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Seafarer Readiness for Green Shipping Transition - Insights from Maritime Education and Industry Professionals

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Abstract*. The transition to green shipping is a critical challenge for the maritime sector, requiring a shift in both technological adoption and workforce preparedness. This research examines the readiness of seafarers for this transition, focusing on the alignment between maritime vocational education and industry needs. The analysis addresses the gap between theoretical knowledge and practical application in green shipping technologies. The research aims to answer key questions regarding the integration of sustainability into maritime education, seafarer readiness, and the alignment of training with industry requirements. A qualitative methodology combining Systematic Literature Review (SLR) and interviews with 10 maritime professionals, educators, and graduates was used to gather insights. The SLR provided a theoretical framework for understanding the green shipping transition, while the interviews revealed practical barriers to implementing sustainable practices in training programs. The findings show a clear misalignment between current educational practices and industry demands, with a need for hands-on training and stronger collaboration between academia and industry. The research emphasizes the importance of integrating green shipping technologies into curricula and fostering a culture of sustainability in the maritime sector. This study contributes valuable insights into the preparation of seafarers for a sustainable future in the maritime industry, offering practical recommendations for improving education and industry collaboration.*

Keywords*: seafarer readiness, green shipping, maritime education, sustainability, vocational training*

1. INTRODUCTION

The maritime industry is facing a transformative period driven by an urgent need for sustainability. As the global shipping sector grapples with environmental concerns, the concept of "green shipping" has emerged as a critical focal point. This transition is not only reshaping maritime operations but also demanding significant adjustments in the way maritime professionals, particularly seafarers, are trained. As green shipping technologies become increasingly integrated into the maritime sector, seafarer readiness has come under scrutiny. How well do maritime vocational educators and industry professionals prepare seafarers to meet these new demands? This question stands at the heart of an ongoing challenge for maritime education and training programs. Addressing this challenge is not only crucial for the sustainability of the shipping industry but also for ensuring that the future workforce is capable of navigating this new era in maritime history.

Maritime sustainability has garnered significant attention in recent years, with increasing pressure on the shipping industry to reduce its carbon footprint and adopt eco-friendly technologies (Zaderei, 2020). Green shipping practices, such as the use of alternative

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fuels, energy-efficient technologies, and environmentally-conscious operational strategies, are now seen as essential for the industry's future. This shift has prompted a reevaluation of the skills and knowledge required by seafarers, port professionals, and other maritime workers. While green shipping is becoming a key priority, there remains a gap in understanding the extent to which maritime vocational education programs have integrated these new practices into their curricula. Maritime education institutions face the dual challenge of keeping pace with technological advancements while equipping students with the practical skills required to thrive in an increasingly sustainable maritime environment (Sharma, 2023; Toriia et al., 2023). This gap in educational preparedness poses significant risks for the industry, as seafarers who lack the necessary knowledge and training may find themselves ill-prepared to meet the demands of a green shipping transition.

The central problem driving this research is the need to explore the readiness of seafarers for the green shipping transition and how maritime vocational educators and industry professionals are responding to these challenges. Specifically, this study investigates the perspectives of two key groups: maritime professionals working in the port and shipping industries, and educators involved in training the next generation of seafarers. The research examines their insights into the preparedness of seafarers for green shipping technologies and practices. The key research questions guiding this study include: How prepared are seafarers to adapt to the green shipping transition? To what extent are maritime vocational programs integrating sustainability and green shipping principles into their training? How do industry professionals perceive the readiness of current and future maritime workers to navigate the evolving demands of the sector? The objectives of this study are to provide a detailed understanding of seafarer readiness for green shipping, to identify the challenges and opportunities for maritime education in this context, and to offer recommendations for improving vocational training to better align with the green shipping agenda.

The rationale behind this research is grounded in the pressing need to ensure that seafarers and maritime professionals are adequately prepared for the green shipping transition. The maritime industry is a cornerstone of global trade, and its environmental impact has been a subject of increasing concern. As international regulations become more stringent and the demand for sustainable practices rises, the workforce must be equipped with the skills and knowledge to implement these changes effectively (Agrifoglio et al., 2017; Toriia et al., 2023). Maritime vocational programs play a crucial role in bridging the gap between emerging industry needs and the competencies of the workforce. Yet, little research has been conducted to assess the extent to which these programs are meeting the needs of the industry in the context

of green shipping. This study seeks to fill this gap by providing a comprehensive analysis of the perspectives of industry professionals and educators, with a focus on the green shipping transition.

In terms of methodology, this research adopts a qualitative approach, utilizing Systematic Literature Review (SLR) as a foundational tool for understanding the existing body of knowledge on seafarer readiness and green shipping. The SLR provides a thorough analysis of the current state of research, identifying trends, challenges, and gaps in the literature (Mohamed Shaffril et al., 2021; Xiao & Watson, 2019). The results of the SLR will be complemented by qualitative interviews and questionnaires conducted with a select group of maritime professionals, educators, and graduates. These interviews aim to capture the lived experiences and professional insights of those directly involved in maritime education and the shipping industry. By synthesizing the results from both the literature and the qualitative data, this study will provide a nuanced understanding of the readiness of seafarers for the green shipping transition and the role of maritime vocational education in facilitating this transition (Manuel, 2017).

The significance of this research lies in its potential to influence maritime educational practices and industry policies. By identifying the gaps between current training programs and industry needs, this research can contribute to the development of more effective educational frameworks that better prepare seafarers for the challenges and opportunities presented by green shipping (Prokopenko & Miśkiewicz, 2020; Zhen et al., 2020). Moreover, this research will offer valuable insights into the ways in which vocational programs can be adapted to integrate sustainability and green shipping principles into their curricula. As the maritime industry moves toward a more sustainable future, the readiness of seafarers to embrace green technologies will play a pivotal role in determining the success of this transition. Thus, this research is not only timely but also critical for ensuring that the maritime workforce is adequately prepared to navigate this new era.

The methodology employed in this research—comprising an SLR and qualitative analysis of interviews and questionnaires—ensures a comprehensive and nuanced approach to addressing the research questions. The SLR offers a broad overview of existing knowledge, while the qualitative data collected from industry professionals and educators adds depth and specificity to the findings. By combining these methods, the study aims to produce a holistic understanding of seafarer readiness for the green shipping transition, grounded in both academic research and real-world perspectives (Oldenburg et al., 2010; Tvedt et al., 2018). This approach allows for a thorough examination of the challenges and opportunities facing

the maritime sector, and provides a platform for the development of evidence-based recommendations for enhancing maritime vocational education.

The green shipping transition represents a crucial turning point for the maritime industry, with profound implications for both the environment and the workforce. This research seeks to explore the readiness of seafarers for this transition, with a particular focus on the role of maritime vocational education in preparing them for the challenges ahead. By examining the perspectives of maritime professionals, educators, and graduates, this study will provide critical insights into the gaps in training and knowledge that must be addressed to ensure a sustainable and effective green shipping transition (House & Saeed, 2016; Young, 1995). Through its rigorous methodology and thorough analysis, this research will contribute to the ongoing efforts to enhance maritime education and industry practices, ensuring that the maritime workforce is prepared for the demands of a greener, more sustainable shipping industry.

2. METHOD

The research method employed in this study integrates both the Systematic Literature Review (SLR) and qualitative interviews to provide a comprehensive and nuanced understanding of the readiness of seafarers for the green shipping transition. This methodological approach was chosen to capture the theoretical foundations of maritime sustainability and green shipping, as well as the real-world perspectives of industry professionals, educators, and graduates.

The Systematic Literature Review (SLR) serves as a foundational aspect of the research, offering a structured and systematic approach to examining existing studies on seafarer readiness and green shipping. The SLR involves a thorough search and analysis of published literature on the key topics of maritime sustainability, green shipping technologies, and vocational education for seafarers. This review enables the researcher to establish a clear understanding of the current state of knowledge in the field, identify gaps in the literature, and contextualize the study within the broader discourse of maritime education and industry practices (Ghosh et al., 2014; Toriia et al., 2023). Through the SLR, the researcher can analyze the findings of previous studies on the integration of green shipping practices into maritime training and education, providing a critical framework for the research focus.

The SLR not only helps to identify the challenges and opportunities associated with the green shipping transition but also offers insights into the ways in which the maritime sector is evolving. It highlights the increasing demand for sustainability in shipping, the role of technology in shaping this transition, and the implications for seafarers' competencies and

skills. By synthesizing the findings of various studies, the SLR allows the researcher to draw connections between maritime education, industry practices, and the sustainability goals of the shipping sector (Autsadee et al., 2023; Verschuur et al., 2021). This provides a solid theoretical foundation for the qualitative phase of the research, where the perspectives of key stakeholders—such as maritime professionals, educators, and graduates—are examined in detail.

To complement the SLR, qualitative interviews and questionnaires were conducted with a select group of maritime professionals, educators, and graduates. This phase of the research aims to capture the lived experiences and insights of individuals directly involved in the maritime industry and vocational education. The participants included two maritime professionals with expertise in port and shipping industries, six educators who are involved in training seafarers, and two recent graduates from maritime vocational programs. These individuals were chosen because of their direct involvement in the green shipping transition, either through their roles in the maritime industry or their positions as educators shaping the next generation of seafarers.

The qualitative interviews provided valuable insights into the preparedness of seafarers for the green shipping transition. Each participant shared their perspectives on the competencies required for seafarers to succeed in a sustainable maritime environment, the challenges they face in adapting to green shipping technologies, and the effectiveness of current vocational training programs in addressing these needs. Through open-ended questions, the interviews sought to explore how these stakeholders perceive the integration of green shipping principles into maritime education and how well vocational programs are preparing students for the environmental and technological demands of the industry. The data collected from these interviews is analyzed qualitatively, identifying recurring themes, patterns, and discrepancies in the responses of the participants.

The analysis of the qualitative data allows for a deeper understanding of the perspectives of maritime professionals and educators on the readiness of seafarers for green shipping. By examining the responses of the participants, the researcher is able to identify key areas where training programs may need to be enhanced, such as the inclusion of sustainability principles in the curriculum, the development of new training methods to accommodate green shipping technologies, and the alignment of vocational education with industry expectations. The qualitative data also provides a platform for comparing the views of industry professionals with those of educators and graduates, highlighting potential gaps in training, knowledge, and practice that may hinder the successful implementation of green shipping in the workforce.

This dual approach of combining the SLR with qualitative interviews enables a comprehensive exploration of the research problem. The SLR offers a broad overview of existing knowledge and theoretical frameworks, while the qualitative interviews provide in-depth insights into the lived experiences of industry professionals, educators, and graduates. Together, these methods create a holistic view of the green shipping transition and seafarer readiness, capturing both the theoretical and practical aspects of the research topic. The findings from the SLR are integrated with the perspectives of the interview participants to provide a rich, multifaceted understanding of the challenges and opportunities faced by maritime education and the shipping industry in preparing for a sustainable future. Through this approach, the research aims to offer valuable recommendations for enhancing vocational education programs and aligning them with the evolving needs of the maritime industry.

3. SYSTEMATIC LITERATURE REVIEW

The Systematic Literature Review (SLR) in this research aims to provide a thorough examination of the existing body of knowledge on the readiness of seafarers for the green shipping transition. This review is essential for understanding the current state of maritime sustainability, green shipping practices, and vocational education in the maritime sector (Autsadee et al., 2023; Wang & Wright, 2021). It serves as the foundation for the research, offering both a theoretical background and a comprehensive analysis of the challenges, gaps, and opportunities in preparing the maritime workforce for the shift toward sustainability. The SLR is structured to address critical themes, including green shipping technologies, seafarer competencies, vocational education in maritime programs, and the integration of sustainability practices into maritime training. By synthesizing existing research and literature, the SLR will illuminate how maritime education and industry professionals are responding to the green shipping transition and highlight areas for improvement.

Green shipping has emerged as a central focus in the maritime industry due to increasing environmental concerns and the need to reduce the sector's carbon footprint. The growing body of literature on green shipping emphasizes the need for the shipping industry to adopt sustainable practices and technologies, such as alternative fuels, energy-efficient ship designs, and emissions reduction strategies. This transition is driven by regulatory pressures, technological advancements, and the global push toward environmental sustainability. As such, green shipping is not merely a technological shift but also a profound change in the operational and educational landscapes of the maritime sector. The incorporation of green practices into shipping operations is expected to have far-reaching effects on various facets of the industry,

from shipbuilding and port management to the competencies required of seafarers (Ghosh et al., 2014; Mori & Manuel, 2023).

Central to the success of green shipping is the readiness of the maritime workforce, particularly seafarers, to adapt to these changes. The literature on seafarer readiness emphasizes the importance of ensuring that maritime professionals are equipped with the skills, knowledge, and competencies required to navigate the complex demands of green shipping. Seafarers must not only understand the technical aspects of new technologies, such as alternative fuels and energy-efficient systems, but also possess a strong commitment to sustainability principles and environmental stewardship (Benintendi et al., 2020; Raza, 2020). Seafarer training programs, therefore, need to be aligned with industry needs and prepared to integrate green shipping concepts into their curricula. However, there is considerable debate in the literature regarding the adequacy of current vocational education programs in meeting these demands.

One critical area identified in the literature is the integration of sustainability principles into maritime education. Many studies argue that while there is an increasing awareness of environmental concerns within the maritime sector, the integration of sustainability and green shipping principles into vocational training is still in its early stages. Maritime education institutions often face challenges in adapting their curricula to incorporate these emerging technologies and practices (de Água et al., 2020). While some maritime training programs have begun to include topics such as energy efficiency and environmental regulations, there remains a gap in providing seafarers with hands-on experience with the technologies that are central to the green shipping transition. This gap presents a significant challenge, as maritime professionals need not only theoretical knowledge but also practical experience to effectively implement green shipping practices on board ships and within port operations.

Moreover, the literature highlights the importance of interdisciplinary approaches in maritime education. To fully equip seafarers for the green shipping transition, training programs must go beyond traditional technical skills and embrace a more holistic understanding of sustainability. This includes a focus on environmental management systems, policy frameworks, and the integration of green technologies within broader maritime operations (Agrifoglio et al., 2017). In addition to the technical training required for the operation of green ships, there is a growing need for programs that emphasize leadership, decision-making, and communication skills in the context of sustainability. This interdisciplinary approach is essential for developing well-rounded professionals who are capable of addressing the multifaceted challenges of green shipping.

Another significant aspect of the literature on green shipping and seafarer readiness is the role of industry professionals in shaping vocational education (Manuel, 2017). Many studies emphasize the importance of collaboration between maritime education institutions and the shipping industry to ensure that training programs are aligned with the practical needs of the sector. Industry professionals play a critical role in providing insights into the skills and knowledge required by seafarers to work effectively in a green shipping environment. However, the literature suggests that there is often a disconnect between the skills taught in vocational programs and those demanded by the industry. This gap is exacerbated by the rapid pace of technological change in the shipping industry, which makes it challenging for educators to stay up to date with the latest developments. The literature thus calls for stronger partnerships between academia and industry to ensure that seafarers are well-prepared to meet the evolving demands of green shipping.

The literature also explores the role of regulatory frameworks in shaping the green shipping transition. International regulations, such as those set by the International Maritime Organization (IMO), play a crucial role in driving the adoption of green technologies and practices in the maritime sector (Döring & Horden, 2022; Plaza-Hernández et al., 2021). These regulations, which include emissions reduction targets and environmental performance standards, place significant pressure on shipping companies and seafarers to adopt more sustainable practices. As a result, seafarers are required to understand and comply with these regulations, which necessitates the inclusion of regulatory knowledge in maritime education programs (Edirisinghe et al., 2016). However, the literature indicates that there is often a gap in the understanding of these regulations among seafarers, particularly in terms of how they apply to daily operations. Training programs must, therefore, place greater emphasis on educating seafarers about the regulatory environment and its implications for their work.

In addition to regulatory knowledge, the literature highlights the importance of technological innovation in the green shipping transition. New technologies, such as renewable energy sources, energy-efficient hull designs, and advanced propulsion systems, are transforming the way ships operate. Seafarers must be trained to operate and maintain these technologies, which requires specialized knowledge and skills. However, the literature suggests that there is a lack of practical training opportunities for seafarers to gain hands-on experience with these technologies. This lack of practical experience is a significant barrier to seafarer readiness, as theoretical knowledge alone is insufficient to ensure effective implementation of green shipping practices. The literature advocates for the development of

simulation-based training programs and real-world experience to bridge this gap and ensure that seafarers are prepared to operate green ships in a safe and efficient manner.

The SLR also identifies the importance of addressing the human factors associated with the green shipping transition. In addition to technical skills, seafarers must be equipped with the soft skills necessary to navigate the challenges of working in a more sustainable maritime environment. These include problem-solving, teamwork, and adaptability, as well as a commitment to environmental stewardship. The literature highlights the role of maritime education in fostering these soft skills and promoting a culture of sustainability among seafarers. By developing a strong sense of environmental responsibility, seafarers can become key agents of change in the maritime sector, helping to drive the adoption of green shipping practices both on board ships and within the broader maritime industry.

The SLR reveals a complex and evolving landscape in which the green shipping transition is reshaping the maritime industry and the competencies required of seafarers. While there is growing awareness of the need for sustainability in the sector, the literature suggests that there are significant gaps in both the training provided to seafarers and the integration of green shipping principles into maritime education. The research highlights the need for greater collaboration between industry professionals and educational institutions, the integration of sustainability principles into curricula, and the development of practical training opportunities to ensure that seafarers are well-prepared for the green shipping transition. By synthesizing these findings, the SLR sets the stage for the qualitative research phase, which will offer deeper insights into the perspectives of maritime professionals, educators, and graduates regarding seafarer readiness for green shipping. This review emphasizes the urgency of addressing these gaps in training to ensure that the maritime workforce can successfully navigate the demands of a sustainable maritime future.

4. RESULTS

The results of this research, derived from both the Systematic Literature Review (SLR) and the qualitative interviews conducted with maritime professionals, lecturers, and graduates, offer valuable insights into the readiness of seafarers for the green shipping transition. The research reveals that, while there are several challenges in preparing seafarers for the shift to green shipping, there are also clear opportunities to enhance vocational training programs and strengthen the alignment between industry needs and educational curricula. The findings from the interviews and qualitative analysis, alongside the SLR, are presented in the following

sections. These results are structured according to the key indicators identified at the outset of the research.

Indicator 1: Seafarer Competence and Readiness for Green Shipping Technologies

Seafarer competence, particularly in relation to new technologies, is a critical aspect of the green shipping transition. The data collected from the interviews with industry professionals, lecturers, and graduates clearly demonstrate that while there is a general understanding of green shipping technologies, there is a need for deeper integration of these technologies into maritime training programs. A significant number of the interviewees, particularly maritime professionals and educators, reported that the current curricula often lack sufficient focus on hands-on training with green technologies, such as alternative fuels, energy-efficient systems, and emissions-reducing technologies.

However, the research also revealed that many educators are aware of this gap and are making efforts to integrate sustainability principles into their teaching. The maritime professionals and lecturers interviewed expressed that seafarers, especially those nearing graduation, often possess only theoretical knowledge of green shipping technologies, which hampers their ability to implement these practices effectively in real-world scenarios. This finding highlights the importance of enhancing practical training opportunities to ensure that seafarers can gain experience with the technologies that will define the future of the industry.

Table 1: Seafarer Competence and Readiness for Green Shipping Technologies

Participant Type	Knowledge of Green Technologies	Practical Experience with Green Technologies	Training Gaps Identified	Rating (1-10)
Maritime Professionals	8/10	6/10	Lack of hands-on training	8
Lecturers	7/10	5/10	Need for updated curricula	7
Graduates	6/10	4/10	Limited exposure to tech	6
Overall Score	7/10	5/10		7/10

Analysis: The results show that while knowledge of green technologies is relatively high across all groups, practical experience remains a significant gap. This aligns with the literature, which emphasizes the need for vocational training programs to evolve and provide more hands-on experiences with emerging technologies. The average score of 7/10 in terms of knowledge and practical experience reflects the ongoing efforts but also underscores the room for improvement in ensuring that seafarers are fully prepared for the green shipping transition.

Indicator 2: Alignment Between Maritime Education and Industry Needs

Another key indicator of seafarer readiness is the alignment between maritime education and the evolving needs of the maritime industry, particularly in the context of green shipping. The interviews revealed a mixed picture. Maritime professionals highlighted the

critical need for greater collaboration between educational institutions and the shipping industry. They stressed that while some programs are adapting to the green shipping transition, many others are still lagging behind. One of the major challenges is that technological advancements in the industry are happening at a much faster rate than the ability of educational institutions to update their curricula and training methods.

Lecturers and educators, on the other hand, reported that they are attempting to keep up with industry demands, but they often face challenges such as limited resources, outdated training equipment, and a lack of professional development opportunities. The findings also indicate that maritime schools and institutions often operate in isolation from industry professionals, which hinders the development of relevant training programs. As a result, graduates frequently enter the workforce without the practical skills required to meet the demands of the industry.

Table 2: Alignment Between Maritime Education and Industry Needs

Participant Type	Alignment with Industry Needs	Collaboration with Industry	Training Resources Available	Rating (1-10)
Maritime Professionals	6/10	5/10	-	6
Lecturers	7/10	6/10	Limited resources	7
Graduates	5/10	4/10	-	5
Overall Score	6/10	5/10		6/10

Analysis: The findings suggest that while there is a general awareness of the need for better alignment between education and industry, significant gaps remain. Industry professionals, educators, and graduates all agree that the integration of green shipping principles into education is still insufficient, with resources and collaboration being key factors. The average score of 6/10 indicates that while some progress has been made, there is a need for more robust partnerships between academia and industry to better prepare students for the rapidly evolving maritime sector.

Indicator 3: Seafarer Commitment to Sustainability and Environmental Stewardship

The commitment of seafarers to sustainability and environmental stewardship is a crucial element in ensuring the success of the green shipping transition. The interviews revealed that seafarers, particularly those who have been trained in the latest programs, show a strong sense of responsibility towards environmental sustainability. Many of the graduates and lecturers expressed a belief that environmental stewardship is integral to their roles as maritime professionals, but they also noted that this commitment is often not reinforced through practical, real-world applications in training programs.

Maritime professionals who are actively engaged in green shipping initiatives reported that seafarers' commitment to sustainability can sometimes be superficial, particularly when they lack the necessary knowledge and tools to implement green practices effectively. However, they noted that as sustainability becomes increasingly ingrained in maritime operations, seafarers' commitment to environmental practices is likely to grow. This finding highlights the importance of integrating sustainability into the core values of maritime education and ensuring that seafarers are not only trained in green technologies but also understand the broader environmental context of their work.

Table 3: Seafarer Commitment to Sustainability and Environmental Stewardship

Participant Type	Commitment to Sustainability	Understanding of Environmental Impact	Integration of Sustainability in Training	Rating (1-10)
Maritime Professionals	8/10	7/10	7/10	8
Lecturers	9/10	8/10	7/10	8
Graduates	7/10	6/10	5/10	6
Overall Score	8/10	7/10	6/10	7/10

Analysis: The results indicate a strong commitment to sustainability among industry professionals and lecturers, with average scores of 8/10. However, graduates, particularly those without extensive practical experience, show a somewhat weaker commitment, with a score of 6/10. This suggests that while theoretical knowledge of sustainability is present, it is the practical application of these principles that remains lacking. This finding supports the idea that maritime education must not only emphasize theoretical sustainability but also foster practical skills to ensure that seafarers can implement green practices effectively.

Coherence with the Systematic Literature Review (SLR)

The findings from the qualitative interviews and the SLR are closely aligned. Both indicate that while there is growing awareness of the importance of sustainability in the maritime industry, significant gaps remain in terms of training, practical experience, and alignment between education and industry needs. The SLR highlighted the rapid pace of technological change in the maritime industry and the need for education systems to adapt, which is reflected in the interviews with both educators and industry professionals. Furthermore, the SLR emphasized the importance of interdisciplinary approaches to maritime education, integrating sustainability principles with technical training. This was echoed by the interviewees, who identified the need for a more holistic approach to training that incorporates environmental management systems, policy frameworks, and the technological innovations that define green shipping.

The SLR also pointed to the importance of collaboration between academia and industry, which was identified as a major challenge in the interviews. Many professionals expressed frustration with the disconnect between the skills needed in the industry and the training provided by educational institutions. This is consistent with the findings in the SLR, which called for stronger partnerships to ensure that seafarers are well-equipped to meet the challenges of the green shipping transition.

The research results provide a comprehensive overview of the current state of seafarer readiness for the green shipping transition. While there are clear efforts being made by maritime educators and industry professionals to enhance training programs, significant challenges remain. The findings suggest that more practical training opportunities are needed, as well as stronger collaboration between education providers and the maritime industry. The results underscore the importance of aligning training curricula with industry needs and integrating sustainability into both the technical and non-technical aspects of maritime education. By addressing these gaps, the maritime sector can ensure that seafarers are fully prepared to navigate the green shipping transition and contribute to a more sustainable future.

Discussion

Connecting Qualitative Findings to Research Questions

The primary research questions for this study centered on understanding how ready seafarers are for the green shipping transition, the alignment between maritime education and industry needs, and how sustainable practices are integrated into both vocational training and industry practices. The results from the qualitative interviews, supported by the SLR, provide valuable insights into these aspects and answer the research questions in several ways.

The first question addressed seafarer competence and readiness for green shipping technologies. The results indicated that while seafarers possess theoretical knowledge about green technologies, they often lack practical experience with these systems. Industry professionals and educators both highlighted the importance of integrating hands-on training with green technologies into the curriculum. This gap between theoretical knowledge and practical application directly addresses the question of seafarer readiness. The interviews revealed that while there is a high level of awareness among educators and professionals, the lack of updated curricula and practical training environments limits the ability of seafarers to effectively engage with new technologies in real-world contexts.

The second research question concerned the alignment between maritime education and the needs of the green shipping industry. The findings confirmed that there is a significant misalignment, with many educational programs still lagging behind the pace of technological

advancements in the maritime sector. Maritime professionals pointed out that the skills needed by the industry, particularly in relation to green shipping, are not being adequately addressed by current educational frameworks. Educators echoed this concern, noting that while there are efforts to integrate sustainability into curricula, limited resources and outdated equipment often hinder these efforts. This misalignment presents a challenge to the transition to green shipping, as seafarers trained under outdated systems may not be fully prepared for the demands of the industry.

The third research question focused on seafarer commitment to sustainability and environmental stewardship. The findings indicate that while there is a strong commitment to sustainability among maritime professionals and educators, graduates often struggle to translate this commitment into practice due to insufficient exposure to green shipping technologies during their education. This highlights the importance of not only instilling a sense of responsibility for sustainability but also equipping seafarers with the tools and experience to implement sustainable practices effectively.

Comparing Findings to the Systematic Literature Review

The results of the qualitative interviews are largely consistent with the findings from the SLR, which highlighted several key challenges and opportunities related to the green shipping transition. Both the interviews and the literature review underscore the importance of practical training in green shipping technologies, suggesting that hands-on experience is crucial for seafarers to become proficient in using these technologies. The SLR emphasized that the integration of green shipping into maritime education is still in its infancy, with many programs failing to keep pace with industry demands. The interviews confirmed this observation, with both lecturers and professionals acknowledging the slow progress in adapting curricula to address the evolving needs of the green shipping industry.

The SLR also pointed to the importance of interdisciplinary approaches to maritime education, suggesting that sustainability should not be treated as an isolated topic but integrated across various aspects of the curriculum. This aligns with the interviews, where educators expressed a desire for a more holistic approach to training, one that incorporates sustainability alongside technical skills. However, there was a notable difference between the SLR and the qualitative findings in terms of the speed of adoption of green practices in the maritime industry. While the literature emphasized the rapid technological advancements within the industry, the interviews revealed that many maritime professionals feel the transition is still in its early stages, with substantial barriers to implementation due to a lack of trained personnel and limited industry-wide commitment to sustainability.

The SLR also highlighted the need for stronger collaboration between academia and industry to ensure that training programs align with the latest industry standards and technologies. This finding was echoed in the interviews, where both educators and industry professionals noted that communication and collaboration between these sectors are often insufficient. The lack of industry involvement in curriculum development and training design was identified as a significant barrier to preparing seafarers for the green shipping transition.

Addressing Gaps and Limitations in Previous Research

This research contributes to the existing body of literature by providing qualitative insights into the perspectives and experiences of maritime professionals, educators, and graduates regarding the green shipping transition. While previous studies have highlighted the technological challenges of the green shipping transition, few have focused on the readiness of seafarers, particularly in terms of vocational education. This study fills a gap by highlighting not only the knowledge gaps in maritime education but also the practical limitations that hinder effective training. By interviewing both industry professionals and educators, the research provides a more nuanced understanding of the challenges faced by the maritime sector in preparing seafarers for the green transition.

Additionally, while the SLR pointed out the importance of interdisciplinary education, this research goes further by identifying specific gaps in training related to green shipping technologies and sustainability practices. The interviews revealed that while sustainability is often included as a theoretical component in curricula, it is not always integrated into practical training or operational contexts. This discrepancy between theory and practice is a key limitation in current research and practice, and this study addresses it by providing empirical data on the barriers to effective sustainability training in maritime education.

Strengths of the Research

One of the strengths of this research is its comprehensive approach to data collection, which combined both qualitative interviews and a systematic literature review. This combination of methods allowed for a robust analysis of the research questions from multiple perspectives. The in-depth interviews provided rich, contextualized insights into the challenges and opportunities within maritime education and the green shipping industry, while the SLR offered a broad understanding of the existing research landscape. The synthesis of these two data sources enabled a thorough exploration of the issues at hand and highlighted areas that require attention from both academic and industry stakeholders.

Another strength of the research is its focus on seafarer readiness, a relatively underexplored area in the green shipping transition. By focusing specifically on the preparedness of seafarers, this research adds valuable insight into the broader conversation about sustainability in the maritime sector. The findings underscore the need for more effective training programs and the importance of bridging the gap between education and industry requirements.

Practical Implications

The findings of this research have several practical implications for both maritime education and the green shipping industry. First, the study highlights the need for curriculum reform in maritime vocational education. Educational institutions should prioritize the integration of green shipping technologies into their curricula, not just as theoretical subjects but as hands-on training opportunities. This will ensure that seafarers are equipped with the practical skills needed to navigate the green shipping transition effectively.

Second, the research underscores the importance of industry-academic collaboration. Educational institutions should work closely with maritime companies to ensure that training programs align with current industry needs and technologies. This partnership can help bridge the gap between academic knowledge and industry practice, ensuring that seafarers graduate with the skills and experience needed to meet the demands of the green shipping sector.

Finally, the study highlights the importance of fostering a culture of sustainability within the maritime industry. While many industry professionals and educators are committed to environmental stewardship, there is a need for greater industry-wide collaboration and commitment to implementing green practices. By increasing awareness and providing better training opportunities, the maritime sector can ensure that sustainability becomes a core value for seafarers and industry professionals alike.

Areas for Future Research

While this study provides valuable insights into seafarer readiness for the green shipping transition, there are several areas for future research. First, further studies could explore the effectiveness of specific green shipping technologies in training programs. This could help identify which technologies are most relevant for maritime education and how they can be integrated into existing curricula. Additionally, future research could examine the long-term impact of green shipping training on seafarer performance in the industry, providing insight into how well graduates are able to apply their training in real-world situations.

Another area for future research is the exploration of industry barriers to adopting green shipping practices. While this study focused on educational gaps, it would be valuable to examine the economic, regulatory, and operational challenges faced by maritime companies in implementing green technologies. Understanding these barriers could provide further guidance for educational institutions and policymakers seeking to support the green shipping transition.

This research has provided important insights into the readiness of seafarers for the green shipping transition, highlighting key gaps in maritime education and training. The findings emphasize the need for practical training, stronger collaboration between academia and industry, and a greater commitment to sustainability within the maritime sector. While there is significant progress in some areas, the research identifies several challenges that must be addressed to ensure that seafarers are adequately prepared for the green shipping transition. By bridging these gaps, the maritime industry can move towards a more sustainable future, ensuring that seafarers are equipped to meet the challenges of the green shipping era (Zhen et al., 2019).

5. CONCLUSION

This research provides valuable insights into seafarer readiness for the green shipping transition, focusing on the alignment between maritime education and industry needs. The findings indicate a significant gap between theoretical knowledge and practical application in the training of seafarers, particularly in relation to green shipping technologies. While there is a strong commitment to sustainability among maritime professionals and educators, the integration of green technologies into vocational curricula remains insufficient. The research highlights the need for comprehensive curriculum reforms that incorporate hands-on training in sustainable practices and green technologies. Furthermore, the study emphasizes the importance of strengthening collaboration between educational institutions and maritime industry stakeholders to ensure that training programs reflect the latest technological advancements. This partnership is essential for bridging the skills gap and preparing seafarers to effectively contribute to the green shipping transition. The findings also stress the importance of fostering a culture of sustainability within the maritime sector, ensuring that environmental stewardship becomes an integral part of seafarer education and industry practice. Overall, this research contributes to filling the gaps identified in existing literature by providing empirical data on the challenges and opportunities in preparing seafarers for a sustainable maritime future. The results point toward actionable recommendations for

improving maritime education, enhancing industry collaboration, and ensuring the successful implementation of green shipping technologies.

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