor-experience-dependent evaluation, and they called for more formal, objective formative-assessment protocols to ensure consistent skill development across training cohorts; deliberate scenario design, rather than simulator exposure alone, has similarly been identified as a decisive factor in whether simulated training transfers into genuine competence (Harrington, 2024). Türkistanlı and Kuleyin (2022) extended this line of research by developing a game-based collision-prevention training module, finding that gamified decision-making exercises meaningfully improved maritime engineering students' collision-avoidance judgment relative to traditional instruction, a pattern consistent with the broader active-learning literature showing that structured, comprehensively measured active-learning approaches outperform passive instruction across higher-education contexts generally (Carr, Palmer, & Hagel, 2015). Comparable simulator-based training research in other maritime specializations, such as pilotage, similarly finds that trainees develop visual and situational expertise progressively through repeated, guided practice in virtual environments (Sellberg, Nordenström, & Säljö, 2024). At a more technical level, Namgung and Kim (2021) proposed a COLREG-compliant collision-risk inference system for maritime autonomous surface ships, while Eriksen, Bitar, Breivik, and Lekkas (2020) developed a velocity-derived heading-obstacle algorithm ensuring autonomous vessels maintain safe separation under COLREGs constraints; Sun (2021) cautions, however, that COLREGs as currently written contain substantial ambiguities that complicate their direct application to unmanned vessels, together illustrating how COLREGs compliance is being actively engineered into, and contested within, the emerging generation of uncrewed and autonomous maritime systems.

Within the Association of Southeast Asian Nations (ASEAN) region, empirical attention to COLREGs training effectiveness has centered on Malaysia. Suhrab and colleagues (2023), based at the Universiti Malaysia Terengganu, found that simulator-based instruction produced measurably stronger COLREGs comprehension among Malaysian nautical science students than self-directed e-learning or conventional classroom teaching alone, a finding subsequently extended by Abid, Suhrab, Osnin, Nik, and Hammad (2024), who conducted a survey-based comparison of self-e-learning, classroom teaching, and simulation training among the same student population and found simulation training to be the most consistently effective modality across learning outcomes. In the Philippines, gender representation within maritime education has also drawn documented concern: Sotes, Agad, Undap, Achicoso, Guiral, Ignacio, Malaki, and Torralba (2024) found, in a descriptive-correlational study of 554 maritime students at MMACI, significant gender disparities favoring male enrollment in both Marine Engineering and Marine Transportation programs, attributing this pattern to interconnected structural and social barriers requiring targeted institutional intervention.

The Merchant Marine Academy of Caraga, Incorporated, established in Butuan City in 2018, has since secured Commission on Higher Education and Maritime Industry Authority recognition for its Bachelor of Science in Marine Transportation program (2019) and International Organization for Standardization

9001:2015 certification (2020), reflecting sustained institutional investment in maritime training quality. Despite the extensive global and regional literature on simulator-based COLREGs training, no published study has evaluated how second-year MMACI students' own profile characteristics, study habits, and their instructor's qualifications relate to their comprehension and application of COLREGs specifically within MMACI's simulated navigational scenarios. This gap justifies the present study, which the researchers undertook to determine the extent of COLREGs comprehension and application among MMACI's second-year maritime students, and to establish whether student profile, study habits, and student-instructor perceptual alignment relate meaningfully to these outcomes.

FRAMEWORK

This study is anchored on David A. Kolb's (1984) experiential learning theory, a constructivist model that defines learning as an iterative cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation. Applied to COLREGs instruction, students engage in concrete experience during simulated navigational exercises, encountering genuine navigational dilemmas that require them to determine which rule applies to a given encounter; they then reflect on their performance, conceptualize the underlying rule logic in the abstract, and actively experiment with refined decision-making in subsequent simulation rounds. This cyclical structure directly frames the present study's central research problem: whether repeated simulated experience, more than static profile characteristics or study habits, drives students' practical comprehension and application of COLREGs.

Kolb's model further predicts that learning effectiveness depends on successfully completing all four stages of the cycle rather than any single stage in isolation, meaning that simulation exposure alone would be insufficient without structured reflection and conceptual reinforcement from instructors. This prediction directly informs the study's inclusion of faculty profile (eligibility, rank, sea-going experience, and International Maritime Organization training) as a study variable, since instructor qualification plausibly shapes the quality of the reflective-observation and abstract-conceptualization stages that convert raw simulation experience into durable comprehension. The study's three input variables, student profile, faculty profile, and study habits, are accordingly positioned as factors that may moderate how effectively students move through Kolb's cycle, while comprehension and application of COLREGs serve as the throughput-stage outcome that the resulting sustainability program output is designed to reinforce.

OBJECTIVES

This study examined the comprehension and application of COLREGs among second-year marine transportation students through the following specific objectives: (1) determined the profile of second-year marine transportation students

in terms of age, sex, and academic performance; (2) determined the profile of the marine transportation faculty in terms of eligibility, rank, sea-going experience, and International Maritime Organization training; (3) described the study habits of second-year marine transportation students in terms of delay avoidance and work method; (4) described the level of comprehension and application of COLREGs among second-year marine transportation students; (5) determined whether a significant relationship exists between student profile and study habits; (6) determined whether a significant difference exists between marine transportation students' and their instructor's perceived comprehension and application of COLREGs; and (7) proposed, based on the results, a sustainability program to improve comprehension and application of COLREGs among maritime students.

METHODOLOGY

Research Design

The study used a quantitative descriptive-correlational design, gathering numerical data to identify patterns, test relationships and differences, and generalize findings to a wider population (Bhandari, 2020). This design allowed the researchers to evaluate students' comprehension and application of COLREGs based on their performance during simulated navigational scenarios, using bridge simulators to assess competencies including situational awareness, decision-making, and teamwork, while also testing whether student profile related to study habits and whether student and instructor perceptions of COLREGs performance differed significantly.

Research Site

The study was conducted at the Merchant Marine Academy of Caraga, Incorporated (MMACI), located at North Montilla Boulevard, Barangay Ong-Yiu, Butuan City, Philippines. Founded in 2018, MMACI received Commission on Higher Education and Maritime Industry Authority recognition for its Bachelor of Science in Marine Transportation and Bachelor of Science in Marine Engineering programs in July 2019.

Participants

Respondents were second-year Bachelor of Science in Marine Transportation students who had completed the COLREGs course during the second semester of school year 2023–2024, drawn from four sections (Alpha, Bravo, Charlie, and Delta) totaling 139 students, plus one course instructor, for a total population of 140. Using the 50-percent-plus-one sampling technique, 71 respondents participated: 70 students proportionally distributed across the four sections, and one instructor specializing in navigation, seamanship, and maritime law with 5 to 20 years of maritime education and practice experience.

Instrumentation

Data were gathered using a three-part survey questionnaire. Part I captured student profile (age, sex, and academic performance) and faculty profile (eligibility, rank, sea-going experience, and International Maritime Organization training). Part II, measuring comprehension of COLREGs, was adapted from a validated instrument developed by Suhrab (2023) for a study of nautical science students' simulator training at the Universiti Malaysia Terengganu; the application-of-COLREGs items were adapted from a large-scale industry survey of COLREGs application among maritime professionals (Syms, 2002). Part III, measuring study habits in terms of delay avoidance and work method, was adapted from a validated instrument developed by Tus (2020) on study attitudes and academic performance. All items used a four-point Likert scale (4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree).

Research Ethics Protocol

Participation was voluntary, and respondents retained the right to decline. Signed informed consent and information forms documented voluntary participation, and an in-person discussion covered the optional disclosure of personal information. The researchers secured written approval from the college dean prior to data collection. Response data were treated with strict confidentiality, stored on a password-protected flash drive accessible only to the research team, and used solely for the stated research purpose.

Data Collection

The data collection process was undertaken following a well-defined and ethical protocol. Approval letters were first prepared and submitted to the school principal and practical research subject teacher to authorize the survey, alongside securing clearance from the dean of the College of Maritime Education through a formal request letter for approval. Subsequently, respondents meeting the predefined criteria were selected through random sampling from students available on the survey date. The purpose of the study was thoroughly explained prior to administering the printed questionnaires to the participants. Upon completion, the filled questionnaires were collected by the researchers. Finally, the findings were interpreted and analyzed to draw conclusions and determine the study's results.

Data Analysis

The researchers used frequency and percentage distributions to summarize respondent profile data, weighted mean to interpret the extent of study habits and COLREGs comprehension and application (Objectives 1–4), the chi-square test to determine whether a significant relationship existed between student profile and study habits (Objective 5), and a one-way analysis of variance to determine whether a significant difference existed between students' and their instructor's perceived comprehension and application of COLREGs (Objective 6).

RESULTS AND DISCUSSION

Student and Faculty Profile

Table 1

Respondent profile by age, sex, academic performance, and faculty qualification

Profile variable	Category	f	%
Student age	19–31 years	71	100.0
Student sex	Male	67	94.4
	Female	4	5.6
Student academic performance (final grade)	Good (2.0–2.1)	13	18.3
	Very good (1.8–1.9)	12	16.9
	Superior (1.6–1.7) / Passed (2.9–3.0)	11 each	15.5 each
	Very satisfactory (2.2–2.3)	8	11.3
	Very superior (1.4–1.5)	7	9.9
	Fair (2.6–2.7)	5	7.0
	Satisfactory (2.4–2.5)	4	5.6
Faculty rank	Master/Captain	1	100.0
Faculty sea-going experience	8 years and above	1	100.0
Faculty IMO training	Model Courses 6.09, 6.10, and 3.12 (all completed)	1	100.0

All 71 student respondents fell within the 19-to-31-year age range, reflecting the typical entry-age profile of maritime training programs and the industry's emphasis on early career preparation. Male students substantially outnumbered female students (94.4% versus 5.6%), consistent with the historically male-dominated composition of maritime education and careers; a comparable descriptive-correlational study of 554 MMACI maritime students similarly found significant gender disparities favoring male enrollment across both Marine Engineering and Marine Transportation programs, attributing this to interconnected structural and social barriers requiring targeted institutional intervention (Sotes et al., 2024). Academic performance clustered most heavily in the "Good" (18.3%) and "Very Good" (16.9%) categories, with no student achieving the highest "Excellent" rating, suggesting generally satisfactory but improvable performance in the COLREGs course specifically.

The sole faculty respondent held the rank of Master/Captain, more than 8 years of sea-going experience, and had completed all three International Maritime Organization model courses required for COLREGs instruction eligibility under Commission on Higher Education Memorandum Order 67, series of 2017: Model Course 6.09 (Training Course for Instructors), Model Course 6.10 (Train the Simulator Trainer and Assessor Course), and Model Course 3.12 (Assessment, Examination, and Certification of Seafarers). This fully credentialed profile confirms that MMACI's COLREGs instruction satisfies the Standards of Training, Certification, and Watchkeeping Code's general qualification standards for

instructors, assessors, and supervisors, though, as the Nautical Institute (2011) has cautioned, the Code specifies little about how instructor quality should be developed and sustained beyond baseline certification, meaning credential compliance alone does not guarantee optimal instructional delivery.

Study Habits

Table 2

Extent of student study habits by domain

Study habit domain	Weighted mean	Verbal description
Delay avoidance	3.53	Strongly agree
Work method	3.49	Strongly agree

Students strongly agreed with statements reflecting both delay-avoidance behaviors, such as persisting through difficult assignments and seeking teacher clarification when struggling (mean = 3.53), and structured work-method behaviors, such as clarifying assignment expectations before beginning work (mean = 3.49). At the same time, several individual items revealed a more nuanced pattern: students also strongly endorsed statements describing distraction, such as media-related time loss and difficulty concentrating during study, indicating that self-reported diligence and self-reported susceptibility to distraction coexist rather than being mutually exclusive in this population. This duality is consistent with study-habits research showing that low-achieving students often report specific, identifiable difficulties, such as inefficient time management, difficulty with technical or written expression, and reluctance to seek clarification, even while broadly endorsing effortful study behavior (Aquino, 2011; Boehler, Rogers, Schwind, Fortune, Ketchum, Dunnington, & Coran, 2001).

Comprehension and Application of COLREGs

Table 3

Extent of student comprehension and application of COLREGs

Domain	Weighted mean	Verbal description
Comprehension	3.53	Strongly agree
Application	3.51	Strongly agree

Students strongly agreed that instructional delivery and simulated exercises supported their comprehension of COLREGs (mean = 3.53), with the highest-rated items concerning clarity of instructional delivery and the value of simulated exercises for reinforcing learning (both mean = 3.59); the lowest-rated item concerned whether allotted practice time was sufficient to learn COLREGs (mean = 3.37), suggesting that while instructional quality is strong, practice time itself may be a binding constraint. This finding directly supports Suhrab and colleagues' (2023) conclusion that simulator-based training produces deeper COLREGs understanding than classroom instruction alone, since MMACI students specifically

credited simulated exercises, rather than lecture delivery alone, as their strongest-rated comprehension driver.

Application scores followed a similar pattern (mean = 3.51, "strongly agree"), with students most confident in understanding technical vessel terminology and narrow-channel right-of-way rules (mean = 3.56 each), but comparatively less confident applying COLREGs in anchorage-area scenarios (mean = 3.42) and interpreting sound signals during overtaking in narrow channels (mean = 3.50). These lower-scoring items identify a specific, actionable weakness: students comprehend and apply COLREGs well in common, frequently simulated encounter types, but show relatively less confidence in less commonly rehearsed scenarios such as anchorage navigation, consistent with Kolb's (1984) prediction that experiential learning is scenario-specific and requires repeated, varied practice to generalize, and with evidence that deliberate variety in scenario design, not simply more simulator hours, is what closes this kind of gap (Harrington, 2024).

Relationship Between Student Profile and Study Habits

Table 4

Relationship between student profile and study habits

Profile variable	χ^2	df	P-value	Decision
Age	Not computed (constant)	—	—	No relationship testable
Sex	36.274	25	0.068	Fail to reject the null hypothesis
Academic performance	96.516	100	0.580	Fail to reject the null hypothesis

No significant relationship was found between sex and study habits ($p = 0.068$) or between academic performance and study habits ($p = 0.580$); age could not be tested because all respondents fell within a single age category. This indicates that, contrary to a common assumption that stronger students necessarily exhibit more disciplined study habits, MMACI's second-year maritime students' study habits do not differ systematically by sex or by academic performance level. This finding aligns with comparable maritime-education research showing that study habits do not directly predict academic success in this field, and that instructional and simulation-based methods may play a more decisive role than individual study behavior in shaping outcomes (Ramos, 2024; Gahir, Sahu, & Sahoo, 2022).

Difference Between Student and Instructor Perceptions

Table 5

Significant difference between student and instructor perceptions of COLREGs comprehension and application

Source	F	df1	df2	p-value	Decision
Between groups	1.020	1	70	0.316	Fail to reject the null hypothesis

No significant difference was found between students' and their instructor's perceived comprehension and application of COLREGs ($F = 1.020$, $p = 0.316$). This indicates that the fully credentialed instructor's assessment of COLREGs comprehension and application converges closely with students' self-assessment, suggesting a shared, calibrated understanding of what adequate COLREGs performance looks like within MMACI's simulation-based training environment. This convergence is consistent with research finding that structured, simulation-centered training environments promote uniform understanding of navigational regulations across the instructor-student relationship, rather than producing divergent expert-novice perceptual gaps (Smelikova, 2023; Baldevarona, San Miguel, Bentulan, & Cerbito, 2024).

CONCLUSIONS

Second-year MMACI students demonstrate strong comprehension and application of COLREGs within simulated navigational scenarios (weighted means of 3.53 and 3.51, respectively), supported by a fully STCW-credentialed instructor whose perceived assessment of student performance does not differ significantly from students' own self-assessment. This study's principal contribution beyond existing literature is its demonstration that, within an already well-functioning simulation-based training environment, the remaining performance gap is concentrated in a specific, identifiable resource constraint, allotted practice time and the frequency of less commonly rehearsed encounter types such as anchorage-area navigation, rather than in student demographics, study habits, or instructor qualification. This finding supports Kolb's (1984) experiential learning theory while refining its application to maritime training: the theory's predicted link between concrete experience and durable comprehension holds, but only where that experience is varied across encounter types, not merely frequent overall. These findings indicate that a targeted, scenario-diversifying enhancement to MMACI's existing simulation-based COLREGs training, rather than a wholesale curricular overhaul, represents the most evidence-based path to closing the remaining comprehension and application gap.

TRANSLATIONAL RESEARCH

Consistent with this study's seventh objective, the findings could be translated directly into a proposed sustainability program: the COLREGs Experiential Learning Enhancement Program (CELEP). The program would address the study's two specific, actionable findings directly. First, since allotted practice time was the

lowest-rated comprehension item, it is suggested that MMACI's College of Maritime Education consider allocating additional dedicated simulator hours within the existing COLREGs course schedule, prioritizing repeated exposure without displacing other curricular requirements.

Second, because anchorage-area scenarios and narrow-channel overtaking sound-signal interpretation were the lowest-rated application items, the program could expand the existing simulation scenario bank to increase the frequency of these specific, currently underrepresented encounter types, helping ensure that Kolb's (1984) concrete-experience stage covers the full range of COLREGs situations rather than concentrating on the most common ones. Third, to help sustain the demonstrated instructor-student calibration documented in this study, CELEP could formalize a structured post-simulation reflection protocol, an explicit reflective-observation and abstract-conceptualization step following each simulation round, so that future instructor cohorts, not only the current highly credentialed instructor, might reliably reproduce this calibration.

It is proposed that CELEP be piloted with the incoming second-year cohort and evaluated using the same comprehension, application, and student-instructor alignment measures employed in this study, which would allow MMACI to track whether the targeted scenario and practice-time enhancements measurably close the gaps identified here.

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