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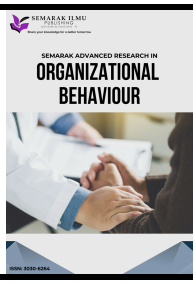

Enhancement of the Combined Class of Chief and Second Engineer Officer of 3000kw or More, Unlimited Trade Voyages (CCSU) Concept Via the Integrated Model of Training Effectiveness and Evaluation

Uzair Martaza[1,*], Yusnenti Faziran Mohd Yunos[1], Husrukhaizam Husin[1], HuzaifahRazab[1]

[1] Department of Marine Engineering, Politeknik Ungku Omar, Jalan Raja Musa Mahadi, 31400 Ipoh, Perak, Malaysia

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ABSTRACT

The Combined Class of Chief and Second Engineer Officer (CCSU) is critical for certifying senior marine engineers, yet existing training frameworks often lack a robust mechanism for evaluating effectiveness and ensuring outcomes align with the evolving demands of maritime operations. This study aims to address this gap by developing an integrated model to enhance the CCSU program systematically. Employing a qualitative methodology based on a systematic analysis of literature from the past three decades on training models and maritime education, this research synthesizes a novel conceptual framework. The primary result is a proposed Integrated Training Effectiveness and Evaluation Model for the CCSU, which embeds continuous evaluation mechanisms—including reaction, learning, behavior, and results assessments—directly into the traditional career progression pathway to create a dynamic feedback loop for curriculum improvement. The study concludes that this integrated model addresses a significant gap by providing a systematic approach to validate training quality, adapt to changes, and enhance competency outcomes, thereby contributing to higher levels of safety and efficiency in global shipping, with future empirical validation identified as a necessary next step.

1. Introduction

The global maritime industry is undergoing a profound transformation, driven by technological advancements, stringent environmental regulations, and the increasing complexity of vessel operations. Within this context, the role of the marine engineer has evolved from a primarily technical focus to one that demands a sophisticated blend of technical expertise, managerial acumen, and leadership capabilities. The Combined Class of Chief and Second Engineer Officer of 3000kW or More, Unlimited Trade Voyages (CCSU) represents a pivotal program designed to qualify marine engineers for these senior positions. However, a critical research gap exists: while the structure of such programs is well-defined by international conventions like STCW, their internal

* *Corresponding author.*
E-mail address: uzairmartaza@gmail.com

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training effectiveness is often assumed rather than systematically measured and validated against real-world operational outcomes [1,2].

Current approaches to maritime training evaluation frequently rely on summative assessments and simulator-based examinations. While these methods verify the attainment of minimum standards, they may not fully capture the development of higher-order competencies such as crisis resource management, strategic decision-making, and crew coordination under stress [3,4]. Prior research in related fields, such as Crew Resource Management (CRM) in aviation and maritime contexts, underscores the value of non-technical skills but also highlights a persistent lack of empirical data on the long-term effectiveness and behavioral transfer of such training [5,6]. This indicates an industry-wide need for more integrated, evidence-based models for training evaluation that can dynamically inform curriculum development.

The research problem central to this paper is the absence of a structured and systematic model to continuously evaluate, validate, and enhance the pedagogical effectiveness of the CCSU program. This gap potentially leads to inconsistencies in graduate competency and missed opportunities for aligning training content with the dynamic needs of the maritime industry.

The novelty and contribution of this work lie in the conceptualization and proposal of an Integrated Model of Training Effectiveness and Evaluation, specifically tailored for the CCSU program. This model synthesizes established training evaluation theory [7,8] with the specific requirements of senior marine engineer education. It moves beyond conventional assessment by incorporating multi-level evaluation metrics and continuous feedback loops directly into the training lifecycle, thereby creating a framework for evidence-based curricular improvement.

This study, therefore, aims to bridge the identified gap by proposing a novel conceptual framework that integrates a multi-level training evaluation model directly into the CCSU career progression pathway. This model can systematically assess and enhance both technical proficiency and non-technical skill acquisition. Establishing a theoretical foundation for future empirical research to validate the model's impact on operational safety and engineer competency.

2. Methodology

This study employed a qualitative research design centered on a systematic document analysis. The methodology was chosen to facilitate a comprehensive synthesis of existing knowledge and theory to construct a robust conceptual framework [9]. The analysis focused on reviewing and interpreting a wide range of documentary sources, including empirical studies, theoretical papers, and normative texts from academic periodicals and monographs published over the last thirty years.

The document collection and analysis process was guided by the following steps:

1. Identification: Key databases (e.g., Scopus, Web of Science, Google Scholar) were searched using terms such as "training evaluation model," "maritime education effectiveness," "Kirkpatrick model," "competency-based assessment," and "Engineer Officer training."

2. Screening: Documents were selected based on their relevance to training evaluation theories, their application in high-risk industries (particularly maritime and aviation), and their direct relevance to competency development for engineers.

3. Analysis: The selected literature was analyzed to identify recurring themes, established models, gaps in the current research, and potential components for an integrated evaluation

framework. The analysis focused on understanding the relationships between training inputs, pedagogical processes, and desired outcomes.

This methodological approach provided the scientific information and theoretical grounding necessary to synthesize the proposed Integrated Model of Training Effectiveness and Evaluation, as presented in the following section.

3. Results

The primary outcome of this research is the development of a proposed conceptual framework: the Integrated Model of Training Effectiveness and Evaluation for the CCSU program. This model, illustrated in Figure 1, enhances the traditional career progression pathway by embedding a cyclical evaluation system at its core.

The framework maintains the established sequence of a marine engineer's career, from a three-year pre-sea degree to the role of Chief Engineer, with the 5-month Combined Class (CCSU) as the critical gateway to senior positions. The novel integration is the central "Integrated Training Effectiveness & Evaluation" module, which actively interacts with the CCSU program.

This central module proposes that the CCSU program be continuously evaluated using a multi-level approach, conceptually aligned with established training evaluation theory [7,8]:

Level 1: Reaction – Gathering immediate participant feedback on training relevance and structure.
Level 2: Learning – Assessing knowledge and skill acquisition through exams and simulator-based assessments.
Level 3: Behavior – Evaluating the application of skills in the workplace during the subsequent 12-month sea service as Second Engineer.
Level 4: Results – Analyzing the long-term impact on operational safety, efficiency, and compliance.

The data from these evaluation levels form a continuous feedback loop. This feedback is systematically analyzed and used to dynamically refine the CCSU curriculum, instructional methods, and assessment tools. This process transforms the CCSU from a static course into a dynamic, self-improving system that is directly responsive to industry needs and trainee performance.

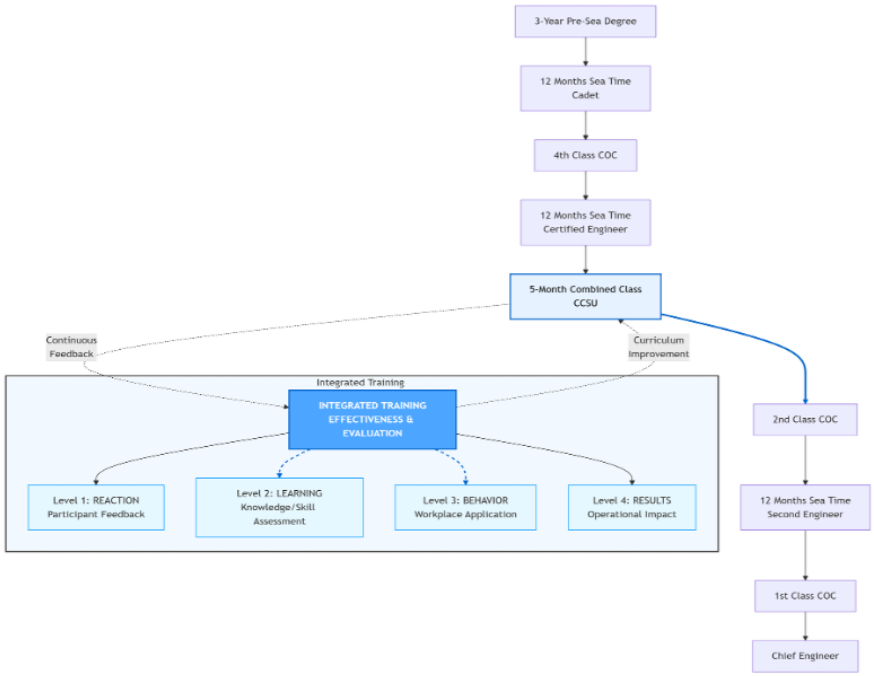

Fig. 1. Proposed integrated model of training effectiveness and evaluation for the CCSU program

The model illustrates the traditional linear career progression (outer loop) enhanced by the central integrated evaluation module, which creates a continuous feedback loop for curriculum improvement.

4. Discussion

The proposed Integrated Model of Training Effectiveness and Evaluation represents a paradigm shift from a fixed curriculum to a dynamic, evidence-based pedagogical system for the CCSU. By institutionalizing multi-stage evaluation, the model creates a robust mechanism for validating training quality and ensuring its relevance to the industry. This directly addresses the research problem concerning the lack of systematic evaluation in advanced maritime training programs.

The core contribution of this model is its explicit linkage of training activities to measurable performance indicators across different levels. For instance, engine room simulator exercises are no longer solely terminal assessments but have become rich sources of data for analyzing decision-making, procedural adherence, and team communication under stress. This aligns with emerging research advocating for more nuanced assessment techniques in maritime training, including psychophysiological evaluation [10] and behavioral marker systems [4].

A significant implication of this research is its potential to elevate the professional standing of marine engineers. By providing tangible evidence of competency development beyond certification, the model can strengthen the credibility of maritime training institutions and provide shipping companies with greater assurance of officer quality.

As a conceptual study, the primary limitation is that the proposed model is theoretical and awaits empirical validation. Its practical efficacy in improving competency outcomes and operational safety remains a proposition to be tested. Therefore, future research should focus on the implementation and validation of this framework. Specific directions include:

1. Pilot Implementation: Applying the model in a live CCSU program to gather data on its feasibility, acceptability, and practical utility for instructors and administrators.

2. Longitudinal Studies: Tracking graduates of an "enhanced" CCSU program to quantitatively and qualitatively measure its long-term impact on career performance, promotion rates, and safety incident reports.

3. Metric Development: Creating and validating specific, standardized metrics for each level of evaluation, such as rubrics for behavioral assessment in simulators and key performance indicators for evaluating the "Results" level in shipboard operations.

4. Stakeholder Analysis: Conducting in-depth interviews and surveys with key stakeholders (trainees, instructors, shipping company managers) to refine the model's components and ensure its industry relevance.

5. Conclusion

This study has addressed a critical gap in maritime education by proposing an enhancement to the CCSU program through the Integrated Model of Training Effectiveness and Evaluation. The proposed framework moves beyond the conventional, static training approach by embedding a continuous, multi-level evaluation system directly into the engineer's career progression pathway. This ensures that the CCSU program remains dynamically aligned with the competencies required for modern ship operations, fostering the development of truly proficient, resilient, and adaptive Chief and Second Engineers.

The adoption and future validation of this model hold significant promise for elevating the standards of maritime training, thereby directly contributing to the enhancement of safety, operational excellence, and environmental stewardship in the global shipping industry. The logical next step is the empirical testing and refinement of this conceptual framework in a real-world educational setting.

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