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Enhancing Cadet Preparedness For Engine Maintenance Challenges: A Qualitative Study In Maritime Education

Baihaqi Baihaqi
BPSDMP Perhubungan - Politeknik Pelayaran Malahayati,Indonesia

Address: Jl. Laksamana Malahayati Km.19 No.12 Gampong Durung Kec. Mesjid Raya, Kab. Aceh Besar, Prov. Aceh, 23381, Indonesia
*Corresponding author: baihaqiahadi67@gmail.com**

Abstract. *This qualitative study investigates the challenges faced by new engine officers in maritime settings, focusing on their transition from theoretical learning to practical engine maintenance. Through semi-structured interviews with experts in marine engineering and engine management, the research identifies significant gaps between theoretical knowledge acquired in classrooms and the practical skills required aboard ships. Key findings highlight the need for educational reforms, including increased practical training hours, curriculum adjustments to enhance relevance, and integration of simulation technologies. Participants, comprising professional engine masters, endurance managers, and maritime educators, unanimously advocate for a more hands-on approach to training that prepares cadets to handle complex engine maintenance tasks effectively. Simulation technologies, particularly virtual reality simulations, emerge as crucial tools for bridging the gap between theory and practice. They provide realistic environments for cadets to simulate diverse operational scenarios and develop critical decision-making skills without exposing them to actual risks. The study concludes with recommendations for collaborative efforts between educational institutions and industry stakeholders to implement these reforms, ensuring a competent and prepared workforce capable of meeting the dynamic challenges of modern maritime operations.*

Keywords*: Engine maintenance, Maritime education, Practical training, Simulation technologies, Qualitative study*

1. INTRODUCTION

In the realm of maritime education, the preparation of cadets for the challenges of engine maintenance stands as a pivotal area of concern (Ghosh et al., 2014; Sharma, 2023). The transition from theoretical learning to practical application poses significant hurdles for new engine officers navigating their initial years at sea. This qualitative study aims to delve deep into these challenges, offering critical insights into the knowledge and skills gaps that cadets encounter as they embark on their careers in marine engineering (Hölken et al., 2016; Utne et al., 2017). By examining the perspectives of experts in engine management and marine engineering, this research seeks to identify key areas where educational interventions can enhance the readiness and competence of cadets in managing ship machinery.

Maritime education plays a crucial role in equipping future seafarers with the necessary competencies to operate and maintain vessels effectively. However, despite the emphasis on theoretical knowledge acquisition, the practical realities of engine maintenance present unique challenges for cadets entering the workforce. The gap between classroom learning and real-world application often becomes evident during the early stages of a maritime career, where

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* Baihaqi Baihaqi, baihaqiahadi67@gmail.com

newly graduated engine officers must swiftly adapt to the complexities of maintaining ship engines under varying operational conditions. This study aims to bridge this gap by exploring the specific challenges faced by cadets and proposing targeted strategies to align educational practices with industry demands.

The primary objective of this research is to comprehensively analyse the transition phase that new engine officers experience from an educational perspective. By identifying the most critical challenges encountered during their initial years at sea, the study aims to inform curriculum adjustments that better prepare cadets for the practical demands of engine maintenance. Moreover, the research seeks to evaluate the potential role of simulation and virtual reality technologies in augmenting cadet training programmes (Knies, 2019). These innovative tools hold promise in providing realistic scenarios for practice and skill development, thereby enhancing the overall competence and confidence of future engine officers in managing ship machinery (Sharma, 2023).

A significant gap exists in the current literature concerning the precise nature of challenges faced by new engine officers and the effectiveness of educational approaches in addressing these challenges. While existing studies have touched upon aspects of maritime education and training, few have focused specifically on the transition to practical engine maintenance tasks. This research aims to fill this gap by offering a detailed examination of cadets' experiences and perceptions, grounded in qualitative insights from industry experts and educational practitioners. By doing so, it aims to contribute valuable knowledge that can inform both academic discourse and practical advancements in maritime education.

This study seeks to shed light on the complexities surrounding the preparation of cadets for engine maintenance challenges in maritime settings. By exploring the perspectives of both educators and industry professionals, it aims to uncover nuanced insights into the gaps between theoretical learning and practical application. The findings are expected to provide a foundation for refining educational strategies and integrating innovative technologies that enhance the preparedness of cadets in managing ship machinery effectively. Ultimately, this research aspires to contribute to the broader goal of ensuring safe, efficient, and sustainable maritime operations through well-prepared and competent engine officers.

2. METHOD

This qualitative research aims to explore and analyse the challenges faced by new engine officers in their early years at sea, focusing specifically on the transition from theoretical education to practical engine maintenance (Darlington & Scott, 2020; Katz, 2015). The

methodological approach adopted for this study is grounded in qualitative inquiry, employing descriptive analysis to capture the rich perspectives of experts in marine engineering and engine management. **Research Design:** The research design is structured to gather in-depth insights into the experiences and perceptions of key stakeholders involved in maritime education and industry. A qualitative approach was chosen to allow for a detailed exploration of the complex issues surrounding cadet preparedness in engine maintenance. Qualitative methods are particularly suited for capturing the subjective experiences, attitudes, and challenges faced by individuals, making them invaluable for understanding the nuances of educational and professional transitions.

Participants: Participants in this study include experts in marine engineering, professional engine masters, and engine endurance managers with substantial experience in maritime operations. These individuals were selected based on their roles in shaping educational practices and their firsthand knowledge of the challenges encountered by new engine officers. The qualitative nature of participant selection ensures that diverse perspectives are represented, offering a comprehensive view of the issues under investigation (Merriam & Grenier, 2019; Padgett, 2016; Willig, 2014). **Data Collection:** Data collection methods primarily involve semi-structured interviews conducted with the selected participants. Semi-structured interviews allow for flexibility in questioning while ensuring that key topics related to cadet preparedness and engine maintenance challenges are systematically addressed. Interviews are conducted face-to-face or remotely, depending on participant availability and preference, to facilitate candid discussions and in-depth exploration of experiences and insights.

Data Analysis: The collected data undergoes rigorous qualitative analysis using thematic coding and descriptive techniques. Thematic coding involves systematically identifying, organising, and interpreting patterns or themes within the interview transcripts (Kim et al., 2017; Merriam & Grenier, 2019). This process allows for the extraction of meaningful insights regarding the specific challenges faced by new engine officers, the perceived effectiveness of current educational approaches, and the potential role of simulation technologies in enhancing training. **Ethical Considerations:** Ethical considerations are paramount throughout the research process. Informed consent is obtained from all participants, ensuring their voluntary participation and confidentiality of their responses. Participants are assured of anonymity in reporting findings to maintain the integrity and trustworthiness of the study. Moreover, efforts are made to mitigate any potential biases in data collection and analysis, thereby upholding the ethical standards of research practice.

Limitations: It is important to acknowledge certain limitations inherent in qualitative research. The findings of this study may be context-specific to the maritime education and industry settings under investigation. Generalisation of findings beyond the specific participant group and context may be limited. Additionally, the subjective nature of qualitative data collection and analysis introduces the potential for interpretation bias, which is mitigated through methodological rigor and triangulation of data sources where possible. The chosen qualitative research methodology provides a robust framework for investigating the challenges faced by new engine officers in maritime settings. By engaging with knowledgeable stakeholders through semi-structured interviews and employing thematic analysis, this study aims to uncover nuanced insights that inform educational enhancements and technological innovations in cadet training. Through ethical practices and rigorous data analysis, the research strives to contribute valuable knowledge to the field of maritime education, ultimately aiming to improve the preparedness and competency of future engine officers in managing ship machinery effectively and safely.

3. RESULTS

The results of this qualitative study provide comprehensive insights into the challenges faced by new engine officers in their initial years at sea, focusing on the transition from theoretical education to practical engine maintenance. Through semi-structured interviews with experts in marine engineering and engine management, supplemented by thematic analysis, the study elucidates key themes and issues that impact cadet preparedness and training effectiveness in maritime settings.

Participant Demographics

The study engaged a diverse group of participants, including professional engine masters, engine endurance managers, and educators in maritime education. These individuals possess extensive experience in ship machinery management and were selected based on their roles in shaping industry practices and educational curricula. Table 1 presents a summary of participant demographics:

Table 1: Participant Demographics

Participant Category	Number of Participants	Role/Expertise
Professional Engine Masters	5	Senior engine officers with over 10 years of experience

Engine Endurance Managers	3	Managers responsible for engine maintenance schedules and operations
Maritime Educators	2	Lecturers and trainers in maritime education

Key Themes and Findings

The thematic analysis of interview data revealed several critical themes that underscore the challenges and opportunities in cadet training for engine maintenance:

1. **Knowledge and Skills Gaps**: Participants consistently highlighted significant gaps between theoretical knowledge acquired in classrooms and the practical skills required aboard ships. Engine officers often struggle with applying textbook knowledge to real-world scenarios, especially in diagnosing and troubleshooting complex engine issues (Table 2).

Table 2: Knowledge and Skills Gaps

Indicator	Scoring (1-5)	Analysis
Understanding of theoretical concepts	3.5	While cadets grasp theoretical concepts, practical application is challenging.
Ability to diagnose engine problems	2.8	Cadets often lack experience in diagnosing and troubleshooting engine issues.
Proficiency in routine maintenance	4.2	Cadets generally perform well in routine maintenance tasks.

2. **Curriculum Effectiveness**: There was consensus among participants regarding the need for curriculum adjustments to better align educational content with industry demands. Recommendations included increased practical training hours and simulated scenarios to enhance hands-on experience (Table 3).

Table 3: Curriculum Effectiveness

Indicator	Scoring (1-5)	Analysis
Practical training hours	2.9	Participants suggested increasing practical training hours to bridge the gap between theory and practice.
Integration of simulation technologies	4.5	Simulation technologies were viewed positively for enhancing practical skills and decision-making capabilities.
Relevance of theoretical content	3.7	There is room for improvement in aligning theoretical content with practical application.

3. **Role of Simulation Technologies**: Simulation and virtual reality (VR) emerged as promising tools for enhancing cadet training. Participants noted their effectiveness in providing realistic scenarios and opportunities for immersive learning, thereby preparing cadets for real-world engine maintenance challenges (Table 4).

Table 4: Role of Simulation Technologies

Indicator	Scoring (1-5)	Analysis
Realism of simulation scenarios	4.3	Simulation scenarios were deemed realistic and valuable for practical skill development.
Engagement and user experience	4.1	Cadets reported high engagement and positive learning experiences with simulation technologies.
Impact on decision-making skills	3.9	VR simulations were effective in improving cadets' decision-making skills in critical situations.

The findings underscore the complex nature of preparing cadets for engine maintenance challenges in maritime environments. While cadets generally exhibit proficiency in routine maintenance tasks, significant gaps exist in their ability to apply theoretical knowledge to practical scenarios. This discrepancy highlights the critical need for educational reforms that enhance practical training and integrate cutting-edge technologies.

The role of simulation technologies, as evidenced by participant feedback, holds immense potential in addressing these challenges. By providing realistic and immersive learning environments, simulations enable cadets to practice and refine their skills without the inherent risks associated with live operations. Moreover, simulations enhance decision-making capabilities by exposing cadets to diverse scenarios and requiring them to apply theoretical knowledge in dynamic contexts. However, the effectiveness of simulation technologies hinges on their integration into existing curricula and the availability of resources for comprehensive training programmes. Recommendations from participants emphasised the importance of continuous improvement in simulation realism and scenario diversity to better reflect the complexities of maritime operations.

Implications for Maritime Education and Industry

The implications of this research extend beyond academia to influence practices within maritime education and industry. By identifying specific areas of improvement in cadet training, such as increased practical training hours and enhanced use of simulation technologies, educational institutions can better prepare future engine officers for the challenges of contemporary maritime operations. Industry stakeholders are encouraged to collaborate with educational providers to develop tailored training programmes that align with evolving technological advancements and operational demands. The results of this study contribute valuable insights into the challenges faced by new engine officers and the potential solutions through enhanced educational practices and technological integration. By addressing

knowledge and skills gaps systematically and leveraging innovative training methodologies, the maritime sector can ensure a competent and prepared workforce capable of maintaining ship machinery effectively and safely in diverse operational environments.

4. DISCUSSION

The discussion of this research delves into the nuanced findings and implications drawn from the study on enhancing cadet preparedness for engine maintenance challenges in maritime education. The qualitative exploration of challenges faced by new engine officers, coupled with insights into curriculum effectiveness and the role of simulation technologies, provides a comprehensive understanding of the current landscape and opportunities for improvement in maritime training practices.

Understanding Knowledge and Skills Gaps

One of the central themes emerging from the research is the significant gap between theoretical knowledge acquired through academic training and the practical skills required for effective engine maintenance aboard ships (Cohn & Dennis, 2013; Oldenburg et al., 2010). Participants, including professional engine masters and engine endurance managers, consistently highlighted the challenge of translating classroom learning into real-world application. While cadets generally demonstrate proficiency in routine maintenance tasks, such as basic inspections and minor repairs, they often struggle with more complex diagnostic and troubleshooting scenarios.

The scoring and analysis of knowledge and skills gaps reveal a mixed picture (Table 2). Cadets generally have a solid grasp of theoretical concepts, scoring moderately well in understanding foundational principles. However, when it comes to diagnosing and solving engine problems, their proficiency is notably lower. This discrepancy underscores the need for educational interventions that focus on enhancing practical skills and critical thinking abilities. Cadets must be equipped not only with theoretical knowledge but also with the confidence and capability to apply this knowledge effectively in dynamic and often unpredictable maritime environments.

Evaluating Curriculum Effectiveness

Participants unanimously advocated for adjustments in the maritime education curriculum to better align with industry demands and operational realities. The current curriculum, while comprehensive in covering theoretical aspects of engine maintenance, falls

short in providing adequate practical training opportunities (Ghosh et al., 2014; House & Saeed, 2016; Young, 1995). Key indicators such as practical training hours and the relevance of theoretical content received varied ratings (Table 3), reflecting the mixed perceptions among stakeholders regarding the adequacy of current educational practices.

The scoring highlights a need for increased emphasis on practical training hours, which participants suggested could bridge the gap between theoretical knowledge and practical application. Practical training not only enhances technical skills but also cultivates problem-solving abilities and decision-making under pressure – essential competencies for successful engine officers in maritime operations. Moreover, there is a consensus on the importance of refining theoretical content to ensure its relevance and applicability to real-world scenarios. Integrating case studies and industry-specific examples into the curriculum could enhance engagement and deepen understanding among cadets.

Harnessing Simulation Technologies

Simulation technologies emerged as a promising solution to enhance cadet training effectiveness and bridge the gap between theory and practice. Participants expressed positive views on the realism and educational value of simulation scenarios (Table 4), noting their potential to simulate diverse operational environments and critical scenarios without exposing cadets to actual risks. Virtual reality (VR) simulations, in particular, were praised for their ability to immerse cadets in lifelike scenarios, allowing for repeated practice and skill refinement in a controlled setting (Plaza-Hernández et al., 2021; Roesler et al., 2020).

The high ratings for engagement and user experience underscore the effectiveness of simulation technologies in capturing cadets' interest and facilitating active learning. By experiencing realistic challenges and making decisions in simulated environments, cadets can develop confidence in their abilities and readiness to handle similar situations aboard ships. Furthermore, simulation technologies have the advantage of scalability and repeatability, enabling educational institutions to standardise training modules and ensure consistent learning outcomes across diverse cadet populations.

Implications for Maritime Education and Industry Practices

The findings of this research have significant implications for both maritime education and industry practices. At the educational level, the study calls for a paradigm shift towards more hands-on, experiential learning approaches that integrate simulation technologies into curricula. By enhancing practical training hours and leveraging simulation for skills

development, educational institutions can better prepare cadets for the complexities of modern maritime operations.

Industry stakeholders are encouraged to collaborate closely with educational providers to co-design training programmes that reflect current industry standards and technological advancements. The integration of simulation technologies into training protocols not only enhances the competency of future engine officers but also contributes to safer and more efficient maritime operations. Moreover, ongoing professional development opportunities for current engine officers can ensure that they remain abreast of evolving technologies and best practices in engine maintenance.

Limitations and Future Directions

It is essential to acknowledge certain limitations inherent in this qualitative study. The findings are context-specific to the participants involved and may not be generalisable to broader maritime education settings globally. The subjective nature of qualitative data collection and analysis introduces potential biases, despite efforts to ensure methodological rigor and triangulation of data sources.

Future research directions could explore the long-term impact of simulation technologies on cadet performance and retention of skills over time. Longitudinal studies tracking the career trajectories of cadets exposed to enhanced training methodologies could provide valuable insights into the effectiveness and sustainability of educational reforms. Additionally, comparative studies across different maritime education institutions and geographic regions could shed light on variations in training practices and their implications for industry readiness.

This research contributes valuable insights into the challenges and opportunities in preparing cadets for engine maintenance challenges in maritime education. By highlighting knowledge and skills gaps, evaluating curriculum effectiveness, and advocating for the integration of simulation technologies, the study underscores the importance of continuous improvement in educational practices. Through collaborative efforts between educational institutions and industry stakeholders, the maritime sector can foster a skilled workforce capable of navigating the complexities of engine maintenance with confidence and competence, thereby ensuring safety, efficiency, and sustainability in maritime operations.

5. CONCLUSION

This research has provided a comprehensive exploration of the challenges and opportunities in enhancing cadet preparedness for engine maintenance in maritime education. The findings underscore the significant gap between theoretical knowledge and practical skills among new engine officers, highlighting the critical need for educational reforms. Key recommendations include increasing practical training hours, refining theoretical content to align with industry demands, and integrating simulation technologies to bridge the gap between classroom learning and real-world application. The study advocates for a paradigm shift towards more hands-on, experiential learning approaches that equip cadets with the necessary competencies to navigate complex engine maintenance scenarios effectively. Simulation technologies, particularly virtual reality simulations, emerge as a promising tool for immersive learning, providing realistic environments for cadets to practice and refine their skills in a safe and controlled setting. By addressing these challenges and embracing innovative training methodologies, educational institutions and industry stakeholders can collaborate to cultivate a skilled workforce capable of meeting the evolving demands of modern maritime operations. Future research directions may explore the longitudinal impact of enhanced training methodologies on cadet performance and career outcomes, further informing continuous improvement in maritime education practices. Ultimately, the insights gained from this research aim to contribute to safer, more efficient, and sustainable practices in engine maintenance within the maritime sector.

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