

Cognitive and Technical Skills Developed Through Simulation Scenarios in Auxiliary Machinery 1: Basis for Enhancing Learning Materials

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Abstract— This study determined the cognitive and technical skills developed through simulation scenarios in the Auxiliary Machinery 1 course among Bachelor of Science in Marine Engineering (BSMarE) students and examined their alignment with the competency requirements of the Standards of Training, Certification and Watchkeeping for Seafarers (STCW). Using a descriptive-comparative-correlational research design, the study involved 151 second-year BSMarE students selected through proportionate stratified random sampling and 16 Marine Engineering professional instructors included through total enumeration. Researcher-developed instruments based on the Intended Learning Outcomes of Auxiliary Machinery 1 were used to identify cognitive skills according to the Revised Bloom's Taxonomy and technical skills categorized as Operation, Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance. Documentary alignment analysis was conducted using the Instructor's Guide, Practical Assessment Development Plan, and applicable STCW competency requirements. Results showed that students predominantly identified Remembering and Understanding, whereas instructors predominantly identified Understanding and Applying. Operation was the most frequently identified technical skill among students and instructors. Significant differences were found between the two groups in their assessments of cognitive skills, $\chi^2(5) = 174.41$, $p < .001$, and technical skills, $\chi^2(5) = 182.37$, $p < .001$. However, cognitive and technical skill scores among students showed a weak positive but statistically non-significant relationship, $p = .108$, $p = .187$. The findings indicate the need to enhance existing learning materials by strengthening higher-order cognitive processes, broadening technical competency development, deliberately integrating cognitive reasoning with technical performance, and ensuring explicit traceability to applicable STCW competency requirements.

Index Terms— Auxiliary Machinery, Cognitive Skills, Marine Engineering Education, Simulation-Based Learning, STCW Competencies, Technical Skills

1. Introduction

Maritime education and training play a critical role in preparing future marine engineers to perform safely and competently in increasingly complex shipboard environments. Marine engineering education requires students not only to acquire theoretical knowledge but also to develop the cognitive and technical competencies necessary to operate, monitor, maintain, and troubleshoot machinery systems. Consequently, instructional approaches that connect theoretical understanding with practical application are essential in preparing students for actual shipboard responsibilities.

Simulation-based learning has become an important instructional approach in maritime education because it allows students to experience realistic operational situations within a controlled learning environment. Through simulation scenarios, students can apply theoretical knowledge, perform technical procedures, interpret system conditions, make operational decisions, and respond to equipment abnormalities without the risks associated with actual shipboard operations. Simulation therefore provides an experiential bridge between classroom instruction and professional practice. Studies have demonstrated the value of simulation and other interactive learning approaches in supporting active learning, decision-making, and competency development [1], [2].

The cognitive dimension of simulation-based learning may be understood through the Revised Bloom's Taxonomy developed by Anderson and Krathwohl [3]. The taxonomy classifies cognitive processes into six levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. Within marine engineering simulation, these processes may range from recalling machinery procedures and explaining operating principles to applying procedures,

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analyzing abnormal system conditions, evaluating possible corrective actions, and generating appropriate solutions. Simulation scenarios can therefore serve not only as opportunities for technical practice but also as learning environments for developing progressively more complex cognitive processes.

Technical competency is equally important in marine engineering education. Auxiliary Machinery 1 provides students with learning experiences involving machinery and systems such as pumps, air compressors, heat exchangers, fresh water generators, ballast systems, oily water separators, and cargo-handling and deck machinery. Within these learning experiences, technical competency extends beyond machinery operation to include Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance. The integration of these competencies into simulation activities is important because marine engineers are expected to interpret operating conditions, identify abnormalities, take appropriate corrective action, and maintain safe machinery operation [4].

The development of these competencies is guided by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), which establishes minimum competency requirements for maritime professionals [4]. Under STCW Table A-III/1, marine engineering personnel at the operational level are expected to demonstrate competencies associated with machinery operation, operational performance, fault detection, and compliance with applicable safety requirements [4]. The STCW Knowledge, Understanding and Proficiency (KUP) requirements therefore provide an important standards-based framework for examining whether course learning outcomes, simulation activities, and assessments contribute to the competencies expected of future marine engineers.

In the Philippine maritime education context, the alignment of instructional practices with regulatory and competency requirements is particularly important. The Joint CHED–MARINA Memorandum Circular provides a national regulatory framework for aligning maritime higher education with competency-based requirements [5]. Curriculum mapping and alignment provide mechanisms for examining the correspondence among Intended Learning Outcomes (ILOs), instructional activities, simulation scenarios, assessment practices, and prescribed maritime competencies [6]. Such alignment strengthens the transparency and accountability of competency-based education and helps identify areas where instructional experiences may require further enhancement.

Despite the established role of simulation in maritime education, an important research gap remains. Existing literature generally supports simulation-based learning as a means of bridging theoretical knowledge and practical application and facilitating cognitive and technical competency development [7], [8]. However, there remains limited localized empirical evidence that simultaneously examines the specific

cognitive and technical skills manifested through simulation scenarios, compares students' perceptions with the professional assessments of instructors, determines their correspondence with applicable STCW requirements, and examines the relationship between cognitive and technical skill development. The literature likewise indicates a need for systematic examination of the alignment between simulation scenarios and STCW-prescribed competencies. Philippine studies have demonstrated benefits associated with simulator-based maritime instruction, but the literature indicates the need for further examination of the cognitive and technical competencies developed through these experiences.

Addressing this gap is particularly relevant to Auxiliary Machinery 1 because the course combines theoretical instruction with practical and simulation-based activities involving essential marine engineering machinery and systems. Examining the competencies developed through these activities can provide evidence for determining whether existing instructional materials sufficiently integrate cognitive processes, technical performance, and applicable maritime competency requirements.

Accordingly, this study determined the cognitive and technical skills developed through the simulation scenarios in the Auxiliary Machinery 1 course as assessed by BSMarE students and Marine Engineering professional instructors. Specifically, it identified the cognitive and technical skills developed through the simulation scenarios; determined their alignment with applicable STCW competency requirements; examined whether significant differences existed between the assessments of BSMarE students and Marine Engineering professional instructors; determined the relationship between cognitive and technical skills; and identified learning materials that may be enhanced based on the findings.

2. Methodology

A. Research Design

This study employed a descriptive-comparative-correlational research design to examine the cognitive and technical skills developed through simulation scenarios in the Auxiliary Machinery 1 course. The descriptive component was used to identify and describe the cognitive and technical skills developed as assessed by BSMarE students and Marine Engineering professional instructors and to determine the alignment of the identified skills with applicable Standards of Training, Certification and Watchkeeping for Seafarers (STCW) competency requirements. The comparative component determined whether significant differences existed between the assessments of the two respondent groups, while the correlational component examined the relationship between the cognitive and technical skills developed through the simulation scenarios. The design also provided the basis

for identifying existing learning materials that may be enhanced based on the findings of the study.

B. Respondents and Sampling

The respondents consisted of 151 second-year Bachelor of Science in Marine Engineering (BSMarE) students who had successfully completed the Auxiliary Machinery 1 course during the first semester of Academic Year 2025–2026 and 16 Marine Engineering professional instructors. The students were drawn from eight sections and were selected from a population of 241 students using proportionate stratified random sampling to ensure adequate representation across sections. The sample size was determined at a 95% confidence level and 5% margin of error.

The 16 professional instructors consisted of four instructors who taught Auxiliary Machinery 1 during the first semester of Academic Year 2025–2026 and 12 instructors who had previously handled the course during Academic Year 2024–2025. Total enumeration was employed for the instructor group. The students assessed the cognitive and technical skills they perceived to have developed through their simulation experiences, while the instructors provided professional assessments of the cognitive and technical skills developed among the students. The Intended Learning Outcomes (ILOs) contained in the Auxiliary Machinery 1 Instructor's Guide served as the common assessment reference for both groups.

C. Research Instruments

The study utilized researcher-developed instruments and documentary sources. Separate instruments were administered to the BSMarE students and Marine Engineering professional instructors to identify the cognitive and technical skills developed through the simulation scenarios. The cognitive skills were classified according to the Revised Bloom's Taxonomy [3] as Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. The technical skills were categorized as Operation, Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance.

The Intended Learning Outcomes from the Auxiliary Machinery 1 Instructor's Guide provided the common assessment reference for both respondent groups. Documentary sources included the Instructor's Guide (IG), Practical Assessment Development Plan (PADP), and applicable provisions of the STCW Code [4]. The PADP provided documentation of the simulation scenarios implemented in the course, while the STCW Code provided the standards-based framework for examining the correspondence between the skills developed by the students and applicable maritime competency requirements.

D. Validation of the Instruments

The researcher-developed instruments underwent content validation to establish their appropriateness, relevance, and alignment with the objectives of the study. Content validation was conducted using Lawshe's Content Validity Ratio (CVR)

[9], which determines the essentiality of instrument items based on expert judgment. The panel of validators consisted of the BSMarE Program Head, Research Director, an English language expert, and a technical expert. Their comments and recommendations were incorporated into the final versions of the instruments before administration to the respondents. The validation process ensured that the instruments appropriately represented the cognitive and technical skill categories and were suitable for the context of Auxiliary Machinery 1.

E. Data Gathering Procedure

Prior to data collection, the researcher secured the necessary permission to conduct the study. Documentary sources were subsequently obtained, including the Practical Assessment Development Plan, Instructor's Guide, and STCW Code [4]. These documents were used to contextualize the researcher-developed instruments and support the subsequent documentary alignment analysis. The instruments were then subjected to expert content validation and revised based on the validators' recommendations.

Following validation, the questionnaires were administered to the respondents. The Marine Engineering professional instructors completed paper-and-pencil questionnaires, while the BSMarE students completed the instruments through Google Forms. Both groups assessed the cognitive and technical skills using the same Intended Learning Outcomes from the Auxiliary Machinery 1 Instructor's Guide as the common reference. Students responded based on their learning experiences in the course, whereas the professional instructors responded based on their professional knowledge and experience in teaching Auxiliary Machinery 1. The accomplished questionnaires were retrieved, checked for completeness, coded, tabulated, and organized for statistical analysis.

F. Statistical Treatment of Data

Frequency and percentage distributions were used to describe the cognitive and technical skills identified by the BSMarE students and Marine Engineering professional instructors. Documentary alignment analysis was employed to examine the correspondence between the skills identified from the student responses and the applicable STCW competency and Knowledge, Understanding and Proficiency (KUP) requirements [4]. The Intended Learning Outcomes contained in the Instructor's Guide and the simulation scenarios documented in the PADP provided the instructional context for the alignment analysis.

The chi-square test of independence was used to determine whether significant differences existed in the distributions of cognitive and technical skills identified by BSMarE students and Marine Engineering professional instructors. Separate chi-square analyses were performed for the cognitive and technical skill categories. Spearman's rank-order correlation coefficient (ρ) was used to determine the strength and direction of the relationship between the cognitive and technical skill scores of the BSMarE students. The null

hypotheses were tested at the .05 level of significance. A p-value below .05 was considered statistically significant.

3. Results and Discussion

A. Cognitive Skills Developed Through the Simulation Scenarios

The cognitive skills developed through the simulation scenarios in Auxiliary Machinery 1 were classified according to the Revised Bloom's Taxonomy of Cognitive Processes [3]: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. The Intended Learning Outcomes (ILOs) contained in the Instructor's Guide served as the common assessment reference for the BSMarE students and Marine Engineering professional instructors.

Table 1

Cognitive Skills Developed Through the Simulation Scenarios as Assessed by BSMarE Students and Marine Engineering Professional Instructors

Cognitive Skill	BSMarE Students f	%	Professional Instructors f	%
Remembering	1,516	38.61	137	19.77
Understanding	1,309	33.34	222	32.03
Applying	354	9.02	151	21.79
Analyzing	315	8.02	120	17.32
Evaluating	212	5.40	51	7.36
Creating	220	5.60	12	1.73
Total	3,926	100.00	693	100.00

Note. f = frequency. Cognitive skills were classified according to the Revised Bloom's Taxonomy [3].

Among the BSMarE students, Remembering obtained the highest frequency with 1,516 occurrences (38.61%), followed by Understanding with 1,309 (33.34%). Applying accounted for 354 occurrences (9.02%), Analyzing for 315 (8.02%), Creating for 220 (5.60%), and Evaluating for 212 (5.40%). The distribution indicates that the students predominantly associated their simulation-based learning experiences with foundational cognitive processes involving the recall and comprehension of knowledge. The considerably lower frequencies for Applying, Analyzing, Evaluating, and Creating suggest that higher-order cognitive processes were less prominently recognized by students across the simulation scenarios.

In contrast, the Marine Engineering professional instructors most frequently identified Understanding, with 222 occurrences (32.03%), followed by Applying with 151 (21.79%) and Remembering with 137 (19.77%). Analyzing accounted for 120 occurrences (17.32%), while Evaluating and Creating obtained 51 (7.36%) and 12 (1.73%), respectively. The instructors therefore perceived the simulation scenarios as emphasizing both comprehension of machinery principles and the practical application of

knowledge. Analyzing was also evident, particularly in learning outcomes involving monitoring and diagnosis, while Evaluating and Creating were comparatively less prominent.

The descriptive results reveal a difference in cognitive emphasis between the two respondent groups. While students predominantly identified Remembering and Understanding, instructors predominantly identified Understanding and Applying. This suggests that instructors viewed the intended cognitive demands of the simulation activities as more application-oriented than the students perceived in their own learning experiences. The limited manifestation of higher-order cognitive processes, particularly Evaluating and Creating, further indicates an opportunity to strengthen simulation scenarios that require learners to analyze complex machinery conditions, evaluate alternative actions, make informed decisions, and formulate appropriate solutions.

B. Technical Skills Developed Through the Simulation Scenarios

The technical skills developed through the simulation scenarios were classified into six competency categories derived from the applicable STCW framework [4]: Operation, Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance. The applicable Intended Learning Outcomes in the Auxiliary Machinery 1 Instructor's Guide served as the common assessment reference for both BSMarE students and Marine Engineering professional instructors.

Table 2

Technical Skills Developed Through the Simulation Scenarios as Assessed by BSMarE Students and Marine Engineering Professional Instructors

Technical Skill	BSMarE Students f	%	Professional Instructors f	%
Operation	877	52.80	101	24.46
Maintenance	348	20.95	16	3.87
Troubleshooting	148	8.91	81	19.61
System Analysis	104	6.26	88	21.31
Instrumentation	62	3.73	65	15.74
Safety Compliance	122	7.34	62	15.01
Total	1,661	100.00	413	100.00

Note. f = frequency. More than one technical skill could be associated with an applicable Intended Learning Outcome.

Among the BSMarE students, Operation was the most frequently identified technical competency, accounting for 877 occurrences (52.80%), followed by Maintenance with 348 (20.95%). Troubleshooting accounted for 148 occurrences (8.91%), Safety Compliance for 122 (7.34%), System Analysis for 104 (6.26%), and Instrumentation for 62 (3.73%).

The predominance of Operation indicates that students primarily associated their simulation experiences with the actual operation of auxiliary machinery and systems. Maintenance was the second most prominent competency, particularly in learning outcomes involving machinery fault diagnosis, while the remaining competencies were identified less frequently.

The Marine Engineering professional instructors demonstrated a more distributed pattern of technical competencies. Operation obtained the highest frequency with 101 occurrences (24.46%), followed by System Analysis with 88 (21.31%), Troubleshooting with 81 (19.61%), Instrumentation with 65 (15.74%), Safety Compliance with 62 (15.01%), and Maintenance with 16 (3.87%). These results indicate that the instructors perceived the simulation scenarios as encompassing a broader range of competencies beyond machinery operation, particularly those involving system analysis, troubleshooting, instrumentation, and safety compliance.

Taken together, the findings reveal different patterns in how students and instructors perceived the technical competencies embedded in the simulation scenarios. Students demonstrated a strong concentration on Operation, whereas the instructors identified a more diversified competency profile. This suggests that some technical competencies intended or recognized by instructors may not be equally explicit or readily recognized by students during their simulation experiences. The findings therefore support making the targeted technical competencies more visible within simulation instructions, activities, and assessment criteria and providing greater opportunities for students to integrate machinery operation with system analysis, troubleshooting, instrumentation, maintenance, and safety-related decision-making.

C. Alignment of Cognitive and Technical Skills with STCW Competency Requirements

The cognitive and technical skills identified by the BSMarE students were examined through documentary alignment analysis against the applicable competency requirements of STCW Table A-III/1 for marine engineering personnel at the operational level [4]. The analysis considered the Intended Learning Outcomes of Auxiliary Machinery 1, the simulation scenarios documented in the Practical Assessment Development Plan, and the applicable Knowledge, Understanding and Proficiency requirements of the STCW Code.

For the cognitive skills, Remembering, Understanding, Applying, Analyzing, and Evaluating demonstrated substantive correspondence with the applicable STCW requirements. Remembering and Understanding supported the knowledge and comprehension of machinery functions, operating principles, pumps and piping systems, and established procedures. Applying corresponded with the execution of established procedures in the operation of

auxiliary machinery and pumping systems. Analyzing was associated with monitoring machinery performance, identifying deviations from normal operating conditions, and detecting faults, while Evaluating corresponded with determining appropriate actions in response to machinery malfunctions and abnormal operating conditions [4].

Creating showed no direct alignment with an explicitly stated requirement to generate new machinery systems or procedures within the operational-level competencies examined. However, this does not imply that creative problem-solving is irrelevant to marine engineering education. Rather, Creating, as defined under the Revised Bloom's Taxonomy [3], was not explicitly prescribed as a distinct cognitive requirement in the applicable STCW competencies considered in the study [4].

For technical skills, all six competency categories—Operation, Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance—demonstrated alignment with applicable STCW Table A-III/1 requirements. Operation corresponded directly with the operation of main and auxiliary machinery, pumps, piping systems, ballast systems, and oily-water separators. Maintenance and Troubleshooting were aligned with requirements involving fault detection, machinery malfunctions, corrective actions, and the prevention of machinery damage. System Analysis and Instrumentation supported the monitoring and interpretation of machinery performance and associated control systems, while Safety Compliance corresponded with safe operating procedures and the prevention of pollution of the marine environment [4].

The documentary analysis therefore indicates that the major cognitive and technical skills identified in Auxiliary Machinery 1 generally correspond with the competencies expected under STCW Table A-III/1. However, STCW alignment and the frequency with which a skill was identified represent different dimensions of the analysis. A skill may be identified less frequently by students while still having substantive alignment with an STCW competency requirement. Consequently, the comparatively lower frequencies of Applying, Analyzing, Evaluating, Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance should not be interpreted as absence of STCW alignment. Rather, they indicate areas in which simulation activities may provide more explicit and sustained opportunities for students to demonstrate the corresponding competencies.

D. Differences in Cognitive and Technical Skills as Assessed by Students and Instructors

The chi-square test of independence was used to determine whether the distribution of cognitive and technical skills differed significantly between the assessments of BSMarE students and Marine Engineering professional instructors.

Table 3

Differences in Cognitive and Technical Skills as Assessed by BSMarE Students and Marine Engineering Professional Instructors

Variable	χ^2	df	p-value	Decision	Interpretation
Cognitive Skills	174.41	5	< .001	Reject H_{01}	Significant
Technical Skills	182.37	5	< .001	Reject H_{02}	Significant

Note. The null hypothesis was rejected when $p < .05$.

For cognitive skills, the analysis revealed a statistically significant difference between the assessments of BSMarE students and Marine Engineering professional instructors, $\chi^2(5) = 174.41$, $p < .001$. Thus, H_{01} was rejected. This indicates that the two respondent groups differed significantly in the distribution of cognitive skills they identified as being developed through the simulation scenarios. Students predominantly identified Remembering and Understanding, whereas instructors placed greater emphasis on Understanding and Applying.

A statistically significant difference was likewise found in the distribution of technical skills, $\chi^2(5) = 182.37$, $p < .001$. Accordingly, H_{02} was rejected. This result indicates that students and professional instructors also differed significantly in their assessment of the technical competencies developed through the simulation scenarios.

The significant differences between the two groups suggest a perceptual gap between the competencies students recognize from their simulation experiences and those that instructors identify as embedded in the Intended Learning Outcomes and simulation activities. Students tended to view the technical experiences primarily in terms of Operation, whereas instructors identified a broader distribution of technical competencies. These differences highlight the importance of making cognitive and technical competency targets more explicit in simulation instructions, learning activities, debriefing, and assessment criteria.

E. Relationship Between Cognitive and Technical Skills

Spearman's rank-order correlation coefficient was used to determine the relationship between the cognitive and technical skill scores of the 151 BSMarE students who completed both instruments. The analysis revealed a weak positive relationship between cognitive and technical skills, $\rho = .108$, $p = .187$. Since the p-value was greater than the .05 level of significance, the null hypothesis was not rejected, indicating that there was no statistically significant relationship between the cognitive and technical skill scores of the students.

Although the positive correlation coefficient indicates a slight tendency for higher cognitive skill scores to occur with higher technical skill scores, the magnitude of the relationship was weak and did not reach statistical significance. Thus, the findings do not provide sufficient evidence to conclude that

the cognitive skills developed through the simulation scenarios were significantly associated with the students' technical skill development.

The result suggests that cognitive and technical skills may function as related but distinct dimensions of learning within the simulation environment. Cognitive skills involve processes such as Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating [3], whereas technical skills involve competencies associated with Operation, Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance [4]. Consequently, the development of cognitive processes may not automatically correspond with the development of technical competencies.

From an instructional perspective, the absence of a significant relationship emphasizes the importance of deliberately integrating cognitive reasoning with technical performance in simulation-based activities. Simulation scenarios may therefore be strengthened by requiring students not only to perform machinery procedures but also to explain their decisions, analyze system conditions, diagnose abnormalities, determine appropriate corrective actions, and justify their technical responses. Such integration may strengthen the connection between theoretical understanding, reasoning, decision-making, and technical performance.

F. Enhancement of Learning Materials

Based on the synthesis of the descriptive findings, documentary STCW alignment analysis, differences between the assessments of BSMarE students and Marine Engineering professional instructors, and the relationship between cognitive and technical skills, several existing learning materials in Auxiliary Machinery 1 were identified for enhancement. These include the Instructor's Guide (IG), Practical Assessment Development Plan (PADP), simulation scenario guides, student activity or laboratory worksheets, and assessment rubrics.

Table 4

Proposed Enhancement of Learning Materials Based on the Findings of the Study

Identified Finding/Gap	Learning Material	Proposed Enhancement	Target Skills/Competencies
Higher-order cognitive processes were less evident.	Instructor's Guide (IG)	Incorporate analytical questions, diagnostic problems, decision-making tasks, and problem-solving exercises into ILO-linked activities.	Analyzing, Evaluating, Creating
Learning was comparatively limited, particularly in the instructors' assessment.	IG and Simulation Scenario Guides	Incorporate open-ended tasks requiring students to formulate alternative procedures, corrective actions, response plans, or solutions to simulated machinery problems.	Creating, Problem Solving
Students predominantly identified Operation among the technical competencies.	Practical Assessment Development Plan (PADP)	Expand operational scenarios to explicitly incorporate Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance.	Broader Technical Competencies
Students and instructors differed significantly in their assessment of cognitive and technical skills.	Simulation Scenario Guides and Student Worksheets	Explicitly identify the cognitive and technical competencies targeted by each simulation activity and strengthen post-simulation reflection and debriefing.	Competency Awareness and Integration
Cognitive and technical skill scores were not significantly related.	Simulation Worksheets and Assessment Rubrics	Develop integrated tasks requiring students to explain decisions, analyze system conditions, perform procedures, and justify corrective actions within the same simulation exercise.	Integrated Cognitive and Technical Skills
Explicit STCW alignment should be maintained in instructional and assessment materials.	IG, PADP, and Assessment Rubrics	Cross-reference simulation tasks and performance criteria with applicable STCW competency and Knowledge, Understanding	STCW-Aligned Competencies

Note. The proposed enhancements were derived from the synthesis of the cognitive and technical skill findings, documentary alignment analysis, comparison of student and instructor assessments, and relationship analysis.

The proposed enhancements emphasize a more balanced development of cognitive and technical competencies within simulation-based instruction. For cognitive development, the existing learning materials may provide greater opportunities for Analyzing, Evaluating, and Creating by extending activities beyond the recall of procedures, explanation of machinery principles, and execution of prescribed operational steps. Students may instead be presented with machinery conditions that require interpretation, diagnosis, decision-making, justification, and formulation of appropriate solutions.

For technical skill development, simulation scenarios may be strengthened by explicitly integrating Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance with machinery Operation. For example, an operational task involving a pump may be extended to require students to interpret abnormal operating parameters, identify possible faults, determine corrective actions, consider maintenance requirements, and apply appropriate safety procedures. This approach may provide a more integrated representation of the competencies required in actual marine engineering practice.

The significant differences between student and instructor assessments also indicate the importance of making the intended cognitive and technical competencies explicit within simulation activities. Clearly identifying the competencies targeted by each activity, combined with structured post-simulation reflection and debriefing, may help students recognize not only the procedures they perform but also the cognitive processes and technical competencies underlying those procedures.

Finally, enhancement of the learning materials should maintain explicit traceability to the applicable STCW competency and Knowledge, Understanding and Proficiency requirements [4]. The proposed enhancements are therefore intended to strengthen, rather than replace, the existing Instructor's Guide and Practical Assessment Development Plan by improving the alignment among Intended Learning Outcomes, simulation scenarios, cognitive processes, technical competencies, assessment activities, and applicable STCW requirements.

4. Conclusion

The study concludes that simulation scenarios in Auxiliary Machinery 1 contribute to the development of both cognitive and technical skills among BSMarE students, although these competencies are manifested at varying levels. Students predominantly associated their simulation experiences with the foundational cognitive processes of Remembering and Understanding, whereas Marine Engineering professional instructors identified Understanding and Applying more prominently. In terms of technical skills, Operation was most evident among the students, while the instructors perceived a broader distribution of competencies encompassing Operation, Maintenance, Troubleshooting, System Analysis, Instrumentation, and Safety Compliance. These findings indicate that simulation-based instruction provides opportunities for multidimensional competency development, although some higher-order cognitive processes and technical competencies may not be equally explicit or recognizable to students.

The documentary analysis further established that the cognitive and technical skills developed through the simulation scenarios generally correspond with applicable STCW Table A-III/1 competency and Knowledge, Understanding and Proficiency requirements [4]. However, alignment with STCW should be distinguished from the frequency with which particular competencies were identified by students. Thus, competencies that appeared less frequently in students' responses may nevertheless remain substantively aligned with the applicable STCW requirements.

The significant differences between the assessments of students and professional instructors demonstrate that the two groups do not perceive the competencies embedded in the simulation scenarios in the same manner. This perceptual gap indicates a need to make intended cognitive and technical competencies more explicit within simulation instructions, learning activities, assessment criteria, reflection, and debriefing. Furthermore, the weak positive but statistically non-significant relationship between cognitive and technical skill scores indicates that development in one dimension does not necessarily correspond directly with development in the other. Cognitive reasoning and technical performance should therefore be deliberately integrated within simulation-based learning activities.

Overall, the findings provide a basis for enhancing the existing Instructor's Guide, Practical Assessment Development Plan, simulation scenario guides, student activity or laboratory worksheets, and assessment rubrics. Strengthening higher-order cognitive activities, broadening the technical competencies explicitly incorporated into simulation scenarios, integrating cognitive reasoning with technical performance, and maintaining clear traceability to applicable STCW requirements [4] may contribute to a more integrated outcomes-based and competency-based approach to marine engineering education.

5. About references

Reference entries [1] and [2] demonstrate the format for journal articles, [3] and [4] for conference papers, [5] and [6] for textbooks, and [7] and [8] for theses. Any additional source types, such as websites, may follow any of the listed styles.

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