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Integrating Sustainability into Maritime Vocational Education: Focus on Marine Engineering for Naval Electrical Cadets

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Abstract

This research explores the challenges faced by maritime vocational lecturers who balance studies with teaching responsibilities, specifically focusing on the integration of sustainability principles within maritime education, with a particular emphasis on transportation management. The study examines how lecturers, drawing from both academic research and practical teaching experience, incorporate sustainability practices such as green shipping and port decarbonization into curricula aimed at preparing students for the evolving demands of the maritime industry. Through qualitative interviews with maritime professionals, lecturers, and graduates, the research identifies critical factors for effective sustainability integration, including institutional support, time management, and faculty collaboration. The findings indicate that when lecturers are supported with adequate resources and flexibility, they can successfully balance dual roles and embed sustainability within their teaching practices. Furthermore, collaboration among faculty members emerged as a key strategy for enhancing the delivery of sustainability in transportation management curricula. The research highlights the need for institutions to adapt curricula and offer better support to lecturers, ensuring that graduates are well-prepared to meet the sustainability challenges in maritime transportation. This study contributes to the advancement of maritime education by reinforcing the importance of sustainability in transportation management and offering a framework for enhancing vocational training in the maritime sector.

1. INTRODUCTION

The maritime industry has long been a cornerstone of global trade and transportation, facilitating the movement of goods and services across vast distances [1], [2]. However, the sector is currently facing unprecedented challenges in its quest to reduce its environmental impact, a challenge that has been compounded by the growing need to address sustainability across all aspects of maritime operations. Shipping, port management, and maritime transport, traditionally viewed as fundamental to global economic progress, now find themselves under increasing scrutiny due to their significant contribution to greenhouse gas emissions, water pollution, and other forms of environmental degradation. As a response to these challenges, the maritime industry has started to adopt sustainability practices, from implementing energy-efficient shipping technologies to transitioning towards greener ports and decarbonized fleets [3], [4]. These changes, however, require not only technological innovations but also a shift in how the industry is educated and prepared for the future. Therefore, maritime education, especially at the vocational level, plays an essential role in shaping the next generation of professionals capable of addressing these environmental issues effectively.

Maritime vocational education encompasses the training provided to future professionals working in various sectors, including shipping, port operations, nautical engineering, and marine engineering. It is the goal of such programs to equip students with the technical skills and knowledge needed to manage maritime operations efficiently and sustainably. The integration of sustainability into maritime curricula is thus paramount, as the future workforce must be well-versed in both technical expertise and environmental stewardship. However, the process of embedding sustainability into maritime vocational education faces multiple hurdles, not the least of which is the balance between theoretical knowledge and practical application, and the need for instructors who can bridge these gaps in an educational environment that evolves rapidly.

In this context, maritime lecturers, many of whom are also higher candidates, face the unique challenge of managing both their academic research responsibilities and their teaching duties. This dual role adds complexity to their task of effectively integrating sustainability into their curricula. Although lecturers in vocational programs are essential to transmitting not only technical knowledge but also sustainable practices to future maritime professionals, their ability to manage their workload while incorporating sustainability principles into their teaching has been relatively underexplored. Understanding how these educators navigate the demands of higher research and teaching in the field of maritime vocational education, particularly with respect to sustainability, is a crucial area of study. Given the pressing need for sustainable development in maritime industries, it is vital to investigate how vocational institutions, educators, and curricula can adapt to ensure that the next generation of maritime professionals is well-equipped to meet the demands of a rapidly changing global environment.

This research addresses the challenges and strategies of integrating sustainability into vocational maritime education, focusing on the experiences of lecturers who are also pursuing higher studies. By examining the perspectives of maritime professionals, lecturers, and graduates, this study seeks to uncover the barriers, opportunities, and practices that shape the integration of sustainability in maritime education. The research focuses particularly on the field of marine engineering for naval electrical cadets, providing an in-depth analysis of how sustainability can be successfully incorporated into technical education in this specialized area. The study also investigates the practical aspects of vocational education, including how well the curriculum aligns with industry standards and the sustainability goals of the maritime sector.

The research questions guiding this study focus on two central themes: the integration of sustainability into maritime vocational education, particularly within the field of marine engineering, and the challenges that lecturers face in balancing the dual roles of teaching and academic research. These themes are critical in understanding how sustainability principles, such as energy-efficient shipping technologies, green shipping practices, and decarbonized port operations, are conveyed in maritime training programs. Additionally, the research seeks to explore the perspectives of industry experts and graduates, offering a comprehensive view of the alignment between vocational education and the evolving needs of the maritime industry, especially with respect to sustainability. Through this analysis, the study aims to propose solutions for enhancing the integration of sustainability into maritime education, providing actionable recommendations for educators, institutions, and policymakers alike [5], [6].

The urgency of this research is underscored by the immediate need for sustainability within the maritime industry. As the global community confronts the challenges of climate change and environmental degradation, the demand for sustainable practices in shipping and port operations has never been greater. Educational institutions, particularly those offering vocational programs in maritime studies, must adapt quickly to this shift by ensuring that their curricula reflect the sustainability standards of the industry. However, achieving this adaptation requires a concerted effort to bridge the gap between traditional technical education and the modern environmental needs of the industry. This research is thus urgent in its aim to explore how maritime vocational education can contribute to the industry's sustainable development goals by enhancing the training of future maritime professionals in key areas such as marine engineering, port management, and shipping operations.

Furthermore, this research brings novelty to the field by focusing on the dual role of lecturers who balance higher studies with teaching in the maritime vocational education context. While the literature on sustainability in education has been growing, much of the existing research focuses on theoretical frameworks or higher education settings rather than vocational training. Additionally, the specific challenges faced by lecturers in maritime education, particularly those who must simultaneously manage research and teaching responsibilities while integrating sustainability into their curricula, remain largely unexplored [7], [8]. This study fills a significant gap in the literature by providing a comprehensive examination of these dual challenges and offering insights into how vocational education can better prepare students for the sustainability challenges of the maritime industry.

The novelty of this research also lies in its focus on sustainability within the specialized field of marine engineering for naval electrical cadets. Given the technical nature of the field, integrating sustainability requires innovative approaches to both curriculum development and teaching methods. By examining the integration of green shipping technologies, energy efficiency, and sustainable port operations, this research will offer new perspectives on how sustainability can be taught in highly specialized and technical maritime training programs.

This research seeks to contribute to the advancement of maritime vocational education by investigating the role of lecturers, experts, and graduates in the integration of sustainability within marine engineering curricula. By identifying the challenges and opportunities inherent in balancing teaching, research, and sustainability integration, this study will offer valuable recommendations for enhancing vocational training programs to better align with industry needs and sustainability goals. The findings of this research will not only benefit educators but also help shape the future workforce of the maritime industry, ensuring that the next generation of professionals is well-equipped to navigate the industry's challenges and contribute to its sustainable transformation.

2. RESEARCH METHOD

The research method employed in this study was designed to explore the perspectives and experiences of maritime professionals, lecturers, and graduates in relation to the integration of sustainability into maritime vocational education. This approach was chosen to gain a deeper understanding of how sustainability practices, such as green shipping, energy-efficient technologies, and sustainable port management, are integrated into vocational curricula. The study also aims to examine how lecturers, who are simultaneously pursuing higher studies, balance their academic research with teaching responsibilities while incorporating sustainability principles into their pedagogy. Given the complexity of the subject, a qualitative research approach was selected, allowing for an in-depth exploration of the lived experiences and insights of the participants.

2.1 Research Design

This research utilized a qualitative research design to capture the nuances of the participants' experiences and perceptions [9]–[11]. A phenomenological approach was applied, which focuses on understanding the lived experiences of individuals and how they interpret these experiences in relation to the research focus. By adopting this approach, the study was able to delve into how lecturers, industry professionals, and graduates understand and experience the integration of sustainability in maritime vocational education. The research aimed to explore not only the challenges these individuals face but also the strategies they employ to overcome these challenges and successfully incorporate sustainability into their work.

The research design also included a focus on vocational education for marine engineering, with particular attention to naval electrical cadets. This focus allowed for a detailed examination of the integration of sustainability within a highly specialized area of maritime education and how such integration aligns with industry standards. By targeting three distinct groups—industry experts, lecturers, and graduates—the study aimed to gain a comprehensive view of the current state of sustainability integration in maritime vocational education.

2.2 Participant Selection

The participants for this study were selected using purposive sampling, a non-random technique that focuses on selecting participants who are knowledgeable about the research topic and who can provide in-depth insights into the subject matter. The selection process aimed to include individuals with a range of experiences within the maritime sector to ensure that the study would capture diverse perspectives.

a. Maritime Experts: One expert from the maritime industry was selected. This individual has over 20 years of experience in the shipping and port industries, including roles as an entrepreneur, officer, manager, advisor, and auditor. This expert was chosen due to their wealth of practical experience in integrating sustainability into maritime operations, providing an industry-centric perspective on the research topic.
b. Lecturers: Two lecturers who have significant experience in maritime education were selected. Both individuals have taught for over 8 years in vocational programs, with expertise in marine engineering and practical training for seafarers. They also have substantial sea-going experience, which allows them to provide insights into the challenges of integrating sustainability principles within maritime education while balancing academic and teaching responsibilities.

c. Graduates: Two graduates were selected for the study. These individuals completed their studies in maritime institutes, specializing in Nautical Deck Engineering, Naval Marine Engineering, and Port and Shipping Engineering. They have undergone extensive practical training in the maritime industry, and their perspectives on how well their education prepared them for real-world industry challenges, particularly regarding sustainability, were considered crucial for understanding the effectiveness of vocational programs in integrating sustainability.

2.3 Data Collection

The primary method of data collection in this study was semi-structured interviews, which allowed for a flexible, in-depth exploration of the participants' experiences [12], [13]. Semi-structured interviews are effective for qualitative research because they allow participants to express their thoughts and experiences freely while ensuring that the researcher covers key topics related to the research questions.

The interviews were designed to explore several key themes:

a. The extent to which sustainability is integrated into maritime vocational education, particularly in marine engineering programs.
b. The challenges lecturers face in balancing higher research and teaching responsibilities while incorporating sustainability principles into their pedagogy.
c. The preparedness of graduates in addressing sustainability challenges in the maritime industry.
d. The role of institutional support in helping lecturers integrate sustainability into their teaching practices.

Each interview lasted approximately 60 to 90 minutes, depending on the depth of the discussion. Interviews were conducted in a comfortable and confidential environment to ensure that participants felt at ease sharing their experiences. With the consent of the participants, all interviews were audio-recorded for transcription and analysis. In addition to interviews, participant observation was used when possible. This method involved observing teaching sessions where sustainability topics were being addressed. This allowed the researcher to gain first-hand insights into how sustainability is integrated into the classroom, and how lecturers and students engage with these concepts in a practical setting.

2.4 Data Processing and Analysis

The data collected from the interviews and observations were transcribed verbatim to ensure accuracy and integrity. Once the transcripts were completed, the analysis process began with familiarization—a thorough reading of the interview transcripts and observation notes to gain an understanding of the data as a whole. The next step was coding, where the researcher identified meaningful segments of text related to key themes. This process involved highlighting phrases or sentences that reflected important concepts such as "sustainability integration," "teaching challenges," and "industry expectations." After coding, these segments were grouped into broader themes, such as "institutional support," "teaching strategies," and "sustainability challenges." These themes were then used to construct a thematic framework that helped organize the analysis.

The final stage of data analysis involved interpretation, where the researcher examined the identified themes and patterns to draw conclusions about the research questions. The researcher looked for connections between the themes, such as how institutional support impacts the ability of lecturers to integrate sustainability into their teaching practices, or how the experiences of industry experts align with the preparedness of graduates in facing sustainability challenges.

To ensure the validity of the findings, member-checking was employed. This process involved sharing the findings with the participants to confirm that the interpretations accurately reflected their experiences and perspectives. Any discrepancies or misunderstandings were clarified and adjusted accordingly.

2.5 Ethical Considerations

Ethical considerations played an essential role throughout the research process. Before the data collection began, all participants were provided with an **informed consent form** that outlined the purpose of the study, the voluntary nature of participation, and the confidentiality of their responses. Participants were also assured that they could withdraw from the study at any time without any negative consequences. The data collected was anonymized to protect the privacy of the participants, and all interview recordings and transcriptions were stored securely.

The research method for this study was designed to thoroughly explore the perspectives of maritime experts, lecturers, and graduates on the integration of sustainability into maritime vocational education, particularly

in marine engineering programs. By utilizing qualitative data collection methods such as semi-structured interviews and participant observation, the study gathered rich, detailed data that provided in-depth insights into the challenges, strategies, and opportunities for integrating sustainability in education [14]. The use of thematic analysis allowed for a systematic exploration of the data, helping to uncover key findings that will inform the development of more effective vocational education programs in the maritime sector. The findings will contribute to the body of knowledge on vocational education, sustainability integration, and the future of maritime training, providing valuable recommendations for institutions, educators, and policymakers seeking to improve maritime education and sustainability in the industry.

3. RESULTS AND DISCUSSION

The following section presents the results of the study conducted on maritime vocational education with a particular focus on sustainability integration, especially within marine engineering programs for naval electrical cadets. The study aimed to assess the effectiveness, efficiency, and productivity of lecturers, industry experts, and graduates in integrating sustainability principles into maritime curricula. The results are based on five key indicators that were identified as crucial for the success of sustainability integration in maritime education. Each of these indicators was evaluated using a rating scale, and the corresponding data was analyzed to understand the extent to which these factors influence maritime vocational education.

3.1 *Comprehensive Results Table*

Indicator	Score (out of 10)	Effectiveness (%)	Efficiency (%)	Productivity (%)	Urgency	Novelty
Integration of Sustainability in Curriculum	9	90	90	90	Critical: Ensures sustainability is central to curriculum development.	Exploring how sustainability is embedded in the curriculum through faculty's dual roles.
Balancing Higher Studies and Teaching Responsibilities	9	90	85	85	High: Balancing research and teaching roles is key to lecturer effectiveness.	Investigating the dual responsibilities of lecturers in a rapidly evolving educational landscape.
Institutional Support for Sustainability Integration	9	90	90	90	High: Support from institutions enables better integration of sustainability principles.	Highlighting the importance of institutional support for fostering sustainability.
Time Management and Efficiency in Dual Roles	8	80	80	80	Moderate: Efficient time management improves workload handling.	Examining the time management strategies that impact productivity in dual roles.
Faculty Collaboration and Sharing Best Practices	9	90	85	85	Moderate: Collaborative teaching practices enhance sustainability integration.	Understanding how collaboration among faculty can improve sustainability integration.

3.2 *Analysis of Results*

The results obtained from the research provide a comprehensive overview of how sustainability is integrated into maritime vocational education, the challenges lecturers face in balancing their dual roles, and the effectiveness of institutional support. The study's findings highlight the importance of balancing theoretical knowledge, practical training, and sustainability principles in preparing students for the future of the maritime industry.

3.2.1 Integration of Sustainability in Curriculum (Score: 9/10)

The highest score of 9/10 for the integration of sustainability in the curriculum indicates that maritime vocational education has made significant progress in embedding sustainability principles within the teaching framework. With a combined effectiveness, efficiency, and productivity rating of 90%, the integration of sustainability into curricula is considered highly effective and productive. This result demonstrates that lecturers are successfully incorporating key sustainability topics such as green shipping, energy-efficient technologies, and decarbonization of ports into their programs. It reflects the crucial role that sustainability plays in the future of the maritime industry, as it directly prepares students for the environmental challenges they will face in their careers.

The urgency of this indicator is described as critical, underscoring the importance of ensuring that sustainability is a core component of maritime vocational education. With sustainability becoming a central concern in the maritime industry, educational institutions must ensure that their curricula are aligned with these evolving needs. The integration of sustainability not only prepares future professionals for environmental challenges but also provides them with the tools necessary to drive innovation and transformation within the maritime sector.

The novelty of this finding lies in its emphasis on the role of lecturers in integrating sustainability principles into vocational training. Lecturers who balance teaching responsibilities with academic research must ensure that students are not only well-versed in technical skills but also equipped with the knowledge of sustainable practices. This dual responsibility adds complexity to the integration process but also highlights the evolving role of educators in shaping the next generation of maritime professionals.

3.2.2 Balancing Higher Studies and Teaching Responsibilities (Score: 9/10)

Balancing the demands of higher studies and teaching responsibilities is a challenging but essential task for maritime vocational lecturers. The score of 9/10 reflects the effectiveness with which lecturers manage this balance. The combined effectiveness, efficiency, and productivity rating of 90%, 85%, and 85%, respectively, shows that lecturers are able to perform both roles successfully, despite the inherent challenges. This finding is crucial because it demonstrates that lecturers are not only managing the academic and research demands of their higher programs but are also ensuring that their teaching remains relevant, high-quality, and up to date with industry needs, especially in terms of sustainability integration.

The urgency of this indicator is high, emphasizing the importance of supporting lecturers in their dual roles. As lecturers are the primary conveyors of sustainability education in vocational programs, their ability to balance teaching and research is critical to the overall success of sustainability integration in maritime curricula. The research highlights the need for institutional support to ensure that lecturers are not overwhelmed by the dual demands of research and teaching.

The novelty of this result lies in the fact that this study uniquely examines the experiences of maritime vocational lecturers who are also pursuing higher studies. While previous research has explored the challenges of balancing teaching and research, this study specifically focuses on how this balance impacts the integration of sustainability into maritime education. This research thus provides a deeper understanding of the pressures faced by educators in this context and offers practical insights into how they can better navigate these challenges.

3.2.3 Institutional Support for Sustainability Integration (Score: 9/10)

The effectiveness of institutional support for integrating sustainability into maritime vocational education is another key finding from this study. The high score of 9/10, with an effectiveness rating of 90%, indicates that when institutions provide adequate resources, flexibility, and professional development opportunities, lecturers are more successful in integrating sustainability into their teaching practices. Institutional support can take many forms, including providing access to updated teaching materials, offering professional development in sustainability topics, and creating a flexible teaching schedule that allows lecturers to balance their research and teaching responsibilities.

The urgency of this indicator is high, reflecting the significant role that institutional support plays in ensuring the success of sustainability integration. Without strong institutional backing, lecturers may struggle to keep up with the rapidly changing demands of sustainability in the maritime industry, which could hinder their ability to effectively teach these principles to students. This finding underscores the need for institutions to be proactive in supporting their faculty members, especially in the face of the increasing emphasis on sustainability in maritime operations.

The novelty of this result is evident in its focus on institutional support within the specific context of maritime vocational education. While much has been written about the importance of institutional support in higher education, this study specifically highlights the role of institutions in enabling sustainability integration within vocational programs. The findings point to the importance of institutional structures that facilitate the seamless incorporation of sustainability into the curriculum and teaching practices.

3.2.4 Time Management and Efficiency in Dual Roles (Score: 8/10)

Time management emerged as a moderate challenge for lecturers who balance teaching and higher research, reflected in the score of 8/10. Although lecturers were generally effective in managing their time, the results indicated that time constraints can still hinder their ability to fully integrate sustainability into their teaching practices. The combined effectiveness and efficiency ratings of 80% reflect the fact that while lecturers are managing their time well, there is still room for improvement, particularly in ensuring that sustainability principles are consistently addressed within the curriculum.

The urgency of this indicator is moderate, highlighting the importance of effective time management strategies for lecturers who balance teaching and research responsibilities. Time management remains an area where institutions can provide additional support, such as offering resources for better workload management or providing more flexible scheduling options.

The novelty of this result is in its examination of time management challenges within the specific context of dual-role lecturers in maritime education. By focusing on how lecturers navigate the demands of both teaching and higher research, this study contributes to the growing body of knowledge on academic workload management, specifically in vocational education.

3.2.5 Faculty Collaboration and Sharing Best Practices (Score: 9/10)

Collaboration among faculty members emerged as an essential strategy for integrating sustainability into maritime vocational education. The high score of 9/10 for this indicator reflects the effectiveness of collaborative teaching practices in enhancing the integration of sustainability. The results suggest that when faculty members work together, share best practices, and support each other, the overall quality of teaching improves. Collaborative efforts enable lecturers to share resources, teaching materials, and insights on how to effectively teach sustainability in maritime education.

The urgency of this indicator is moderate, indicating that while faculty collaboration is important, it is not as critical as institutional support or the integration of sustainability into curricula. Nevertheless, fostering a collaborative teaching environment remains an important factor in ensuring that sustainability is successfully integrated into maritime education. The novelty of this result lies in its focus on faculty collaboration as a key driver for sustainability integration in maritime education. While faculty collaboration has been widely discussed in the context of general education, this study provides specific insights into how collaboration among maritime vocational educators can enhance the delivery of sustainability education. The results of this research provide a comprehensive understanding of the factors that influence the integration of sustainability into maritime vocational education. The study highlights the critical role of institutional support, faculty collaboration, and effective time management in enabling lecturers to balance their dual roles and successfully integrate sustainability principles into their teaching practices. The findings emphasize the importance of aligning vocational education with the evolving needs of the maritime industry, particularly in terms of sustainability.

The research also underscores the need for maritime vocational education to evolve in response to the industry's sustainability goals. The study offers valuable insights into how institutions can better support lecturers in their efforts to integrate sustainability into curricula and teaching methods. Furthermore, it highlights the importance of collaboration among faculty members in enhancing the overall quality of sustainability education. This research contributes significantly to the field of maritime education by providing a deeper understanding of the challenges and opportunities associated with integrating sustainability into vocational training. It offers practical recommendations for enhancing vocational education frameworks, ensuring that the next generation of maritime professionals is well-equipped to meet the sustainability challenges of the industry.

4. CONCLUSION

This research highlights the critical role of integrating sustainability into maritime vocational education, particularly in marine engineering programs for naval electrical cadets. The study reveals that lecturers, despite the challenges of balancing higher studies with teaching responsibilities, are highly effective in

incorporating sustainability principles into their curricula. Institutional support, time management, and faculty collaboration emerged as key factors enabling lecturers to successfully navigate their dual roles while maintaining high standards of education. The results show that sustainability integration into the curriculum is crucial, with industry practices such as green shipping and energy-efficient technologies being increasingly embedded in vocational training programs. This is essential for preparing future maritime professionals to tackle the environmental challenges facing the industry. Additionally, the research underscores the need for ongoing support from educational institutions to provide lecturers with the resources and flexibility they need to effectively integrate sustainability into their teaching practices. Furthermore, the study highlights the importance of faculty collaboration in enhancing the delivery of sustainability education. By sharing best practices and resources, lecturers can collectively improve the quality of education and better equip students to address sustainability challenges in their future careers. Ultimately, the findings offer valuable insights for institutions aiming to enhance vocational education in the maritime sector, ensuring that graduates are prepared to meet the sustainability demands of the industry. This research contributes to the ongoing effort to transform maritime education to be more aligned with sustainable industry practices.

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