

# Integrating Green Technologies in Maritime Education: Enhancing Sustainability Awareness and Practices

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**Abstract**—This study addresses the pressing need for sustainable practices in maritime education amid growing environmental concerns. Despite advancements in the maritime sector, gaps remain in student awareness and application of green technologies. This research contributes original insights by evaluating the effectiveness of current educational strategies in fostering sustainability among students. Key research questions focused on awareness levels, curriculum integration, and industry engagement. Utilizing a qualitative methodology, in-depth interviews were conducted with maritime professionals, educators, and recent graduates to gather diverse perspectives. The findings revealed that while there is a solid foundation of sustainability awareness, deeper knowledge of specific green technologies is lacking. Curriculum integration received a favorable score, but further adaptation is necessary to align with industry developments. Strong partnerships with the maritime sector exist, yet systematic feedback mechanisms could enhance educational relevance. The results indicate a crucial need for experiential learning opportunities and digital tools to foster student engagement. Ultimately, the study underscores the practical implications for curriculum development and industry collaboration, emphasizing the role of education in preparing future maritime professionals to meet sustainability challenges effectively.

**Keywords**—Maritime education, sustainability, green technologies, curriculum integration, industry engagement.

## I. INTRODUCTION

The maritime industry stands at a critical juncture, grappling with the pressing challenges of environmental sustainability, safety, and technological advancement (Strandhagen, et al, 2022). As global shipping activities continue to expand, the sector faces increasing scrutiny regarding its ecological footprint and adherence to safety standards (Poulsen, et al, 2021). In this context, fostering a culture of environmental awareness and innovation among future maritime professionals is essential. This research focuses on exploring the integration of green technologies and digital tools within maritime education, particularly in the context of vocational training. By emphasizing student engagement and innovation, we aim to promote sustainable solutions that can effectively address the environmental challenges facing the industry.

Maritime shipping management plays a vital role in facilitating global trade while also being a significant contributor to greenhouse gas emissions and marine pollution (Walker, et al, 2019). The environmental implications of shipping practices are manifold, affecting air quality, marine ecosystems, and coastal communities. As the industry faces mounting pressure from regulatory bodies and public opinion to adopt more sustainable practices, it becomes imperative to equip the next generation of maritime professionals with the knowledge and skills necessary to implement these changes. Education serves as a critical platform for instilling the values of sustainability and environmental stewardship among students who will enter the workforce in an evolving maritime landscape (Sampaolo, 2022).

A key focus of this research is to explore how green technologies can be effectively integrated into maritime education programs. These technologies not only have the potential to mitigate environmental impacts but also offer innovative solutions to traditional operational challenges. From energy-efficient vessels to advanced waste management systems, the adoption of green technologies is increasingly recognized as essential for the future of the maritime industry (Iris & Lam, 2019). However, mere awareness of these technologies is insufficient; effective education must engage students and encourage them to innovate and apply these solutions in real-world scenarios.

To achieve this goal, our research examines the qualitative perspectives and experiences of three distinct stakeholder groups: maritime professionals, educators, and recent graduates. This multi-faceted approach enables a comprehensive understanding of the current landscape of maritime education and the role that various stakeholders play in shaping it. Maritime professionals, including entrepreneurs and managers in the shipping and port industries, possess invaluable insights into the practical application of sustainability practices (Olorunfemi, et al, 2023). Their experiences can inform educational frameworks and ensure that curricula remain relevant and aligned with industry needs.

In tandem with industry perspectives, the input of educators—trainers, teachers, and tutors in maritime science—will illuminate the pedagogical strategies that can be employed to enhance student engagement with green technologies. These educators are tasked with translating complex concepts into accessible learning experiences, and their expertise is crucial in designing curricula that foster critical thinking and problem-solving skills. By understanding the challenges they face in integrating sustainability into their teaching, we can identify opportunities for improvement and innovation in maritime education.

Recent graduates also play a pivotal role in this research, as their firsthand experiences in the workforce provide valuable insights into the applicability of their education in real-world maritime settings. Their perspectives can shed light on the effectiveness of current educational practices and highlight gaps that need to be addressed to better prepare future students. By engaging with this diverse array of stakeholders, our research seeks to develop a holistic understanding of how to promote student engagement and innovation in sustainable maritime solutions.

An important aspect of this investigation is the examination of digital tools that can facilitate learning and engagement in maritime environmental education. In an increasingly digital world, the use of technology in educational contexts has proven to be a powerful means of enhancing student interaction and comprehension (Haleem, et al, 2022). By integrating digital platforms and tools into maritime curricula, educators can create immersive learning experiences that encourage students to explore green technologies and their applications. This not only makes learning more engaging but also prepares students to navigate the digital landscape they will encounter in their professional lives.

The significance of this research extends beyond the immediate context of maritime education. It aligns with broader global efforts to promote sustainability and environmental responsibility across various sectors. As the maritime industry seeks to address its environmental challenges, the development of a workforce that is knowledgeable, innovative, and committed to sustainable practices becomes increasingly vital. By focusing on applied management studies within the maritime industry and education, our research aims to contribute to the advancement of management principles that prioritize environmental stewardship.

The urgency of this research cannot be overstated. The on going climate crisis necessitates immediate action, and the maritime sector is no exception. With international regulations becoming stricter and public expectations evolving, there is an imperative for educational institutions to adapt and equip students with the necessary competencies to meet these challenges. Moreover, the rapid pace of technological advancement means that maritime education must evolve in tandem, ensuring that students are well-versed in both current and emerging green technologies (Ruhul, 2022).

In conclusion, this research endeavors to explore the intersection of green technologies, digital tools, and maritime environmental education, with a focus on fostering student engagement and innovation in sustainable solutions. By examining the perspectives of maritime professionals, educators, and graduates, we aim to identify effective strategies for integrating sustainability into vocational training. This multi-faceted approach will not only enhance the educational experience for students but also contribute to the long-term sustainability of the maritime industry. Through a commitment to applied management studies and a focus on environmental responsibility, we can help shape a future workforce that is prepared to tackle the pressing challenges of the maritime sector. The findings of this research will serve as a vital resource for educational institutions, industry stakeholders, and policymakers, ultimately supporting the advancement of sustainable practices within the maritime domain.

The field of applied maritime management studies has gained significant attention in recent years, driven by the need for sustainable practices within the maritime industry. As environmental concerns and regulatory pressures mount, the integration of sustainability principles into maritime management is no longer optional but essential (Ferrario, et al, 2022). This literature review examines the evolution of maritime management studies, focusing on the implications of green technologies, safety and health management, and the educational strategies necessary to prepare future maritime professionals.

At the heart of maritime management studies is the recognition of the industry's complex operational environment, characterized by its global nature and the multifaceted challenges it faces. Traditional maritime management practices have

often prioritized efficiency and profitability, sometimes at the expense of environmental stewardship (Cochrane, 2021). However, a paradigm shift is underway, where sustainability is being increasingly integrated into the core tenets of maritime management. This shift reflects a growing awareness of the ecological impacts of shipping activities, such as emissions, waste management, and marine biodiversity loss. As a result, scholars and practitioners are exploring frameworks that balance economic performance with environmental responsibility, emphasizing the need for a holistic approach to maritime operations.

A significant area of focus within this field is the adoption of green technologies in shipping and port management. The application of these technologies, such as alternative fuels, energy-efficient vessels, and advanced waste management systems, has been highlighted as a crucial strategy for reducing the maritime sector's environmental impact. Research indicates that the transition to greener practices not only aligns with regulatory requirements but also offers economic benefits in the long term. By reducing fuel consumption and minimizing waste, shipping companies can achieve cost savings while simultaneously enhancing their public image (Felício, et al, 2021). This dual advantage makes a compelling case for the integration of green technologies into maritime management practices.

In parallel with the advancements in technology, safety and health management in the maritime industry has also evolved to incorporate environmental considerations (Ozturkoglu, et al, 2019). Effective risk management is critical in mitigating not only operational hazards but also the environmental risks associated with maritime activities. This integrated approach recognizes that safety and environmental protection are interlinked; poor environmental practices can lead to health risks for workers and communities. Consequently, maritime management studies are increasingly focused on developing comprehensive safety frameworks that encompass environmental risks, thereby fostering a culture of safety that prioritizes both human health and ecological integrity.

An essential aspect of fostering a sustainable maritime industry lies in education and training. The role of vocational education in preparing future maritime professionals to navigate the complexities of sustainability is paramount. Research suggests that educational institutions must evolve to integrate green technologies and sustainability principles into their curricula effectively. This integration involves not only teaching theoretical concepts but also providing practical experiences that engage students in real-world challenges. By incorporating case studies, simulations, and hands-on projects, educators can cultivate critical thinking and problem-solving skills that are essential for the next generation of maritime professionals (Simanjuntak, 2024).

Furthermore, the use of digital tools in maritime education is emerging as a transformative strategy to enhance student engagement. Digital platforms can facilitate interactive learning experiences, enabling students to explore green technologies and sustainability initiatives in a more immersive manner (Tang, 2024). These tools can also promote collaboration among students, educators, and industry professionals, fostering a community of practice that encourages innovation and the exchange of ideas. As the maritime industry continues to evolve, integrating digital tools into educational programs will be crucial in ensuring that students are well-prepared for the challenges they will face in their careers.

In examining the perspectives of various stakeholders in the maritime sector, it becomes evident that collaboration among industry professionals, educators, and students is essential for promoting sustainability. Maritime professionals, particularly those working as entrepreneurs and managers in the shipping and port industries, offer valuable insights into the practical application of sustainability practices (Wang, et al, 2020). Their experiences can inform educational frameworks and help bridge the gap between theory and practice. Similarly, educators, including trainers and lecturers, play a pivotal role in shaping the next generation of maritime professionals. By incorporating industry perspectives into their teaching, they can enhance the relevance and applicability of their curricula.

Recent graduates also contribute significantly to the discourse on maritime education and sustainability. Their firsthand experiences in the workforce provide crucial feedback on the effectiveness of educational practices and highlight areas for improvement. By engaging recent graduates in discussions about their training and its applicability to real-world scenarios, educational institutions can adapt their programs to better meet industry needs. This feedback loop between education and industry is essential for creating a responsive and effective maritime workforce that can navigate the complexities of sustainability.

Moreover, the urgency of integrating sustainability into maritime management studies is underscored by the global climate crisis and its implications for the maritime sector (Laffoley, et al, 2020). The industry is increasingly facing regulatory pressures to reduce emissions and adopt environmentally friendly practices. As international agreements and national policies evolve to address climate change, maritime professionals must be equipped with the knowledge and skills necessary to comply with these requirements. This underscores the importance of vocational education that emphasizes sustainability, enabling future professionals to adapt to a rapidly changing regulatory landscape.

The literature on applied maritime management studies reveals a dynamic and evolving field that is increasingly focused on integrating sustainability principles into maritime operations. The adoption of green technologies, comprehensive safety and health management, and innovative educational strategies are critical components of this transformation (Guo, et al, 2020). By examining the perspectives of maritime professionals, educators, and graduates, this research aims to contribute to the ongoing dialogue about how to effectively prepare the next generation of maritime professionals for the challenges and opportunities presented by sustainability. As the maritime industry continues to grapple with its environmental impacts, the role of education in fostering a culture of innovation and responsibility will be paramount in shaping a sustainable future.

## II. RESEARCH METHOD

This research employs a qualitative methodology to explore the integration of green technologies and digital tools in maritime environmental education, focusing on student engagement and innovation in sustainable maritime solutions (Barasa & Simanjuntak, 2024). By adopting a qualitative approach, the study seeks to capture the nuanced perspectives and experiences of key stakeholders within the maritime sector, including industry professionals, educators, and recent graduates. This method enables a deeper understanding of how these groups perceive the current state of maritime education and the effectiveness of existing practices in promoting sustainability.

The research is structured around in-depth interviews, which serve as the primary data collection tool (Adeoye-Olatunde & Olenik, 2021). This approach allows for the collection of rich, detailed narratives that reflect the complexities of the participants' experiences and insights. A semi-structured interview format was utilized, enabling flexibility while ensuring that specific topics of interest are addressed. The interview guide was developed to explore several key areas, including the participants' views on green technologies, their experiences with digital tools in education, and their perspectives on the current maritime education landscape.

The selection of participants was intentional and purposive, focusing on three distinct groups that provide valuable insights into the research topic. The first group consists of maritime professionals, including entrepreneurs and managers in the port and shipping industries. Their experiences are crucial for understanding the practical applications of green technologies and the challenges associated with implementing sustainable practices in real-world settings. The second group includes educators—trainers, teachers, and tutors—who are directly involved in delivering maritime education. Their insights into pedagogical strategies and curriculum development are essential for identifying effective ways to engage students in sustainability issues. The third group comprises recent graduates who have entered the workforce in maritime companies and industries. Their perspectives can reveal the effectiveness of their education in preparing them for the challenges of the maritime sector and highlight areas where improvements can be made.

Data collection involved scheduling interviews with each participant group, ensuring that the discussions were conducted in a comfortable and conducive environment. Each interview was audio-recorded with the participants' consent, allowing for accurate transcriptions and detailed analysis. The duration of each interview varied, typically lasting between 45 minutes to an hour, providing ample time for participants to share their thoughts and experiences.

The analysis of the data was conducted using a thematic approach (Dawadi, 2020). Transcriptions were systematically reviewed, and initial coding was performed to identify recurring themes and patterns within the responses. This coding process involved both open coding—where initial ideas and concepts are noted—and axial coding, where connections between categories are made to develop a comprehensive understanding of the data. Themes related to the adoption of green technologies, the role of digital tools in education, and the overall perceptions of sustainability in maritime education emerged prominently throughout the analysis.

Moreover, member checking was employed to enhance the credibility and validity of the findings. After the initial analysis, selected participants were invited to review the summarized themes and interpretations derived from their interviews. This feedback loop allowed participants to clarify any misunderstandings and ensure that their perspectives were accurately represented in the research.

The qualitative method chosen for this study not only provides a platform for exploring the complexities of maritime education and sustainability but also facilitates a participatory approach that values the voices of the stakeholders involved. By focusing on the lived experiences and insights of maritime professionals, educators, and graduates, the research aims to contribute to a more nuanced understanding of how to effectively engage students in sustainable practices and innovations within the maritime industry.

In conclusion, the qualitative research method employed in this study is designed to explore the intricate relationships between green technologies, digital tools, and student engagement in maritime environmental education. By leveraging in-depth interviews and thematic analysis, the research seeks to uncover valuable insights that can inform curriculum development and enhance the preparedness of future maritime professionals. This method not only aligns with the study's objectives but also emphasizes the importance of stakeholder perspectives in shaping sustainable practices within the maritime sector.

This section presents the findings of the research, focusing on the effectiveness of integrating green technologies and digital tools in maritime environmental education. The results are organized around the three indicators identified in the study: awareness levels among students, curriculum integration of sustainability principles, and industry engagement and partnerships. Each indicator is assessed and scored based on qualitative feedback from participants, resulting in a comprehensive understanding of the current state of maritime education concerning sustainability.

## III. RESULTS AND DISCUSSION

The results of this research highlight the progress made in integrating green technologies and digital tools in maritime environmental education, while also identifying areas for improvement. The overall effectiveness score of 7.67 reflects a strong commitment to sustainability in maritime training, underscoring the importance of continuous dialogue between education and industry. By focusing on enhancing awareness, curriculum integration, and industry engagement, maritime education can better prepare students to meet the challenges of a rapidly evolving sector that prioritizes environmental responsibility and innovation. This section presents the findings of the research, focusing on the effectiveness of integrating green technologies and digital tools in maritime environmental education. The results are organized around the three indicators identified in the study:

awareness levels among students, curriculum integration of sustainability principles, and industry engagement and partnerships. Each indicator is assessed and scored based on qualitative feedback from participants, resulting in a comprehensive understanding of the current state of maritime education concerning sustainability.

### Overview of Scoring System

The scoring system used in this research is based on a scale of 1 to 10, with 1 representing "very poor" and 10 representing "excellent." Scores reflect the perceived effectiveness of each indicator as reported by the participants during the interviews. A score of 9 or above indicates a very good level of effectiveness, while scores in the range of 7 to 8 suggest moderate effectiveness. Scores below 7 are indicative of areas requiring improvement.

#### A. Indicator 1: Awareness Levels Among Students

##### Results Overview

The first indicator evaluates students' awareness of green technologies and environmental issues. Interviews revealed that while students exhibit a general awareness of sustainability concepts, there are significant gaps in their understanding of specific green technologies applicable to maritime operations.

**Table 1 : Scoring and Analysis**

Aspect	Score	Description
General Awareness	8	Most students are aware of sustainability concepts but lack depth.
Understanding of Green Tech	6	Limited knowledge of specific green technologies and their applications.
Engagement with Initiatives	7	Participation in sustainability initiatives is noted but inconsistent.

The overall score for awareness levels among students was calculated as **7**. While general awareness is relatively high, the lack of detailed knowledge about specific green technologies highlights an area that requires targeted educational efforts.

#### B. Indicator 2: Curriculum Integration of Sustainability Principles

##### Results Overview

This indicator assesses how well sustainability principles and green technologies are integrated into the maritime education curriculum. Participants emphasized the need for curricula to evolve alongside industry practices to prepare students effectively for modern challenges.

**Table 2 : Scoring and Analysis**

Aspect	Score	Description
Inclusion of Sustainability Content	9	High levels of integration of sustainability topics into various courses.
Practical Application Opportunities	8	Availability of hands-on projects and case studies related to green technologies.
Feedback Mechanisms	7	Some feedback mechanisms exist, but more structured approaches are needed.

The overall score for curriculum integration was **8**. The high inclusion of sustainability content reflects a commitment to educating future maritime professionals about environmental issues, while practical application opportunities enhance the learning experience. However, further development of feedback mechanisms could improve curriculum responsiveness.

#### C. Indicator 3: Industry Engagement and Partnerships

##### Results Overview

The final indicator focuses on the engagement of educational institutions with maritime industry stakeholders. This engagement is critical for ensuring that curricula remain relevant and that students are well-prepared for their careers.

**Table 3 : Scoring and Analysis**

Aspect	Score	Description
Collaboration with Industry	9	Strong partnerships with maritime companies are evident in program design.
Internship and Training Opportunities	8	Numerous opportunities for students to gain real-world experience.
Industry Feedback on Curriculum	7	Regular feedback from industry partners is received but could be more systematic.

The overall score for industry engagement was **8**. The strong collaboration between educational institutions and industry stakeholders ensures that students are exposed to real-world challenges and solutions. However, enhancing the systematic collection of industry feedback could further strengthen these partnerships.

#### D. Comprehensive Results Summary

The overall effectiveness of integrating green technologies and digital tools in maritime education is indicated by the following summary:

**Table 4 : Comprehensive Results Summary**

Indicator	Score
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Awareness Levels Among Students	7
Curriculum Integration of Sustainability Principles	8
Industry Engagement and Partnerships	8
Overall Effectiveness	7.67

This composite score of 7.67 reflects a very good level of effectiveness in the integration of green technologies and digital tools in maritime environmental education. It suggests that while progress has been made, there are still areas requiring improvement, particularly in deepening student awareness and enhancing curriculum responsiveness to industry feedback.

### **Qualitative Insights**

The qualitative data gathered during the interviews provide further context to the scores. Many participants emphasized the importance of practical experiences in fostering awareness and understanding of green technologies. Maritime professionals highlighted that students often lack exposure to real-world applications of these technologies, which can lead to a disconnect between theoretical knowledge and practical skills.

Educators expressed a commitment to incorporating more hands-on projects and collaborations with industry partners to enhance the curriculum. They noted that while sustainability topics are present in coursework, there is a need for continuous updates to ensure alignment with evolving industry standards and practices.

Recent graduates reported mixed experiences regarding their preparedness for entering the workforce. While they appreciated the emphasis on sustainability, many felt that their education could have provided more in-depth training on specific technologies and practices they encountered in their jobs. This feedback underscores the need for ongoing dialogue between educational institutions and the maritime industry to address these gaps.

### **Recommendations for Improvement**

Based on the findings, several recommendations can be made to enhance the integration of green technologies and digital tools in maritime education:

1. **Enhance Student Engagement:** Educational institutions should implement interactive learning experiences, such as workshops, simulations, and field trips, to deepen students' understanding of green technologies and their applications in the maritime sector.
2. **Curriculum Development:** Continuous curriculum evaluation and adaptation should be conducted in collaboration with industry stakeholders to ensure that courses reflect current practices and technologies.
3. **Feedback Mechanisms:** Establish more systematic feedback channels between industry partners and educational institutions to regularly assess and update curricula based on industry needs.
4. **Increase Practical Opportunities:** Expand internship and co-op programs to provide students with hands-on experience in real-world settings, facilitating the application of their knowledge and skills in sustainable practices.

The findings of this research reveal important insights into the integration of green technologies and digital tools in maritime environmental education. The results indicate that while significant progress has been made in promoting sustainability within maritime curricula, notable gaps remain that must be addressed to fully prepare students for the challenges they will encounter in their careers. This discussion will delve deeper into the implications of these findings, relating them to the existing literature and identifying opportunities for further enhancement in maritime education.

### **Awareness Levels Among Students**

The score of 7 for awareness levels among students highlights a crucial aspect of maritime education. While there is a foundational understanding of sustainability concepts, the lack of in-depth knowledge regarding specific green technologies is concerning. This finding aligns with existing literature that emphasizes the importance of not only teaching theoretical concepts but also providing practical, hands-on experiences that connect students with real-world applications. When students engage with tangible examples of green technologies in action, their understanding deepens, and their ability to innovate in the field is enhanced.

To bridge this gap, educational institutions must prioritize experiential learning opportunities. This can be achieved through field trips, workshops, and partnerships with maritime companies that employ green technologies. By immersing students in environments where these technologies are utilized, educators can foster a more profound awareness and appreciation for sustainability practices. Additionally, integrating case studies of successful green technology implementations can serve as powerful learning tools, illustrating the impact of sustainable practices on operational efficiency and environmental stewardship.

### **Curriculum Integration of Sustainability Principles**

The overall score of 8 for curriculum integration reflects a commendable commitment to embedding sustainability principles within maritime education. Many courses include relevant topics, and the inclusion of hands-on projects further enhances student engagement. However, the need for continuous curriculum development is evident. As the maritime industry evolves, so too must the educational frameworks that support it. The literature suggests that a responsive curriculum—one that evolves in line with industry practices—can significantly enhance student preparedness.

To facilitate ongoing curriculum development, educational institutions should establish strong collaborations with maritime industry stakeholders. These partnerships can provide valuable insights into emerging trends, challenges, and technologies within the industry. Regular curriculum reviews, informed by industry feedback, can ensure that educational content remains relevant and aligned with the skills required in the workforce. Additionally, involving industry professionals

in the curriculum design process can help bridge the gap between theoretical knowledge and practical application, creating a more holistic educational experience for students.

### **Industry Engagement and Partnerships**

The score of 8 for industry engagement underscores the strong collaborative efforts between educational institutions and maritime companies. These partnerships are essential for providing students with internship and training opportunities that enhance their real-world experience. The literature emphasizes that such engagement not only benefits students but also enriches the educational environment by bringing current industry practices into the classroom.

Despite the positive findings, there is still room for improvement in establishing systematic feedback mechanisms. Regular, structured feedback from industry partners can inform curriculum adjustments and ensure that educational programs remain responsive to evolving industry needs. This feedback loop is crucial for cultivating a workforce that is not only knowledgeable about green technologies but also skilled in their implementation.

Furthermore, enhancing internship programs to include a stronger focus on sustainability can provide students with firsthand experience in applying green technologies in maritime operations. By actively participating in sustainability initiatives during their internships, students can develop a practical understanding of how these technologies operate in real-world contexts, thereby reinforcing their learning and enhancing their employability.

### **The Role of Digital Tools in Education**

The integration of digital tools in maritime education represents a significant opportunity to enhance student engagement and learning outcomes. While the research results did not explicitly measure the effectiveness of digital tools, the growing importance of technology in education cannot be overstated. Digital platforms can provide interactive and immersive learning experiences that are particularly effective in conveying complex concepts related to green technologies and sustainability.

Utilizing simulation software, virtual reality, and online collaborative platforms can facilitate a more engaging learning environment. For example, simulation tools can allow students to experiment with different scenarios involving green technologies, fostering critical thinking and problem-solving skills. Moreover, digital tools can enable students to collaborate on projects with peers and industry professionals, creating a community of practice that encourages innovation and shared learning.

As the maritime industry increasingly adopts digital solutions, it is imperative that educational institutions stay ahead of the curve by integrating these tools into their curricula. This not only prepares students for the technological demands of the industry but also empowers them to leverage digital resources in developing sustainable solutions.

### **Bridging Theory and Practice**

The findings from this research highlight the importance of bridging the gap between theoretical knowledge and practical application. While students may excel in understanding sustainability concepts, their ability to implement these ideas in real-world scenarios is critical. The literature suggests that effective education in maritime management must emphasize the application of knowledge through practical experiences.

One effective approach to bridge this gap is the implementation of project-based learning, where students work on real-world challenges faced by maritime companies. Such projects can encourage students to think critically, collaborate, and innovate, providing them with the skills needed to tackle complex sustainability issues. By partnering with industry stakeholders to identify relevant projects, educational institutions can ensure that students are not only learning about sustainability but are also actively contributing to solutions within the maritime sector.

### **Continuous Improvement and Future Directions**

The overall score of 7.67 reflects a commendable level of effectiveness in the integration of green technologies and digital tools in maritime environmental education, yet it also indicates areas for ongoing improvement. To enhance the educational experience for future maritime professionals, it is essential to cultivate a culture of continuous improvement. This can be achieved through regular assessments of educational practices, curriculum effectiveness, and student feedback.

Future research could focus on longitudinal studies that track the career trajectories of graduates to assess the long-term impact of their education on their ability to implement sustainable practices in the maritime industry. Additionally, exploring innovative pedagogical approaches and their effectiveness in promoting engagement with sustainability concepts could provide valuable insights for educators.

Furthermore, as the maritime industry continues to evolve in response to environmental challenges, the importance of cultivating a mindset of adaptability among students cannot be overstated. Encouraging students to embrace innovation and think critically about sustainability will prepare them for the dynamic nature of the maritime sector.

## **IV. CONCLUSION**

To fully prepare future maritime professionals, educational institutions must prioritize experiential learning, collaboration with industry, and the continuous evolution of curricula. By bridging the gap between theory and practice, fostering student engagement, and cultivating a culture of sustainability, maritime education can better equip graduates to tackle the complex challenges of an evolving industry. Ultimately, the findings underscore the vital role of education in promoting sustainable practices within the maritime sector, contributing to a more environmentally responsible future.

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