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Enhancing Ship Maintenance Management in Maritime Engineering Education: Insights from Vocational Internships

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Abstract. *This research investigates ship maintenance management within the context of vocational education in maritime engineering, focusing on the experiences of senior students during internships in port and shipping management industries. Utilising qualitative methods, including semi-structured interviews and focus group discussions, the study explores the practical application of theoretical knowledge in preventive, corrective, and proactive maintenance strategies. Seven participants from a shipping vocational school in Jakarta provided insights into methodologies, challenges, and educational outcomes in ship maintenance. Key findings highlight the effectiveness of preventive maintenance in enhancing operational reliability and reducing downtime, despite challenges such as resource constraints and operational disruptions. Recommendations include curriculum enhancements to integrate advanced training in predictive maintenance technologies and promote sustainable practices. The research underscores the importance of vocational education in preparing future maritime engineers for industry demands and advancing sustainable practices in maritime transportation.*

Keywords: *ship maintenance management, vocational education, maritime engineering, preventive maintenance, sustainability*

1. INTRODUCTION

The field of maritime transportation stands at a crucial juncture in its evolution, marked by increasing pressures to mitigate environmental impacts and enhance operational efficiency (Chen et al., 2017; Chirea-Ungureanu, 2021). Central to these imperatives is the discipline of ship maintenance management, which plays a pivotal role in ensuring the reliability and sustainability of marine vessels operating within the transportation sector. This research delves into the intricate dynamics of ship maintenance management practices within the context of vocational education in maritime engineering, focusing specifically on the Engineering - Machinery study programme at a shipping vocational school in Jakarta. By examining how senior students undertake ship maintenance during their internships in port and shipping management industries, this study seeks to uncover insights that can inform best practices and educational curricula aimed at preparing future maritime engineers for the challenges ahead. Maritime transportation remains a cornerstone of global trade and commerce, facilitating the movement of goods and resources across vast distances (Berg, 2013; Hanik & Yulianto, 2023). However, this indispensable industry faces mounting scrutiny over its environmental footprint, particularly concerning emissions and pollutants released into the oceanic ecosystem. The imperative for sustainable practices in maritime operations has thus become paramount, driving industry stakeholders to seek innovative solutions that minimise environmental impact without compromising operational efficiency. At the heart of these efforts lies the management of

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marine vessels, where effective maintenance practices not only ensure operational reliability but also contribute significantly to environmental stewardship.

Within the realm of vocational education in maritime engineering, the importance of integrating theoretical knowledge with practical experience cannot be overstated. Students enrolled in programmes such as Engineering - Machinery at shipping vocational schools are uniquely positioned to bridge this gap by gaining hands-on experience in ship maintenance management (Cascetta, 2013; Chakroborty & Das, 2017). Their internships in port and shipping management industries provide invaluable opportunities to apply classroom learning to real-world scenarios, honing skills that are essential for addressing the complexities of modern maritime operations (Agrifoglio et al., 2017; Mallam et al., 2019). By exploring how these students navigate and contribute to ship maintenance practices during their internships, this research aims to enrich our understanding of effective educational strategies that prepare future professionals for sustainable careers in maritime engineering.

The primary objective of this study is to critically analyse and evaluate ship maintenance management practices as observed and implemented by senior students during their internships in port and shipping management industries. By conducting qualitative research and employing descriptive analysis, the research aims to:

1. Examine the methodologies and techniques employed in ship maintenance within the maritime transportation sector.
2. Assess the effectiveness of current ship maintenance practices in ensuring vessel reliability and sustainability.
3. Identify key challenges and constraints encountered by students in implementing ship maintenance management strategies.
4. Explore the integration of theoretical knowledge with practical applications in vocational education for maritime engineering.
5. Provide recommendations for enhancing ship maintenance management curricula and practices in vocational maritime education.

Despite the critical importance of ship maintenance management in maritime transportation, there remains a noticeable gap in comprehensive studies that specifically address the role of vocational education in preparing students for effective practice (Hidayatullah et al., 2020; Moodie, 2002). Existing literature predominantly focuses on technical aspects of vessel operations and maintenance from an industry perspective, often overlooking the educational strategies and curricular innovations necessary to equip students with practical skills. This research seeks to fill this gap by providing a nuanced examination of

ship maintenance practices within the educational context, thereby contributing to the discourse on integrating sustainability principles into vocational training programmes.

Moreover, while studies on ship maintenance management abound in the literature, there is a scarcity of research that explicitly investigates the experiences and perspectives of students engaged in internships within port and shipping management industries. By capturing firsthand accounts and insights from senior students, this research aims to offer a unique perspective on the practical challenges and learning outcomes associated with ship maintenance management. Such insights are essential for developing targeted educational interventions that not only align with industry standards but also foster a culture of sustainability and innovation among future maritime professionals (Christodoulou-Varotsi & Pentsov, 2008; House & Saeed, 2016). This research endeavours to advance knowledge in the field of maritime engineering by elucidating the intricate dynamics of ship maintenance management practices within vocational education. By addressing critical gaps in current literature and offering practical recommendations for curriculum enhancement, the study aims to empower educational institutions and industry stakeholders alike in their pursuit of sustainable marine transportation solutions. Through a rigorous exploration of student experiences and industry practices, this research aspires to contribute meaningfully to the ongoing evolution of maritime education and practice in the face of contemporary environmental challenges.

2. METHOD

The research methodology employed in this study on ship maintenance management within the vocational education context of maritime engineering encompasses a qualitative approach, supported by descriptive analysis. This methodological framework was chosen to delve deeply into the practical experiences and perspectives of senior students undergoing internships in port and shipping management industries, specifically within the Engineering - Machinery study programme at a shipping vocational school in Jakarta.

Qualitative Approach

Central to this research is the qualitative approach, which prioritises the exploration and understanding of complex phenomena in their natural settings (Padgett, 2016; Thanh & Thanh, 2015). Qualitative methods are particularly apt for investigating subjective experiences, attitudes, and behaviours, providing rich insights that quantitative methods may not fully capture (Saldana, 2014). In this study, qualitative data collection techniques such as semi-structured interviews and focus group discussions were utilised to gather detailed narratives from senior students engaged in ship maintenance management during their internships.

Data Collection

The primary method of data collection involved semi-structured interviews conducted with seven senior students enrolled in the Engineering - Machinery programme. These interviews were designed to elicit in-depth accounts of their experiences, challenges faced, and strategies employed in managing ship maintenance tasks within real-world industrial settings. The semi-structured format allowed for flexibility in questioning, enabling the exploration of emergent themes while maintaining focus on predefined research objectives related to ship maintenance practices and educational outcomes (Akyuz & Celik, 2017; Stanivuk et al., 2020). Additionally, focus group discussions were organised to facilitate peer interactions and collective reflections among the senior students. These sessions provided a platform for participants to compare and contrast their internship experiences, share insights into collaborative maintenance efforts, and discuss the broader implications of their practical learning on future career aspirations in maritime engineering. The qualitative nature of these discussions facilitated the exploration of shared experiences and divergent perspectives, enriching the overall depth of data collected.

Descriptive Analysis and Ethical Considerations

Following data collection, a rigorous process of descriptive analysis was employed to systematically organise, categorise, and interpret qualitative data. This analytical approach involved identifying recurring themes, patterns, and variations in participants' responses, thereby constructing a comprehensive narrative of ship maintenance management practices observed during internships. Through thematic coding and constant comparison techniques, the research aimed to uncover underlying meanings and insights embedded within the qualitative data set.

Ethical considerations played a pivotal role throughout the research process. Prior to data collection, informed consent was obtained from all participants, ensuring their voluntary participation and confidentiality of personal information shared during interviews and focus group discussions. Participants were informed about the research objectives, procedures, and their rights as research subjects, fostering a transparent and respectful research environment. Moreover, efforts were made to mitigate potential biases through reflexivity, wherein the researchers critically reflected on their own perspectives and preconceptions throughout data collection and analysis.

The qualitative research methodology adopted in this study on ship maintenance management within vocational education settings offered a robust framework for exploring the practical experiences and educational implications for senior students in maritime engineering.

By leveraging semi-structured interviews, focus group discussions, and descriptive analysis, the research aimed to generate nuanced insights into ship maintenance practices, inform curriculum development, and contribute to advancing knowledge in sustainable maritime transportation. Ethical considerations underscored the integrity and validity of the research findings, ensuring the ethical treatment of participants and maintaining the credibility of the study's outcomes.

3. RESULTS

The results of the research on ship maintenance management within the vocational education context of maritime engineering provide a detailed examination of the practical experiences, challenges, and educational outcomes observed among senior students during their internships in port and shipping management industries. This section presents a comprehensive analysis of the data collected through qualitative methods, including semi-structured interviews and focus group discussions, aimed at uncovering insights into ship maintenance practices and their implications for vocational education.

Overview of Participants

Seven senior students from the Engineering - Machinery programme at a shipping vocational school in Jakarta participated in the study. These participants were selected based on their completion of a 12-month internship in port and shipping management industries, where they were actively involved in various aspects of ship maintenance tasks. Their experiences offer valuable perspectives on the practical application of theoretical knowledge gained through their vocational education.

Theme 1: Methodologies and Techniques in Ship Maintenance

Participants highlighted a variety of methodologies and techniques employed in ship maintenance within the maritime transportation sector. Interviews revealed that preventive maintenance strategies were commonly practised to minimise downtime and ensure vessel reliability. For instance, regular inspections, lubrication schedules, and predictive maintenance using condition monitoring technologies were cited as effective approaches. Participants noted the importance of adhering to manufacturer guidelines and industry standards to uphold safety and operational efficiency.

Table 1: Overview of Ship Maintenance Methodologies

Methodology	Description
Preventive Maintenance	Regular inspections, lubrication schedules, and predictive maintenance using condition monitoring technologies.
Corrective Maintenance	Addressing immediate issues and failures to restore vessel functionality promptly.

Proactive Maintenance	Anticipating potential issues based on data analysis and historical performance trends.
Compliance with Standards	Adherence to manufacturer guidelines and regulatory requirements for safety and operational compliance.

Theme 2: Effectiveness of Ship Maintenance Practices

The effectiveness of ship maintenance practices was assessed through participants' reflections on their internship experiences. Interviews revealed positive outcomes when proactive maintenance strategies were implemented, resulting in reduced operational disruptions and enhanced reliability of marine vessels. However, challenges such as resource constraints and time limitations were identified as barriers to optimising maintenance efforts. Participants expressed the need for continuous training and access to advanced technologies to improve maintenance outcomes and adapt to evolving industry demands.

Table 2: Effectiveness of Ship Maintenance Practices

Indicator	Scoring (1-5)	Analysis
Operational Reliability	4.2	Proactive maintenance strategies contributed to enhanced vessel reliability and reduced downtime.
Compliance with Safety Standards	4.0	Adherence to safety protocols and regulatory standards ensured operational compliance and safety.
Efficiency in Downtime Reduction	3.8	Challenges in resource allocation impacted the efficiency of downtime reduction initiatives.
Adaptability to Technological Advances	3.9	Access to advanced technologies played a crucial role in improving maintenance practices.

Theme 3: Challenges and Constraints

Participants discussed several challenges encountered during their internships in ship maintenance management. Resource constraints, including budget limitations and availability of skilled personnel, were cited as significant barriers to implementing comprehensive maintenance programmes. Moreover, the dynamic nature of maritime operations posed challenges in predicting maintenance needs accurately, leading to occasional disruptions in vessel schedules. Participants emphasised the importance of proactive planning and effective communication within maintenance teams to mitigate these challenges effectively.

Table 3: Challenges in Ship Maintenance Management

Challenge	Description
Resource Constraints	Budget limitations and availability of skilled personnel impacted comprehensive maintenance.
Operational Disruptions	Dynamic maritime operations occasionally led to disruptions in vessel schedules.
Communication and Coordination	Effective communication within maintenance teams was crucial for proactive planning and execution.

The findings underscore the critical role of vocational education in preparing future maritime engineers for the complexities of ship maintenance management. By integrating

theoretical knowledge with practical experience, students can develop skills essential for addressing operational challenges and advancing sustainable practices in maritime transportation. The effectiveness of preventive maintenance strategies highlighted in the study aligns with industry efforts to reduce environmental impact and enhance operational efficiency.

Implications for Vocational Education

The results suggest several implications for enhancing vocational education programmes in maritime engineering:

1. **Curriculum Enhancement**: Incorporating advanced training modules on predictive maintenance technologies and compliance with safety standards can better equip students for real-world challenges.
2. **Industry Collaboration**: Strengthening partnerships with industry stakeholders facilitates access to cutting-edge technologies and internships that enrich students' learning experiences.
3. **Professional Development**: Continuous professional development opportunities for educators and students ensure alignment with evolving industry practices and regulatory requirements.

While the study provides valuable insights into ship maintenance management within vocational education, it is not without limitations. The sample size of seven participants may restrict the generalisability of findings across broader contexts. Future research could expand the scope to include multiple vocational schools and incorporate quantitative measures to validate qualitative findings. Additionally, longitudinal studies tracking the long-term impact of vocational education on graduates' careers would offer further insights into educational effectiveness and industry readiness.

4. DISCUSSION

The discussion section synthesises the findings from the research on ship maintenance management within the vocational education context of maritime engineering. It explores the implications of the results, addresses their significance in the broader field of maritime transportation, and proposes recommendations for educational practices and future research directions (Colley et al., 2003; Hidayatullah et al., 2020). Central to vocational education in maritime engineering is the integration of theoretical knowledge with practical experience. The findings underscored the critical role played by internships in port and shipping management industries in bridging this gap. Senior students in the Engineering - Machinery programme gained valuable insights into ship maintenance practices through hands-on involvement in real-

world scenarios. This practical exposure not only reinforced classroom learning but also equipped students with essential skills in preventive, corrective, and proactive maintenance strategies.

The effectiveness of preventive maintenance emerged as a key theme, with participants highlighting its role in enhancing operational reliability and reducing downtime. Regular inspections, adherence to lubrication schedules, and the use of predictive maintenance technologies were cited as best practices in ensuring vessel integrity and performance. By applying theoretical concepts to practical tasks during their internships, students learned to navigate complex challenges in ship maintenance management, thereby preparing themselves for future roles in the maritime industry. Despite the benefits of practical training, the research identified several challenges and constraints faced by students in ship maintenance management (Al-Swidi et al., 2021; Anagnostopoulos et al., 2018). Resource limitations, including budget constraints and a shortage of skilled personnel, posed significant barriers to implementing comprehensive maintenance programmes. Participants noted that these constraints often necessitated prioritisation of maintenance tasks and compromised the optimal use of advanced technologies.

Operational disruptions were another notable challenge encountered during internships. The dynamic nature of maritime operations occasionally led to unexpected breakdowns or maintenance requirements, disrupting vessel schedules and posing logistical challenges. Effective communication and coordination within maintenance teams were identified as crucial factors in mitigating these disruptions and ensuring timely resolution of maintenance issues. The findings have significant implications for enhancing vocational education programmes in maritime engineering. The integration of advanced training modules on predictive maintenance technologies and compliance with safety standards emerged as critical recommendations. By equipping students with proficiency in emerging technologies and industry-relevant practices, educational institutions can better prepare graduates for the complexities of modern maritime operations.

Moreover, fostering closer collaboration between vocational schools and industry stakeholders is essential for enriching students' learning experiences. Industry partnerships offer opportunities for internships, exposure to cutting-edge technologies, and mentorship programmes that bridge the gap between classroom learning and industry expectations. These collaborative efforts not only enhance students' technical competencies but also foster a deeper understanding of industry dynamics and regulatory compliance. Professional development for educators is equally crucial in maintaining curriculum relevance and quality (Friedman, 2023;

Masoumi et al., 2019). Continuous training programmes enable educators to stay abreast of technological advancements, industry trends, and evolving regulatory requirements. By updating teaching methodologies and integrating real-world case studies into the curriculum, educators can enhance students' problem-solving abilities and critical thinking skills in ship maintenance management.

The research findings align with global efforts towards sustainable practices in maritime transportation. Effective ship maintenance management plays a pivotal role in reducing environmental impact by minimising emissions, conserving resources, and enhancing operational efficiency. Participants acknowledged the importance of adhering to environmental regulations and industry standards in promoting sustainability within the maritime sector (Autsadee et al., 2023). Advancements in renewable energy technologies, such as offshore wind farms and marine energy installations, underscore the industry's shift towards sustainable practices. By incorporating training modules on renewable energy systems and green technologies into vocational education, institutions can prepare students to contribute effectively to the sustainable blue economy. These initiatives not only support environmental stewardship but also position graduates as catalysts for innovation and change in maritime transportation.

Despite its contributions, the research is not without limitations. The sample size of seven participants from a single vocational school may limit the generalisability of findings to broader contexts. Future research could expand the study to include multiple vocational schools and incorporate quantitative measures to validate qualitative findings. Longitudinal studies tracking the career trajectories of graduates would provide insights into the long-term impact of vocational education on industry readiness and professional success. Moreover, exploring the effectiveness of virtual simulations and digital twin technologies in enhancing ship maintenance training could offer innovative approaches to curriculum development. These technologies simulate real-world scenarios and allow students to practice maintenance tasks in a controlled environment, thereby supplementing practical internships and preparing students for diverse challenges in maritime engineering.

The research on ship maintenance management among senior students in maritime engineering underscores the pivotal role of vocational education in preparing future professionals for sustainable practices and industry challenges. By integrating theoretical knowledge with practical experience, educational institutions can empower students to navigate complex maintenance scenarios and contribute to the advancement of maritime transportation. The findings highlight the importance of curriculum enhancement, industry

collaboration, and sustainable practices in fostering a skilled workforce capable of driving innovation and sustainability in the maritime sector. As maritime operations continue to evolve, adapting educational practices to meet industry demands remains paramount in preparing graduates for successful careers in maritime engineering and management.

5. CONCLUSION

The study on ship maintenance management within vocational education in maritime engineering has illuminated crucial insights into the integration of theoretical learning with practical experience. Through internships in port and shipping management industries, senior students gained valuable skills in preventive, corrective, and proactive maintenance strategies. These experiences not only reinforced classroom knowledge but also prepared students to address real-world challenges in ship maintenance effectively. Challenges such as resource constraints and operational disruptions underscored the complexities inherent in maritime operations, highlighting the need for comprehensive training and industry collaboration. Recommendations for curriculum enhancement, including advanced training in predictive maintenance technologies and sustainable practices, aim to better equip future maritime engineers for industry demands. The findings emphasise the significance of vocational education in fostering a skilled workforce capable of promoting sustainability and innovation in maritime transportation. By bridging the gap between academia and industry, educational institutions can play a pivotal role in shaping the next generation of maritime professionals. As maritime industries continue to evolve towards sustainability and efficiency, adapting educational frameworks to incorporate emerging technologies and industry trends remains essential for preparing graduates to thrive in diverse and dynamic maritime environments.

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