

# Students' Achievement in Science and Specialized Maritime Courses' Matched Learning Competencies

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**Abstract:** Science is considered the backbone of technology. This study examined the matched learning competencies between Earth and Life Science and Navigational Watch among students in the Technical-Vocational-Livelihood Maritime strand at a public secondary school in Central Philippines. Experts were tapped to examine the learning competencies in science and maritime courses in senior high school. Competency mapping validated by maritime experts revealed clear links between geoscientific concepts and practical maritime skills, confirming the effectiveness of integrated curriculum models. Matched competencies were identified and a 50-item multiple choice examination was developed, validated (CVI = 0.81) and pilot-tested (Fleiss Kappa = 0.77). The test was administered to 79 Grade 11 and 12 TVL Maritime students, who showed a reasonable overall performance, with Grade 11 students outperforming Grade 12 students, indicating stronger information retention and motivation at the earlier stage. Four contextualized lesson plans aligned with DepEd's MELCs were developed, integrating Earth and Life Science principles with navigation practices. These serve as both instructional tools and resources for disaster risk reduction and maritime safety, highlighting the value of multidisciplinary education in producing scientifically literate and navigationally skilled seafarers.

**Keywords:** Science Education, Maritime Education, Interdisciplinary Learning, Descriptive Research, Central Philippines.

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## I. INTRODUCTION

The Philippine maritime education system has undergone significant changes in the context of the K-12 curriculum, notably the addition of the TVL Maritime strand in SHS. Navigational Watch 1 and 2 courses - the fundamental subjects in this curriculum program, created to conform with international marine standards and for the purpose of sustaining the increasing demand for profoundly competent seafarers [1]. These distinct programs are skillfully crafted to conform with STCW or the Standards of Training, Certification and Watchkeeping for Seafarers Convention pursuant to both the Maritime Industry Authority's (MARINA) prerequisites, jointly with the Department of Education (DepEd). The curriculum includes vital competencies such as safe navigational watchkeeping practices, maritime communications procedures, collision prevention regulations, and emergency procedures [2].

Through classroom and simulator-based instruction, students build proficiency in ship handling, passage planning, and marine safety critical to careers as professional mariners. The integration of these classes into the Senior High School

(SHS) program certifies careful consideration regarding their inclusion. They serve entirely as preparatory education for students who wish to pursue a career in shipping, which may be through Bachelor of Science courses in nautical and marine engineering (e.g., BSMT or BSMarE). Furthermore, they develop key professional characteristics, including self-discipline, responsibility, and ethical decision-making, which are important in the maritime arena [3].

Alongside specialized maritime instruction, Earth and Life Science is a core component of the SHS curriculum, enabling students to gain a comprehensive understanding of Earth's systems and biodiversity. This scientific foundation is based on geological procedures, atmospheric dynamics [4], and oceanographic principles that cover ecosystem interactions. These are areas of knowledge that pertain to maritime operations. The embedding of Earth and Life Science in maritime curriculum addresses important ecological literacy requirements for seafarers. Current issues in maritime and seas include the impacts of climate change on the seas, extreme weather, and the maintenance of marine ecosystems, which demand that seafarers have advanced knowledge of environmental science [4-7]. Studies have shown that mariners

with solid scientific backgrounds make better decisions in navigation, weather routing, and environmental risk assessment. The focus on sustainable shipping and environmental compliance in international maritime law also requires seafarers to have a general scientific background [7].

The incorporation of scientific knowledge and maritime technical skills typifies a shift in paradigms within MMLE towards diversified competence development. This integration recognizes that contemporary maritime operations require cadres able to combine theoretical scientific considerations with practical knowledge of navigation [7]. This cross-fertilization is no more obvious than in modern-day maritime problems. For instance, the identification of meteorological conditions and marine events in Earth and Life Science is immediately related to navigation safety and economic efficiency. Likewise, understanding of marine ecosystems and environmental processes underpins implementation of international environmental standards and the use of sustainable forms [8], [9]. The literature on TIP in higher education shows that an interdisciplinary approach to teaching and learning enhances students' problem-solving, critical thinking, and professional flexibility [10]. Additionally, this combined approach is consistent with competency-based education systems that aim to apply acquired theoretical knowledge in practitioner roles.

Recent studies on maritime education research in the ASEAN and the Philippines have also moved to the fore, with Maung [11] showing that simulation-based learning enhances students' navigation ability and confidence, Jogo & Rosmayana [12] in both opportunities and problems of digital technology integration, Soritua Sijabat et al. [13] establishing more appropriate competency assessment frameworks of international standards is proposed, and Carlos [14] revealing high correlations between interdisciplinary skills and maritime professional success. However, there is a pressing need to understand the science competencies and how they apply to the realization of maritime training outcomes in Philippine senior high school settings. Although marine and science education are two separate areas of study, little is known about their integration in the K-12 curriculum as an interdisciplinary category. In the absence of empirical knowledge about how Earth and Life Science skills support maritime competency development, educators are challenged to target their curriculum design better and determine which students will need targeted additional support. This gap is attempted to be addressed in this study involving students from a public secondary school in the central Philippines, one of the few schools under the DepEd that offer the specialized maritime course when senior high school was implemented in 2016. The research examines the performance of maritime students in Earth and Life Science, as well as their cognitive alignment with Navigational Watch competencies, to inform curriculum development, teaching practices, and student support services in Philippine maritime education.

## II. METHODOLOGY

This study utilized a descriptive-quantitative research design with a cross-sectional approach to examine the achievement of learning competencies in Earth and Life Science among specialized maritime students. The quantitative methodology was selected for its capacity to provide objective, measurable data that can be statistically analyzed to determine

patterns and relationships in student academic performance [15]. This design enables the systematic collection of numerical data while maintaining objectivity in data interpretation, which is essential for educational assessment research [16]. The cross-sectional nature of the study allows for the capture of student achievement and motivational factors at a specific point in time, providing a comprehensive snapshot of the current state of learning outcomes in the specialized maritime program [17].

The study was conducted at a public secondary school in central Philippines during the 2024-2025 academic year. The school was selected through purposive sampling as it offers the Technical-Vocational-Livelihood (TVL) Maritime strand as part of its Senior High School (SHS) program, which aligns with the Department of Education's K-12 curriculum framework. To ensure curriculum alignment and maintain educational standards, Learning Resource Evaluators from the school's division where the study was conducted served as expert consultants throughout the study. This collaboration ensured that all assessment instruments and procedures adhered to official curriculum guidelines and competency standards (DepEd, 2023).

The study population comprised 79 TVL-Maritime SHS students, comprising 39 Grade 11 and 40 Grade 12 students. Participants were selected using purposive sampling. This sampling technique was deemed appropriate given the study's focus on a specific subgroup within the broader student population, maritime students with exposure to science-related competencies.

Before the construction of the data-gathering instrument, expert consultations were held with maritime education specialists from two higher education maritime schools. A comprehensive mapping of interconnected competencies was established, revealing significant pedagogical connections between Earth science concepts and practical maritime navigation skills. This will address the objective of matching learning competencies between science and maritime courses.

Data collection was conducted using a 50-item valid (CVI = 0.81) and reliable ( $\kappa = 0.77$ ) researcher-developed questionnaire designed specifically for this study. The instrument consists mainly of a multiple-choice test questionnaire designed for senior high school students in Earth and Life Science, integrated with Maritime/Navigation concepts. The instrument assesses knowledge of Earth's characteristics, geological hazards, navigational tools, ship behavior, hazard mapping, weather patterns, and navigational rules, and was carefully aligned with Department of Education competency standards and validated learning outcomes for the maritime strand [2].

Formal coordination with school administrators and relevant authorities was conducted to secure the necessary permissions and facilitate the ethical implementation of data-gathering activities. Participants, specifically Grade 11 and Grade 12 students enrolled in the TVL-Maritime strand, were thoroughly briefed on the study's objectives, procedures, and confidentiality protocols before providing informed consent. The questionnaire was then administered under controlled conditions to minimize external influences and ensure uniformity in administration across all respondents. Following data collection, the responses were systematically encoded,

reviewed for completeness and accuracy, and subjected to statistical analysis using appropriate quantitative methods.

Descriptive statistics, including means and standard deviations, were calculated to summarize participant characteristics and achievement levels across learning competencies.

To address the general principles of conducting research, the researcher observes the ethical guidelines set by the Philippine Health Research Ethics Board (PHREB).

### III. RESULTS AND DISCUSSION

#### A. Matched competencies of Earth and Life Science and Navigational Watch 1 and 2 in Grade

This study examined the alignment between Earth and Life Science competencies and Maritime Navigation (Navigational Watch 1 and 2) learning outcomes among Grade 11 TVL-Maritime students. Through expert consultation with maritime education specialists from two higher education maritime schools, a comprehensive mapping of interconnected competencies was established, revealing significant pedagogical connections between Earth science concepts and practical maritime navigation skills.

Table 1 Matched Competencies of Earth and Life Science and Navigational Watch 1 and 2 in Grade 11 Maritime Students from Expert A

Earth and Life	Navigational Watch 1 and 2
1. Recognize the uniqueness of the Earth being the only planet in the solar system with properties necessary to support life.	1. Use magnetic and gyro compasses a. Describe the compass and its parts b. differentiate the limitations of the compass c. determine the limitations of the compass d. box the compass
2. Explain how the movement of plates leads to the formation of folds and faults.	2. Match competencies, for example, verify readings between the magnetic and gyro compasses or vice versa.

Table 1 presents the competency alignment identified through expert consultation with a maritime instructor from a well-established maritime school. The analysis reveals a fundamental connection between Earth science understanding and navigational competence, particularly in the relationship between planetary properties and compass navigation systems. The Earth and Life Science competency of recognizing Earth's uniqueness as the only planet in the solar system with properties necessary to support life directly correlates with the maritime navigation competency of using magnetic and gyro compasses. This connection demonstrates how students' understanding of Earth's magnetic field properties enhances their comprehension of compass functionality and limitations in maritime navigation [18]–[21].

The expert mapping process identified that students who understand Earth's magnetic properties are better equipped to comprehend compass behavior, differentiate between

magnetic and gyro compass limitations, and accurately determine navigational readings. This integration supports the constructivist learning theory, which emphasizes building new knowledge upon existing conceptual foundations [22]. The competency alignment extends to practical applications, where students must verify readings from magnetic and gyro compasses, requiring a deep understanding of Earth's magnetic field variations and their effects on navigational instruments [23].

Table 2 expands the competency analysis through consultation with two more experts, revealing more complex interdisciplinary connections between Earth science hazard understanding and maritime safety protocols. The alignment between describing various hazards from earthquakes, volcanic eruptions, and landslides and distinguishing external forces affecting ship movement demonstrates sophisticated pedagogical integration. Students who understand geological hazards and their environmental impacts are better prepared to comprehend how external natural forces affect vessel behavior in different maritime conditions [24]–[27].

Table 2 Matched Competencies of Earth and Life Sciences and Navigational Watch 1 and 2 in Grade 11 Maritime Students from Experts B and C

Earth and Life	Navigational Watch 1 and 2
1. Describe the various hazards that may happen in the event of earthquakes, volcanic eruptions, and landslides.	1. distinguish external forces affecting ship movement while steering. a. describe the behavior of the ship in still and calm waters and rough seas b. explain the rate of turn of a ship during a bend and certain in alterations c. describe the cause and effects in resistance in a narrow channel or a restricted area d. explain the squat effect in relation to the depth of water and the vessel speed
2. Using hazard maps, identify areas prone to hazards brought about by tropical cyclones, monsoons, floods, and ipo-ipo.	2. Apply Part B. a. discuss Rule 14. Head on b. discuss Rule 15. Crossing situation c. discuss Rule 16. Action by give way vessel d. discuss Rule 17. Action by stand on vessel

The expert consultation revealed that students' understanding of natural hazards directly enhances their ability to describe ship behavior across a range of sea conditions, from calm waters to rough seas influenced by geological and meteorological phenomena. This connection is particularly evident in competencies related to explaining ship resistance in narrow channels and restricted areas, where understanding of geological formations and water dynamics becomes crucial for safe navigation. The relationship between Earth science knowledge and maritime safety protocols demonstrates the practical application of scientific principles in professional maritime contexts.

Competency alignment analysis has significant implications for assessment practices in maritime education. Traditional assessment approaches that evaluate Earth science and navigation competencies separately may fail to capture students' integrated understanding and practical application capabilities. The identified connections suggest that assessment strategies should evaluate students' ability to apply scientific principles to solve navigational problems and make informed decisions in maritime contexts. The expert-validated competency relationships indicate that students who demonstrate strong performance in integrated Earth science-navigation assessments are better prepared for professional maritime careers. This finding supports the development of performance-based assessments that require students to demonstrate both scientific understanding and practical application skills simultaneously [28]–[30]. Such assessment approaches better reflect the integrated nature of professional maritime practice and provide more authentic measures of student readiness for maritime careers.

The competency-matching analysis also suggests that achievement in Earth and Life Science may predict success in maritime navigation courses. Students who develop a strong understanding of Earth's properties, geological processes, and environmental hazards may be better equipped to master complex navigational concepts and safety protocols [29], [31], [32]. This relationship has implications for academic advising, student support services, and intervention strategies in maritime education programs.

*B. Students' Achievement on Matched Learning Competencies of Earth and Life Sciences and Navigational Courses*

The results of this study reveal significant insights into the achievement patterns of specialized maritime students in matched learning competencies between Earth and Life Science and Navigational Watch courses. The findings demonstrate both the effectiveness of interdisciplinary curriculum integration and the need for targeted pedagogical interventions to address grade-level performance variations.

Table 3 Achievement Scores of Specialized Maritime Students on Matched Competencies in Earth and Life Science and Navigational Courses

Grade	Mean	Interpretation	SD
11	37.67	Moving Towards Mastery	4.12
12	34.83	Moving Towards Mastery	5.43
As a whole	36.23	Moving Towards Mastery	5.00

Maritime students demonstrated an overall mean achievement score of 36.23 (SD = 5.00) [Table 3], indicating progress towards mastery in Earth and Life Science, with substantial individual variation that warrants careful examination within the context of contemporary vocational education standards. The standard deviation indicates moderate heterogeneity in student performance, which falls within the typical range observed in vocational science education programs. The learners went beyond simply understanding the material; they actively sought to apply it, analyze it critically, and create new knowledge. This deeper level of engagement

fosters a more comprehensive understanding and a greater ability to problem-solve and think critically.

The mean score of 36.23 positions these maritime students within the moving towards mastery range when compared to established benchmarks in vocational science education. According to the latest international comparative study by the European Centre for the Development of Vocational Training [33], technical education programs typically exhibit mean performance scores of 32–42 on standardized competency assessments, placing maritime students near the center of this distribution. However, the substantial standard deviation of 5.00 reveals significant performance stratification within the student cohort.

*C. Level of Achievement on Matched Competencies*

Table 3 also presents the comparison of achievement levels between Grade 11 and Grade 12 students. Grade 11 students attained a higher mean score of 37.67 with a standard deviation of 4.12, while Grade 12 students had a mean score of 34.83 and a higher standard deviation of 5.43. The overall mean score across both groups was 36.23. This suggests a move towards mastery-level performance in Earth and Life Science competencies that align with Navigational Watch learning outcomes. Grade 11 students not only performed better on average but also showed more consistency in their scores.

These findings present an intriguing educational phenomenon that challenges conventional expectations. Typically, senior students are expected to outperform juniors due to accumulated knowledge and experience. However, Cognitive Load Theory (CLT) explains this reversal. As curriculum complexity increases in higher grade levels, students may experience greater cognitive burden—a trend supported by Philippine studies linking task complexity to higher cognitive load among Grade 11 science students [34], and by research showing that instructional design and task structure influence cognitive load in online learning [35]. CLT emphasizes managing extraneous load and aligning intrinsic load with learners' prior knowledge [36], both of which are critical in understanding this pattern.

Grade 12 maritime students face multiple academic and personal demands, including advanced coursework, college preparation, and employment concerns, which may collectively cause cognitive overload and hinder performance on integrated competency assessments. The higher standard deviation among Grade 12 students (5.43 vs. 4.12) also suggests greater performance variability; some students excel, while others struggle significantly. This heterogeneity is consistent with longitudinal findings by Donnelly et al. (2020), which indicate that final-year students often exhibit increased variability in academic performance due to differing post-graduation goals and levels of academic commitment.

The lower standard deviation among Grade 11 students suggests more consistent performance across the cohort. Grade 11 students may have more recently completed foundational Earth and Life Science coursework, thereby improving retention of scientific concepts. Vocational education contexts suggest that Grade 11 students may exhibit higher intrinsic motivation as they begin specialized training, whereas Grade 12 students may experience motivational decline due to senioritis or uncertainty about plans [38]–[40]. The performance pattern may also reflect optimal curriculum

sequencing, in which Earth and Life Science competencies are most effectively integrated during Grade 11, with Grade 12 focusing on advanced maritime applications that may not directly align with the assessment instrument used in this study.

#### D. Extent of Alignment between Competencies

Based on the questionnaire used, the items covered content areas from both Earth and Life Science and Navigational Watch subjects. The overall mean score of 36.23 across both grade levels suggests moderately high achievement in matched competencies, indicating successful integration of Earth and Life Science concepts with Navigational Watch applications. This finding is supported by Honra et al. [41], who showed that students' integrated biology-technical-vocational skills increase significantly when biology concepts are embedded within career-oriented pedagogy. Similarly, Ignacio & Yabut [42] found that Grade 9 STE program students demonstrated strong science process skills when curricular elements stressed both content and application, reinforcing the idea that the contextual embedding of science in vocational-oriented programs yields positive achievement outcomes.

The questionnaire design, incorporating overlapping domains such as weather systems, oceanographic conditions, environmental hazards, and navigational decision-making, demonstrates clear interdisciplinary linkage. This alignment validates contemporary competency-based education approaches that emphasize authentic, integrated assessments [43]. The construction of test items reflected overlapping domains, including weather systems, oceanographic conditions, environmental hazards, and navigational decision-making, indicating a clear interdisciplinary linkage. The mean scores and strong performance on aligned questions imply that the Earth and Life Science curriculum supports and enhances students' understanding of maritime applications, particularly in Navigational Watch 1 and 2. This alignment validates the curriculum's interdisciplinary design.

#### D. Implication for Curriculum Design

The demonstrated alignment between Earth and Life Science and Navigational Watch competencies offers substantial evidence in support of theoretical frameworks that promote integrated curriculum models in vocational education. This result affirms the constructivist learning principle that knowledge is most effectively acquired when presented in authentic, interconnected contexts rather than as isolated subject matter [44], [45].

Jackson et al. [46] demonstrated that students in integrated programs show superior knowledge transfer and practical application skills compared to those in siloed subject approaches. The alignment demonstrated in this study suggests that Earth and Life Science concepts, including meteorological phenomena, oceanographic principles, geological processes, and environmental systems, serve as essential foundational knowledge that directly enhances maritime navigation competencies. This integration creates cognitive bridges, enabling scientific understanding to facilitate deeper comprehension of maritime applications and vice versa [7].

## IV. CONCLUSION

The study demonstrates that meaningful alignment exists between Earth and Life Science competencies and Maritime Navigation learning outcomes, validating the theoretical

framework that supports interdisciplinary curriculum integration in specialized vocational education. The expert-validated competency mapping establishes that scientific understanding of Earth's properties, geological processes, and environmental phenomena directly enhances students' comprehension and application of maritime navigation principles, creating cognitive bridges that facilitate deeper learning in both domains.

The successful demonstration of competency alignment validates contemporary competency-based education approaches that emphasize authentic, integrated assessments over traditional subject-isolated evaluation methods. The moderate achievement levels across both grade levels indicate that, while students demonstrate a foundational understanding of integrated concepts, there remains considerable potential for improvement through targeted pedagogical interventions and improved instructional strategies.

## V. RECOMMENDATIONS

To optimize the impact of this research on maritime education, stakeholders must adopt a holistic, integrated approach to competency development. Students should actively bridge Earth and Life Science with maritime navigation through metacognitive strategies and supplemental simulation exercises to solidify the link between theory and practice. This student-led engagement is bolstered by parents who provide structured study environments and emotional support, fostering the discipline required for seafaring professions.

Simultaneously, educators must transcend disciplinary silos through collaborative lesson design, using contextualized examples such as oceanographic processes to enhance retention. By adopting active learning and performance-based assessments, teachers can better reflect the practical requirements of the industry. Institutionally, curriculum development should prioritize utilizing explicit competency mapping to ensure scientific principles are continuously reinforced through maritime applications across grade levels. This restructuring is particularly vital to address the observed decline in Grade 12 performance, ensuring sustained achievement throughout the program.

Finally, future research should employ longitudinal and comparative designs to track student cohorts and validate the predictive value of integrated competencies for long-term career success. By implementing differentiated instruction and fostering professional development in interdisciplinary instruction, schools can address diverse learning needs. Ultimately, shifting toward an assessment model that requires the simultaneous demonstration of scientific and practical maritime mastery will better prepare students for the complexities of the global maritime sector.

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