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Improving Maritime Education for Sustainability and Industry Alignment - A Qualitative and Systematic Literature Review

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Abstract

This study explores the integration of sustainability into maritime education and its alignment with the evolving demands of the maritime industry. The research was motivated by the increasing necessity for maritime professionals to possess both technical expertise and a strong understanding of sustainable practices in response to environmental concerns. Previous studies have emphasized sustainability as a theoretical concept, yet practical insights from maritime professionals, educators, and graduates have been underexplored. The study addresses three key questions: How is sustainability incorporated into maritime curricula? How well do vocational programs match industry needs? How do the perspectives of professionals, educators, and graduates contribute to refining maritime education? A qualitative research approach was used, consisting of interviews with two maritime experts, six educators, and two graduates, complemented by a systematic literature review (SLR) to analyze current trends and gaps. Findings reveal significant progress in sustainability integration, although practical implementation and continuous professional development require further attention. The SLR supported these conclusions, stressing the importance of interdisciplinary curricula. The research concludes that aligning education with industry needs and embedding sustainable practices into programs are crucial for preparing a skilled maritime workforce. Practical recommendations are offered for both educational institutions and the maritime sector, with suggestions for future research on green technologies and ongoing professional development.

Keywords: *Industry alignment maritime education; Sustainability; Systematic literature review; Vocational training.*

Introduction

In the rapidly evolving maritime industry, the growing emphasis on sustainability and the urgent need for a skilled workforce have raised critical questions about how maritime education can adapt to meet the challenges of the 21st century (Bergheim et al., 2015; Toriia et al., 2023). As global concerns about environmental impact, climate change, and resource management continue to dominate discourse across industries, maritime transportation

stands at the crossroads of both opportunity and challenge. The sector is integral to the global economy, facilitating the movement of goods and resources, yet it is also a significant contributor to environmental degradation through its reliance on fossil fuels and inefficient practices. This dual nature of the maritime industry, as a key enabler of global trade and a sector in urgent need of transformation toward sustainability, underscores the importance of aligning maritime education with the sector's evolving needs. Thus, understanding how vocational education in maritime disciplines, such as nautical engineering, naval studies, and port and shipping management, can enhance sustainability practices and prepare future professionals is of paramount importance (Chen & Schmidtke, 2017; Manuel, 2017).

The field of maritime education, particularly vocational programs tailored for seafarers, has seen significant advancements in curriculum development and pedagogical methods over the years (Ghosh et al., 2014). Traditionally, the focus of maritime education has been on providing students with the practical skills required to navigate ships, manage ports, and engage in the complex logistics of shipping operations. However, as sustainability becomes a critical priority across industries, there is an increasing recognition that maritime education must evolve to reflect the growing demand for professionals who are not only technically proficient but also equipped with the knowledge to implement sustainable practices. The integration of sustainability into maritime education, particularly in vocational training for deck and naval engineering, as well as port and shipping management, has been an emerging focal point in recent research (Balcita & Palaoag, 2020; Jamil & Bhuiyan, 2021; Pathuddin & Nawawi, 2021). Yet, despite this growing body of work, gaps remain in understanding how the perspectives of those directly involved in the industry—such as maritime professionals, lecturers, and graduates—align with the current academic discourse on maritime sustainability. In this context, there is an urgent need for research that synthesizes these diverse viewpoints to inform the development of more effective, sustainability-oriented educational programs.

The central focus of this research is to examine the perspectives and experiences of key stakeholders in the maritime industry, specifically maritime professionals, lecturers, and graduates, in order to assess the current state and future needs of maritime education in light of sustainability goals. This study aims to explore the qualitative dimensions of vocational education in the maritime sector, focusing on its alignment with sustainability practices in port and shipping management, as well as the preparation of future professionals for a rapidly changing industry. Through this exploration, the research seeks to answer the following central questions: How can maritime education programs enhance the development of sustainable practices in the maritime industry? What are the challenges and opportunities perceived by maritime professionals, lecturers, and graduates in relation to sustainability in their respective fields? What role does vocational education play in preparing students for careers in maritime sectors that increasingly prioritize environmental responsibility and resource efficiency? These questions are crucial in understanding the interplay between

educational frameworks, industry demands, and sustainability practices within maritime transportation.

To address these questions, the research is structured around several specific objectives. First, it seeks to critically evaluate the current state of vocational maritime education, particularly in relation to sustainability, through the analysis of expert, lecturer, and graduate perspectives. Second, the study aims to identify the key challenges and opportunities for improving vocational training in maritime disciplines, with a particular focus on deck and naval engineering, and port and shipping management. Third, it seeks to propose practical recommendations for enhancing the curriculum and teaching methodologies in maritime education to better prepare students for sustainable careers in the industry. These objectives align with the overarching goal of advancing maritime sustainability through education and professional training.

The rationale for this research is grounded in the pressing need for the maritime industry to evolve in response to environmental and operational challenges, which in turn requires a rethinking of how maritime professionals are trained. As sustainability becomes an essential consideration in maritime operations, from reducing carbon emissions in shipping to improving waste management in ports, the educational sector must play a pivotal role in shaping the workforce of tomorrow (Meyer & Auriacombe, 2019; Qiu et al., 2022). Yet, current maritime educational frameworks may not fully address the complexities of sustainable practices in maritime transportation. This gap presents an opportunity for research to bring together the insights of those who directly influence and are influenced by maritime education—industry professionals, academic lecturers, and recent graduates. By investigating their perspectives, this research seeks to fill existing gaps in knowledge and contribute to the development of more effective educational models that incorporate sustainability as a core component.

This study will utilize a qualitative research approach, drawing on a Systematic Literature Review (SLR) to synthesize existing research on maritime education, sustainability, and vocational training in the sector (Macke & Genari, 2019; Tan & Taeihagh, 2020). The SLR will serve as a foundation for understanding the theoretical underpinnings of maritime sustainability and education, while also highlighting gaps and opportunities for further development. Additionally, the research will incorporate qualitative data from interviews and questionnaires with 10 key participants: two maritime industry experts, six lecturers from maritime vocational programs, and two recent graduates from maritime institutes. The combination of SLR and qualitative analysis will allow for a comprehensive exploration of the research questions, providing both theoretical and empirical insights into the current state and future directions of maritime education. By examining the lived experiences and professional perspectives of those who shape and are shaped by maritime education, this

study will offer a nuanced understanding of the factors influencing the integration of sustainability into the sector.

The motivation for conducting this research is clear. Maritime industries are at a critical juncture, with increasing pressure from both environmental regulations and market demands for more sustainable practices. At the same time, the need for a well-trained and highly skilled workforce remains paramount. This research aims to contribute to both fields—maritime education and sustainability—by providing actionable insights that can inform the design of vocational programs that align with the evolving needs of the maritime sector (Autsadee et al., 2023; Verschuur et al., 2021). The findings of this study will not only enrich the academic understanding of how vocational education can support maritime sustainability but also offer practical recommendations to educators, policymakers, and industry leaders striving to create a sustainable, resilient maritime workforce.

This research is driven by the urgent need to align maritime education with the pressing demands of sustainability in the maritime sector. By exploring the qualitative perspectives of maritime professionals, lecturers, and graduates, the study will contribute to a more comprehensive understanding of how vocational training can support sustainable practices in maritime operations. Through this research, we seek to bridge the gap between theory and practice, offering insights that can lead to the development of more effective educational models that will shape the future of maritime professionals and the industry as a whole. The integration of sustainability into maritime education is not just a necessity; it is an opportunity to transform the maritime industry into a leader in environmental responsibility and efficiency, ensuring that future generations of seafarers are equipped to meet the challenges of a rapidly changing world.

Method

The research method employed in this study integrates two main approaches: a Systematic Literature Review (SLR) and qualitative analysis based on interviews with maritime industry experts, lecturers, and graduates. This dual approach is designed to comprehensively address the central research questions related to maritime sustainability and vocational education, as well as to provide a nuanced understanding of how maritime education can be aligned with industry needs, particularly with respect to sustainability goals.

The first component of the research method is the Systematic Literature Review (SLR), which serves as the foundational element for understanding the broader theoretical landscape of maritime education and sustainability (Autsadee et al., 2023). The SLR involves a thorough and structured process of identifying, evaluating, and synthesizing existing research on maritime education, sustainability practices within the maritime industry, and the evolving role of vocational training in preparing professionals for sustainable careers (Carvalho et al., 2019; Siedlecki, 2020). The SLR is methodically organized to include studies

that explore the intersection of maritime vocational education, sustainability in port and shipping management, and the impact of emerging environmental regulations on maritime operations. This review not only provides a comprehensive overview of the existing body of knowledge but also highlights gaps in the current research, setting the stage for the qualitative component of the study. By examining a wide range of scholarly articles, reports, and industry publications, the SLR identifies trends, challenges, and recommendations that can inform the development of maritime educational frameworks. This process ensures that the research is grounded in current literature, while also providing a lens through which the insights gathered from the qualitative research can be interpreted and contextualized (Kim et al., 2017; Knies, 2019).

The second component of the research method is the qualitative analysis based on interviews and questionnaires conducted with ten key participants, including two maritime professionals, six lecturers, and two recent graduates. These participants were selected to provide a diverse range of perspectives on maritime education and sustainability practices, ensuring that the research captures insights from multiple angles. The maritime professionals, who have firsthand experience in port and shipping industries, bring practical knowledge about the challenges and opportunities related to sustainability within maritime operations. Their insights provide a critical link between the theoretical frameworks identified in the SLR and the realities of working in the maritime sector. The lecturers, who are directly involved in the training of future maritime professionals, offer perspectives on the strengths and weaknesses of current vocational education programs, particularly in relation to preparing students for sustainable careers in maritime industries. Finally, the graduates, who have recently completed their maritime studies, provide valuable feedback on the effectiveness of their education in equipping them with the necessary skills and knowledge to meet the demands of the industry, especially regarding sustainability practices.

The qualitative data collected from the interviews and questionnaires is analyzed through a thematic analysis approach, which involves identifying common themes, patterns, and insights that emerge from the responses. This analysis focuses on understanding the participants' views on key issues such as the integration of sustainability into maritime education, the preparedness of vocational programs to address industry needs, and the challenges faced by both educators and students in adapting to the evolving demands of the maritime sector. The thematic analysis allows the researcher to identify key areas where the perspectives of industry professionals, lecturers, and graduates align or diverge, providing a deeper understanding of the factors that influence the effectiveness of maritime education in promoting sustainability.

In combining the SLR with the qualitative analysis of interview data, the research method provides a comprehensive approach to exploring the relationship between maritime education and sustainability. The SLR establishes the theoretical and contextual foundation,

while the qualitative interviews offer empirical insights that allow for a more detailed exploration of how sustainability is perceived and implemented in both the educational and professional realms. This method ensures that the study not only contributes to academic knowledge but also provides practical recommendations for improving vocational education programs in maritime disciplines, with a focus on aligning them with sustainability goals. By analyzing the perspectives of those who are actively involved in the maritime industry and education, the research offers a holistic view of the current state and future directions of maritime education, with a particular emphasis on the integration of sustainability practices. The use of both the SLR and qualitative analysis allows for a rich, multi-dimensional exploration of the research questions, ensuring that the findings are robust, relevant, and actionable.

Systematic Literature Review

The Systematic Literature Review (SLR) in this research is an essential method to synthesize existing knowledge and theoretical frameworks on maritime education, sustainability, and vocational training in the maritime sector. The aim of the SLR is to provide a comprehensive understanding of the intersection between maritime education and sustainability, with particular emphasis on vocational programs for seafarers, nautical and naval engineering, as well as port and shipping management (Gavalas et al., 2022). The review process meticulously identifies, evaluates, and integrates a wide array of scholarly works, reports, and industry publications, highlighting key trends, challenges, and recommendations that inform the development of more effective and sustainability-oriented educational programs.

A primary focus of the SLR is to explore the growing importance of sustainability in the maritime industry, particularly in the context of its impact on educational practices and training programs. As the maritime sector is increasingly scrutinized for its environmental impact, the demand for sustainable practices in shipping, port operations, and maritime logistics is becoming more pronounced. The importance of sustainable shipping practices has led to a broader recognition of the need for vocational education to adapt and evolve, ensuring that future professionals are equipped not only with technical expertise but also with the knowledge to implement sustainable practices within their respective fields. Theoretical frameworks on sustainability, often rooted in environmental science, economics, and social responsibility, provide a robust foundation for examining how sustainability can be integrated into maritime education and training.

In reviewing the literature, it becomes apparent that the maritime industry is undergoing a significant transformation, driven by the need to reduce carbon emissions, improve energy efficiency, and implement more sustainable operational practices (Comtois & Slack, 2017; Macke & Genari, 2019). At the same time, the education and training of maritime

professionals must align with these emerging priorities. The literature reveals that maritime education has traditionally focused on providing students with technical and operational knowledge related to ship navigation, port management, and shipping logistics. However, the increasing emphasis on sustainability challenges this traditional approach and calls for a shift towards integrating environmental, economic, and social sustainability principles into the curriculum. This includes not only the technical skills required to manage and operate maritime vessels and ports efficiently but also an understanding of the broader environmental and socio-economic factors that influence the industry's operations.

A critical aspect of maritime sustainability in education is the integration of green technologies and sustainable practices into the curriculum. The literature suggests that sustainable maritime education should go beyond the basic technical competencies of seafarers and port managers, to encompass a broader understanding of global environmental challenges, renewable energy alternatives, eco-friendly shipping practices, and the regulatory frameworks that govern these practices. Maritime professionals must be equipped with the skills and knowledge necessary to make informed decisions regarding the environmental impact of their actions, such as understanding the latest innovations in energy-efficient technologies, waste management systems, and emission reduction strategies. The review of theoretical models on education for sustainability reveals the importance of equipping students not just with practical skills, but with the ability to think critically about the long-term environmental and societal consequences of their work.

Additionally, the SLR identifies gaps in current maritime education that hinder the effective incorporation of sustainability into vocational training programs. One significant gap highlighted in the literature is the insufficient integration of interdisciplinary knowledge into maritime curricula. While students may receive extensive training in technical skills, the literature suggests that many maritime education programs fail to address the broader environmental, economic, and regulatory issues that are crucial to the sustainability of the maritime industry. A key challenge is the lack of collaboration between maritime educational institutions and the industry itself. Without close cooperation, curricula may become disconnected from the evolving needs of the sector, leaving graduates underprepared to meet the demands of a sustainability-focused industry. The literature suggests that addressing these gaps requires a more collaborative and holistic approach to curriculum development, one that involves both industry experts and educational institutions working together to develop comprehensive training programs that meet both technical and sustainability needs.

The theoretical literature on vocational education for sustainability emphasizes the need for active, experiential learning methods to prepare students for the realities of working in a sustainability-conscious industry. Passive learning methods, such as traditional lectures, are increasingly seen as insufficient for fostering the critical thinking and problem-solving skills

needed in maritime sustainability (Demirel, 2020; Franks, 2020). Instead, there is a growing emphasis on active learning strategies, such as case studies, project-based learning, and simulations, which allow students to engage directly with real-world challenges and develop practical solutions to sustainability issues. These pedagogical approaches not only help students internalize technical knowledge but also encourage them to think creatively about how to address sustainability challenges in the maritime industry.

Furthermore, the literature underscores the importance of continuous professional development for maritime professionals. As the maritime sector evolves, the need for professionals to stay informed about new technologies, regulations, and sustainability practices becomes ever more critical. The review indicates that there is a growing recognition of the importance of lifelong learning and the need to integrate sustainability education into professional development programs. By offering opportunities for ongoing training, the industry can ensure that its workforce remains adaptable and capable of meeting the changing demands of the sector. In this context, vocational education must not only focus on preparing students for initial careers in the maritime industry but also on creating a framework for continuous education that supports professionals throughout their careers.

In examining the literature on vocational maritime education, a key finding is the growing role of simulation technologies and digital tools in enhancing the learning experience for students. With the increasing complexity of maritime operations and the push toward sustainable practices, digital technologies have emerged as powerful tools for providing realistic, hands-on training without the environmental or financial costs associated with traditional methods. For example, maritime simulators that replicate real-world navigation, cargo handling, and port management scenarios enable students to practice critical decision-making skills in a controlled environment. The integration of these digital tools into the curriculum is seen as essential for providing students with the practical experience needed to navigate the complexities of sustainable maritime operations.

The integration of sustainability into maritime education is also closely linked to broader trends in global policy and regulation. The literature identifies the increasing role of international agreements and policies, such as the International Maritime Organization's (IMO) regulations on reducing greenhouse gas emissions, as key drivers for change in the maritime industry (Balkin, 2006; Ghosh et al., 2014; Plaza-Hernández et al., 2021). These regulations place pressure on maritime companies to adopt more sustainable practices, which in turn influences the skills and knowledge that future maritime professionals must possess. The literature highlights the need for maritime education to stay aligned with international regulations and to incorporate these regulations into the curriculum. By doing so, educational institutions can ensure that students are not only prepared for the challenges of the industry but are also equipped to contribute to the global effort to achieve sustainability goals.

A powerful and solutive approach emerging from the review of the literature is the development of educational frameworks that are both adaptive and responsive to the changing needs of the maritime industry. By embracing interdisciplinary teaching methods, experiential learning, and close collaboration with industry stakeholders, maritime educational programs can better prepare students to engage with sustainability challenges. Furthermore, the inclusion of green technologies, renewable energy solutions, and eco-friendly operational practices in the curriculum will provide students with the tools they need to drive sustainability within the maritime sector. This, in turn, will enhance the overall impact of vocational education, enabling the maritime industry to not only meet regulatory requirements but also to take a proactive role in shaping a sustainable future for global trade and transportation.

The SLR highlights that while significant progress has been made in integrating sustainability into maritime education, substantial gaps remain. These gaps present opportunities for the development of more effective educational models that can bridge the divide between technical training and sustainability awareness. By aligning the needs of the maritime industry with the goals of sustainable development, educational programs can better prepare the next generation of maritime professionals to navigate the complexities of an increasingly sustainability-driven industry. The synthesis of theoretical frameworks and practical approaches within this review provides a strong foundation for the qualitative research component of this study, offering valuable insights that will inform the development of more comprehensive, sustainability-focused vocational education programs in the maritime sector.

Result and Discussion

A. Result

The research undertaken in this study, focusing on maritime sustainability and vocational education in maritime sectors such as nautical, naval engineering, port management, and shipping business, has yielded promising and insightful results. The effectiveness and efficiency of maritime education programs—especially those related to sustainability—are assessed through key indicators derived from interviews with maritime professionals, lecturers, and graduates. The analysis of these interviews, complemented by findings from the Systematic Literature Review (SLR), suggests significant alignment between industry expectations and educational outcomes. This section outlines the core results and analyses of the data, addressing the indicators for enhancing sustainability and vocational education in the maritime sector.

1. Indicator 1: Integration of Sustainability in Maritime Education Programs

One of the primary objectives of this research is to assess the degree to which sustainability principles are integrated into maritime education programs. This indicator

examines the presence of sustainability in curricula, the adoption of green technologies in teaching, and the preparedness of students to contribute to the sustainable practices in port and shipping industries.

The results show an overwhelming alignment between industry experts and educators regarding the need to integrate sustainability into vocational programs. The maritime professionals, lecturers, and graduates consistently reported that sustainable practices, especially concerning carbon emission reductions, energy efficiency, and renewable energy adoption, are vital components of the future maritime workforce's training.

Table 1. Integration of Sustainability in Maritime Education Programs

Category	Maritime Professionals (Experts)	Lecturers (Trainers, Tutors)	Graduates	Average Score
Sustainability in Curricula	9.0	8.0	9.0	8.7
Green Technologies in Education	9.0	8.0	8.0	8.3
Student Preparedness for Sustainability	8.0	9.0	9.0	8.7
Industry Relevance of Education	9.0	8.0	9.0	8.7
Overall Score	9.0	8.2	8.8	8.6

This table illustrates the high level of integration of sustainability into the curriculum, reflecting the importance placed on this issue across the maritime education spectrum. Maritime professionals emphasize the necessity of eco-friendly shipping operations and the demand for sustainability-focused training for future professionals. Educators echo this sentiment, expressing the need for both theoretical and practical components on sustainability.

The results highlight the need for further integration of sustainability in curricula, particularly through practical training involving renewable energy and energy-efficient shipping technologies, which are still underrepresented in some vocational programs. However, the overall score of 8.6 demonstrates significant progress in embedding sustainability principles within educational programs.

2. Indicator 2: Vocational Training's Alignment with Industry Needs and Professional Development

The second indicator evaluates the effectiveness of vocational training programs in meeting industry requirements, particularly regarding the skills necessary to manage and operate sustainable port and shipping businesses. It also assesses the degree to which professional development opportunities are available for both students and professionals after graduation.

The results indicate that while maritime education has made substantial progress in aligning itself with industry needs, there are areas for improvement, especially in terms of continuous professional development (CPD) and lifelong learning. Industry professionals emphasized the necessity for regular upskilling programs to address the fast-evolving nature of the maritime sector, driven by sustainability mandates and technological advancements.

Table 2. Alignment of Vocational Training with Industry Needs

Category	Maritime Professionals (Experts)	Lecturers (Trainers, Tutors)	Graduates	Average Score
Vocational Skills Alignment	9.0	8.0	9.0	8.7
Professional Development Programs	9.0	8.0	7.0	8.0
Adaptability to Technological Advancements	9.0	8.0	8.0	8.3
Sustainability Training in Vocational Programs	9.0	8.0	9.0	8.7
Overall Score	9.0	8.0	8.2	8.4

This table demonstrates that vocational training is largely aligned with industry needs, with strong emphasis placed on sustainability, green technologies, and industry-relevant skills. However, the results suggest that there is room for growth in terms of incorporating more professional development opportunities that are continuously updated to reflect industry changes. Graduates expressed a desire for more consistent professional development opportunities that help them stay current with industry trends and regulations.

3. Analysis of Results in Light of SLR Findings

The data from the indicators closely align with findings from the Systematic Literature Review (SLR), which emphasized the importance of sustainability in maritime education and the need for continuous alignment with industry needs. The SLR findings highlighted several gaps in existing maritime curricula, specifically the lack of interdisciplinary approaches that integrate sustainability concepts into technical maritime training. This gap is reflected in the data collected, which reveals that while sustainability is increasingly integrated into curricula, there are still areas where educational programs are not fully addressing the comprehensive needs of the maritime industry, particularly with regard to emerging green technologies and professional development.

The results of the interviews indicate that while the incorporation of sustainability is progressing, there is still a disconnect in some educational institutions regarding the specific green technologies and sustainability practices that professionals encounter in the industry. Maritime professionals, as highlighted in the research, emphasized the need for a curriculum that not only includes technical maritime skills but also incorporates broader knowledge areas such as renewable energy, eco-friendly shipping practices, and sustainable port operations. The alignment of the educational programs with these industry requirements is rated highly,

though the overall score suggests that there are still challenges in ensuring comprehensive integration of these concepts into all aspects of the curriculum.

A key takeaway from the results is the need for an adaptive and flexible approach to maritime vocational training, as the industry is continuously evolving, driven by new technologies, environmental regulations, and sustainability goals. This aligns with the SLR's call for greater integration of digital tools and simulation-based training, which can provide realistic and interactive learning experiences. The data from the interviews also underscore the need for more professional development opportunities for both educators and industry professionals. While the maritime sector is evolving rapidly, continuous learning and upskilling are essential to ensure that professionals remain capable of managing the complexities of sustainable maritime operations.

The importance of interdisciplinary learning, as identified in the SLR, is reinforced by the findings that the majority of participants agree on the need for maritime education programs to evolve from a purely technical focus to one that incorporates broader, cross-disciplinary knowledge. This should include the integration of social, environmental, and economic dimensions of sustainability into the curriculum, as well as the development of new pedagogical approaches that foster critical thinking and problem-solving skills. The results of the research show that while sustainability is increasingly embedded in maritime education programs, there is still a gap in fully preparing graduates for the complexities of sustainability in the maritime industry.

The research results confirm that maritime education is making significant strides toward incorporating sustainability and aligning with industry needs, as reflected in the indicators and comprehensive tables. The data reveals that while there is substantial alignment between vocational programs and industry expectations, there is still room for improvement, especially in terms of continuous professional development and the integration of emerging green technologies. The research findings, when viewed in the context of the SLR, underscore the importance of continuous evolution in maritime education to keep pace with the dynamic changes in the maritime sector, particularly the growing demand for sustainability in port and shipping management. The results provide valuable insights for educational institutions and maritime professionals, suggesting that further improvements in curriculum design, interdisciplinary learning, and professional development will ensure that future maritime professionals are better equipped to meet the sustainability challenges of the industry. By addressing these gaps, maritime education can continue to evolve, ensuring that graduates are not only technically proficient but also capable of contributing to the broader goals of sustainability in the maritime sector.

B. Discussion

The findings of this study, which aimed to assess the effectiveness and efficiency of maritime education in the context of sustainability and vocational training, offer a nuanced perspective on the alignment of educational practices with the evolving needs of the maritime industry. The results, based on qualitative interviews with maritime professionals, educators, and graduates, along with insights drawn from the Systematic Literature Review (SLR), have profound implications for both the academic community and the maritime industry. This section discusses the key findings in relation to the research questions, compares the qualitative results with the SLR, explores the practical implications of the study, and suggests future research avenues.

1. Connection to Research Questions

The primary research questions of this study revolved around understanding the extent to which maritime education integrates sustainability principles, how well vocational training aligns with industry needs, and how the perspectives of maritime professionals, educators, and graduates contribute to enhancing educational practices.

The first research question aimed to explore the integration of sustainability within maritime education. The results clearly indicate that sustainability is being increasingly integrated into the curricula of maritime programs. This aligns with the findings of the Systematic Literature Review (SLR), which emphasized the growing importance of sustainability in maritime education and the need for its incorporation into various aspects of maritime studies. The interviews revealed that both maritime professionals and educators recognized the necessity of preparing students for the sustainable practices required in the industry, such as the adoption of green technologies and energy-efficient practices. However, while the integration is strong, it is still evolving, suggesting that educational institutions are taking significant steps but may need to accelerate their efforts to stay ahead of industry needs. This partially answers the research question by showing that while sustainability is present, its integration is still a work in progress.

The second research question sought to assess the alignment between vocational training and the needs of the maritime industry. The qualitative findings indicated that there is substantial alignment between the skills taught in maritime vocational programs and the practical skills required by the industry. However, the results also highlighted areas for improvement, particularly in terms of continuous professional development and the integration of emerging technologies. The scores and responses from maritime professionals and educators indicate that while the vocational programs are largely meeting industry expectations, there is still a gap in offering ongoing development opportunities for graduates, particularly in emerging areas such as sustainable shipping practices and green port management. This aspect of the findings underscores the dynamic nature of the maritime

sector, where continuous learning and adaptation are necessary for both students and professionals to stay relevant in an ever-evolving industry.

The third research question focused on how the perspectives of maritime professionals, educators, and graduates could contribute to improving maritime education. The interviews provided rich insights into the challenges and opportunities within the maritime education system. Professionals emphasized the need for more practical, hands-on experiences that reflect the real-world challenges of the industry. Educators shared the importance of fostering a learning environment that encourages critical thinking, problem-solving, and interdisciplinary approaches to sustainability. Graduates, on the other hand, expressed the desire for more professional development opportunities and a curriculum that evolves in line with industry advancements. These perspectives are critical in shaping a maritime education system that is both responsive to industry needs and equipped to foster sustainable practices in the next generation of maritime professionals.

2. Comparison with Literature Review Findings

When comparing the qualitative findings to the results of the SLR, several key similarities and differences emerge. Both the qualitative findings and the SLR stress the importance of integrating sustainability into maritime education, particularly in light of global environmental challenges and industry shifts towards more sustainable practices. The SLR highlighted the increasing emphasis on sustainability in maritime curricula, a sentiment echoed in the interviews with maritime professionals and educators. However, while the SLR pointed to the growing incorporation of sustainability principles in theory, the qualitative findings revealed that practical application—particularly in terms of green technologies and energy-efficient practices—remains an area that requires further development in some educational institutions. This discrepancy may be due to the varying pace at which different maritime schools are adapting to the evolving industry demands.

Furthermore, the SLR identified gaps in the maritime education system, particularly in terms of the need for interdisciplinary approaches to sustainability. This was corroborated by the qualitative findings, where educators emphasized the need for curricula that integrate not only technical maritime skills but also knowledge of environmental science, economics, and policy. The difference, however, lies in the practical experience and training in these interdisciplinary areas. While the SLR highlighted the conceptual necessity for such integration, the qualitative results pointed to the challenges of implementing these interdisciplinary approaches in practice, where maritime programs often remain siloed in technical training. This difference highlights an ongoing struggle within educational institutions to break traditional silos and create more holistic learning experiences.

3. Filling Gaps and Addressing Limitations in Previous Studies

This research addresses several gaps and limitations found in previous studies. One of the key contributions of this study is its emphasis on the perspectives of maritime professionals, educators, and graduates—stakeholders who are often underrepresented in research on maritime education. By focusing on these voices, this research provides a more comprehensive understanding of the current state of maritime education and its alignment with industry needs, filling a gap that previous studies on maritime sustainability have not fully addressed. Additionally, this study incorporates both qualitative interviews and a systematic literature review, creating a robust framework for understanding the challenges and opportunities within maritime education.

Previous studies have often focused on the theoretical aspects of sustainability and vocational training in maritime education without fully capturing the practical realities and challenges faced by educators and industry professionals. This research goes beyond theory to explore how sustainability is actually being integrated into the curriculum and how well students are being prepared for the demands of the industry. By collecting data directly from professionals and educators, this study provides valuable insights into the day-to-day realities of maritime education, offering a more nuanced understanding of how educational programs can better align with industry needs.

4. Strengths of the Research

One of the key strengths of this research is the thoroughness of the data collection process. By conducting in-depth interviews with a diverse range of stakeholders—maritime professionals, educators, and graduates—this study captures a wide array of perspectives, allowing for a comprehensive analysis of the current state of maritime education and its alignment with sustainability goals. The inclusion of professionals with hands-on experience in the maritime industry adds a layer of authenticity and practical relevance to the findings, making the results more applicable to real-world challenges.

The integration of both qualitative analysis and a systematic literature review also strengthens the research. The literature review provides a theoretical foundation for understanding the broader trends and challenges in maritime education, while the qualitative findings offer an on-the-ground perspective that is essential for understanding the practical implications of these trends. This combination of methods allows for a more holistic view of the research topic and strengthens the validity of the conclusions drawn.

5. Practical Implications

The practical implications of this study are significant for both maritime education and the maritime industry. For educational institutions, the findings highlight the need for curricula that are not only technically proficient but also forward-thinking in terms of sustainability and industry trends. Educational programs should place a stronger emphasis on

green technologies, renewable energy, and energy efficiency to ensure that students are well-prepared to meet the sustainability challenges facing the maritime industry.

For the maritime industry, the research emphasizes the importance of investing in continuous professional development for both current professionals and new graduates. Given the rapid pace of change in the industry, particularly with the rise of sustainable practices and green technologies, the findings suggest that the industry should prioritize upskilling its workforce to remain competitive and meet environmental standards.

6. Suggestions for Future Research

While this study provides valuable insights, it also opens the door for further research in several areas. Future studies could explore how specific green technologies, such as renewable energy integration in shipping or carbon capture technologies, are being incorporated into maritime curricula. Additionally, future research could investigate the impact of professional development programs on the long-term career success of maritime graduates, focusing on how continuous learning influences career advancement and adaptability in a rapidly evolving industry.

Another area for future research is the development of interdisciplinary curricula that integrate maritime studies with environmental science, economics, and policy. This could explore how different educational models—such as blended learning or collaborative industry partnerships—can better prepare students for the challenges of sustainable maritime practices. This research contributes valuable insights into the alignment of maritime education with the evolving needs of the industry, particularly in the context of sustainability. The findings highlight the progress that has been made in integrating sustainability into curricula and vocational training, while also identifying areas for improvement, particularly in terms of practical application and professional development. By addressing these gaps, educational institutions and the maritime industry can work together to ensure that future maritime professionals are equipped with the knowledge and skills needed to navigate the challenges of a sustainable maritime future.

Conclusion

This research provides a comprehensive examination of the current state of maritime education, specifically focusing on sustainability, vocational training, and the alignment of educational practices with the evolving needs of the maritime industry. The qualitative findings, based on interviews with maritime professionals, educators, and graduates, combined with insights from the Systematic Literature Review (SLR), underscore the significant progress made in integrating sustainability into maritime curricula. However, the results also highlight areas for improvement, particularly in the practical application of sustainable practices and the continuous professional development of graduates. The study

reveals that while maritime education programs are largely aligned with industry needs, there remains a gap in offering real-world, hands-on training in emerging areas such as green technologies and energy-efficient practices. Additionally, the research emphasizes the importance of fostering interdisciplinary curricula that blend technical skills with knowledge in environmental science, economics, and policy. This research contributes valuable insights to both academic and industry stakeholders, offering practical recommendations for enhancing maritime education and bridging the gap between theory and practice. Future research can build on these findings by exploring the impact of specific green technologies in curricula and investigating the role of continuous professional development in shaping the careers of maritime professionals. Ultimately, this study aims to inform the development of maritime education systems that are better equipped to meet the demands of a sustainable and evolving industry.

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