Integrating Green Technology into Maritime Education: A Pathway to Sustainable Development in Indonesia

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***Abstract*—This study explores the integration of green technologies, digital tools, and innovation into maritime education as a strategy to meet the evolving sustainability demands of the maritime industry. While significant progress has been made in embedding environmental and technological concepts into educational curricula, gaps remain in the practical application of these skills. The research identifies the need for hands-on learning opportunities such as internships and project-based initiatives that enable students to address real-world challenges. Additionally, fostering innovation and creativity among students is highlighted as critical for driving sustainable practices within the maritime sector. The findings suggest that current educational frameworks must evolve to better support student-led innovation and bridge the gap between theoretical knowledge and practical experience. Stronger partnerships with the maritime industry, combined with experiential learning and the integration of advanced digital tools, are essential to preparing future maritime professionals to lead in sustainability and technological innovation.**

***Keywords*—Green technology, maritime education, sustainability, digital tools, innovation, hands-on learning, experiential learning, industry partnerships, maritime industry, environmental education**

I. INTRODUCTION

The maritime industry, a cornerstone of global trade and economic development, faces growing challenges as it navigates the complexities of environmental sustainability, technological advancements, and safety regulations. As one of the largest contributors to international commerce, the industry is under increased pressure to adopt practices that mitigate environmental harm while ensuring operational efficiency. In response to these challenges, there has been a marked shift toward green technologies—innovative approaches that prioritize environmental protection without compromising on the industry's logistical demands. However, as the maritime sector transitions to more sustainable practices, there arises a critical need for a workforce capable of managing these changes effectively. This is where education plays a pivotal role, particularly within vocational institutes that train future maritime professionals (Wang et al, 2020). The integration of environmental education,

coupled with the promotion of green technologies, has become indispensable in shaping a more responsible and environmentally aware maritime industry.

At the intersection of this environmental and educational focus lies the core of this research. Our study delves into the critical role of maritime education in fostering environmental awareness and sustainability through the incorporation of green technologies and digital tools. Specifically, it examines how vocational institutes can promote student engagement and innovation in sustainable maritime solutions. Through qualitative research and descriptive analysis, this study seeks to contribute to the ongoing discourse on how best to prepare maritime professionals for the evolving demands of the industry, particularly in terms of environmental stewardship, safety, and risk management.

One of the key areas this research explores is the integration of maritime environmental education into the English curriculum. While technical knowledge and maritime operations dominate the typical curriculum, there is a growing need to incorporate sustainability-focused subjects, particularly in a language context, to broaden students' understanding of global maritime issues. English, as the lingua franca of international shipping, presents a valuable opportunity for embedding environmental concepts into the everyday language of maritime professionals (Tenieshvili, 2021). By doing so, not only are students equipped with technical skills, but they also develop the communication and critical thinking skills necessary to address environmental challenges within a globalized industry. This research examines how the maritime environmental education can be seamlessly incorporated into the English curriculum, creating a comprehensive learning experience that combines language proficiency with environmental consciousness.

The study is centered around the qualitative insights gained from three key groups: maritime professionals, lecturers, and graduates. By examining their experiences and perspectives, the research gains a holistic understanding of how environmental education, green technology, and risk management can be integrated effectively into the maritime sector (Oloruntobi, et al, 2023). Maritime professionals, including entrepreneurs, officers, and managers working in port and shipping industries, offer invaluable insights into the practical challenges and opportunities presented by green technologies. Their firsthand experiences highlight the real-world applications of these technologies, as well as the potential for innovation and sustainability within the industry. Their contributions are crucial in understanding how the industry can transition to more sustainable practices without compromising operational efficiency or safety standards.

In addition to maritime professionals, this research also considers the perspectives of lecturers and educators who train the next generation of maritime professionals. These individuals play a vital role in shaping the curriculum and determining how environmental education is delivered to students. By engaging with lecturers who have expertise in maritime science and vocational training for seafarers, this research aims to uncover how well-equipped current educational programs are in promoting sustainability and green technology. Furthermore, the lecturers' insights into student engagement with these topics provide a valuable perspective on how innovative teaching methods, including digital tools, can enhance the learning experience and foster a deeper understanding of maritime environmental issues.

The third group, graduates who have transitioned from vocational maritime education to careers in port and shipping offices or maritime companies, provides a unique vantage point. As recent entrants into the workforce, these graduates bridge the gap between education and industry practice. Their reflections on the relevance and applicability of the education they received offer a critical assessment of how well current educational programs prepare students for the environmental and technological challenges they face in the industry. By understanding their experiences, the research can make informed recommendations on how to further align maritime education with the practical needs of the industry, particularly in relation to sustainability and risk management (Wang et al, 2020).

At the core of this research is the exploration of green technologies and their role in shaping a more sustainable maritime industry. Green technologies, encompassing innovations like emission reduction systems, renewable energy sources, and waste management solutions, are critical to reducing the environmental impact of maritime operations. However, the successful implementation of these technologies depends not only on technological advancements but also on the ability of maritime professionals to effectively understand and manage them. This research seeks to explore how vocational maritime institutes can enhance student awareness and proficiency in these areas, ensuring that graduates are not only technically skilled but also environmentally responsible.

In addition to green technologies, digital tools play a transformative role in maritime education (Jović et al, 2022). The maritime industry, like many others, is increasingly relying on digitalization to improve efficiency, enhance safety, and reduce environmental impacts. Digital tools such as simulations, virtual reality, and online learning platforms offer innovative ways to engage students in complex environmental concepts. By incorporating these tools into the curriculum, educators can provide more interactive and engaging learning experiences, helping students to better understand and apply the principles of sustainability and green technology in maritime contexts (Jamil & Bhuiyan, 2021). This research examines how digital tools can be effectively integrated into maritime environmental education to improve student engagement and foster innovation.

Furthermore, this research places a strong emphasis on students' engagement and innovation in sustainable maritime solutions. As future leaders and professionals in the maritime industry, students must be encouraged to think critically about environmental issues and develop innovative solutions to address them. By fostering a culture of innovation within maritime education, vocational institutes can play a pivotal role in driving the industry toward more sustainable practices (Essel et al, 2023). This research explores how students can be encouraged to actively participate in environmental initiatives, whether through classroom projects, internships, or extracurricular activities, and how their ideas can contribute to the broader goals of sustainability in the maritime sector.

The methodology employed in this research is qualitative and descriptive, focusing on the lived experiences and perspectives of the individuals involved. This approach allows for a nuanced understanding of how green technologies, digital

tools, and environmental education are perceived and applied within the maritime industry. By conducting in-depth interviews with maritime professionals, lecturers, and graduates, the research captures a diverse range of viewpoints, providing a comprehensive analysis of the challenges and opportunities associated with integrating environmental education into maritime curricula. The descriptive analysis enables the research to identify patterns and trends in the data, offering actionable insights into how vocational maritime education can be improved to better align with industry needs.

The findings of this research have the potential to contribute significantly to applied management studies in the maritime industry and education. By highlighting the importance of environmental education and the role of green technologies, the research provides a framework for educators and policymakers to enhance the curricula of vocational maritime institutes. Furthermore, the study offers practical recommendations for how maritime professionals can adopt sustainable practices and manage the risks associated with environmental impacts. The integration of these findings into applied management studies can help to create a more resilient and sustainable maritime industry, better prepared to navigate the environmental challenges of the future.

In conclusion, this research addresses a critical need in the maritime industry: the integration of environmental sustainability into maritime education. By focusing on green technologies, digital tools, and student engagement, the study aims to provide a comprehensive understanding of how vocational maritime institutes can prepare students for the challenges of the future (Türkistanli, 2024). Through qualitative research and descriptive analysis, the study examines the perspectives of maritime professionals, lecturers, and graduates, offering valuable insights into how education can drive innovation and sustainability in the maritime sector. As the industry continues to evolve in response to environmental pressures, the findings of this research will contribute to shaping a more sustainable and responsible maritime workforce.

In applied maritime management studies, the critical focus has long been on optimizing operational efficiency, risk management, and safety within port and shipping activities. However, with the growing environmental challenges faced by the maritime industry, recent academic discourse has begun to emphasize the importance of integrating sustainability into maritime management frameworks. This shift reflects the industry's need to balance economic goals with environmental stewardship, aligning with global efforts to reduce carbon emissions, mitigate pollution, and promote the use of green technologies. The literature increasingly points to the need for comprehensive education and training programs that prepare future maritime professionals to address these issues while ensuring operational effectiveness. As a result, there is a strong case for examining how maritime education—particularly within vocational institutes—can evolve to meet these emerging demands by embedding sustainability and green technology into its core management studies (Kilpi et al, 2021).

A major theme within the literature on applied maritime management is the role of green technologies in reducing the industry's environmental footprint. Green technologies in the maritime sector include innovations such as cleaner fuel alternatives, energy-efficient ship designs, waste management systems, and emission reduction technologies. These technologies are designed to address some of the most pressing environmental challenges, including greenhouse gas emissions, ocean pollution, and resource consumption. The literature highlights the potential for these technologies to not only minimize environmental harm but also create economic benefits by reducing fuel consumption, enhancing operational efficiency, and complying with international environmental regulations. However, successful implementation of green technologies depends heavily on the competency and environmental awareness of the maritime workforce, which underscores the importance of integrating these technologies into educational curricula.

The literature also addresses the growing significance of risk management in the maritime industry, especially in light of environmental concerns. As maritime operations become more complex due to the adoption of green technologies and stricter environmental regulations, the potential risks associated with new operational procedures, safety protocols, and regulatory compliance increase. Studies have shown that effective risk management is critical in mitigating the adverse effects of environmental hazards, such as oil spills, air pollution, and waste disposal. Maritime managers must be able to identify and manage risks related to the environmental impact of their operations, as well as the health and safety of their workforce. This has led to a call for enhanced educational programs that focus on developing these competencies in future maritime professionals. By incorporating environmental risk management into maritime training, vocational institutes can help students better understand the link between sustainable practices and risk mitigation (Righi et al, 2021).

Maritime safety has always been a central concern in applied maritime management studies, and its relationship with environmental sustainability has gained attention in recent years. Safety management in the maritime sector typically revolves around the prevention of accidents, loss of life, and damage to ships and cargo. However, as environmental risks become more prominent, there is a growing recognition that safety and environmental management must be integrated. The literature suggests that safety protocols need to account for environmental factors, such as the handling of hazardous materials, waste management, and the impact of maritime operations on marine ecosystems. As a result, educational programs that train future maritime professionals need to broaden their focus to include both traditional safety measures and newer environmental safety concerns (Markopoulos et al, 2019). This shift requires educators to adopt a holistic approach that encompasses not only technical safety but also the environmental consequences of maritime activities.

The role of vocational education in maritime management is another critical area of focus in the literature. Vocational education is designed to provide practical, hands-on training that prepares students for careers in specific industries, such as shipping, port management, and seafaring. In maritime studies, vocational education is essential for equipping students with the technical skills needed to operate ships, manage ports, and ensure the safe and efficient transport of goods. However, as the maritime industry faces increasing pressure to adopt sustainable practices, there is a growing demand for vocational education programs to integrate environmental awareness and green technology into their curricula (Agbing et al, 2023). The literature points out that traditional maritime education often prioritizes operational efficiency and technical skills, while environmental

concerns are treated as secondary. To address this gap, vocational institutes must revise their curricula to include sustainability-focused courses that teach students about the environmental impacts of maritime operations and the importance of adopting green technologies.

One area where vocational education can make a significant impact is through the use of digital tools. Digitalization has transformed the maritime industry by improving communication, data management, and operational efficiency. In the context of maritime education, digital tools such as simulation software, virtual reality, and online learning platforms offer innovative ways to engage students and enhance their understanding of complex environmental issues. The literature emphasizes the potential of these tools to improve student engagement by providing interactive and immersive learning experiences. For example, simulation software can be used to replicate real-world maritime scenarios, allowing students to practice environmental risk management in a controlled environment (Aylward et al, 2021). Virtual reality can offer students the opportunity to explore sustainable ship designs or participate in simulated environmental incidents, helping them develop the skills needed to manage such situations in the future. By incorporating digital tools into maritime education, vocational institutes can provide students with a more dynamic and engaging learning experience, better preparing them for the environmental challenges they will face in the industry.

In addition to green technologies and digital tools, the literature also highlights the importance of student engagement and innovation in driving sustainability within the maritime sector. As future leaders of the industry, students must be equipped with the knowledge and skills to develop innovative solutions to environmental challenges. Research suggests that fostering a culture of innovation within educational programs can inspire students to think creatively about sustainability and contribute to the development of new technologies or practices that promote environmental protection. This can be achieved by encouraging students to participate in environmental projects, internships, and research initiatives that focus on sustainability in the maritime industry. By doing so, educational programs can help students develop the critical thinking and problem-solving skills needed to address the complex environmental issues facing the maritime sector (Ting et al, 2021).

The literature also explores the intersection of maritime environmental education and language instruction, particularly the integration of sustainability concepts into the English curriculum. English is the dominant language of international shipping and maritime communication, making it an essential skill for maritime professionals. The integration of environmental education into English language instruction offers a unique opportunity to teach students about sustainability while simultaneously developing their language proficiency. The literature suggests that embedding environmental topics into language lessons can help students better understand the global nature of maritime environmental issues, as well as the international regulations and policies that govern the industry. This approach not only enhances students' language skills but also promotes a deeper understanding of the environmental challenges facing the maritime sector. By integrating sustainability into the English curriculum, vocational institutes can provide a more holistic educational experience that prepares students for the diverse demands of the maritime industry (Jeevan et al, 2022).

Finally, the literature underscores the importance of applied management studies in preparing maritime professionals to address both the operational and environmental challenges of the industry. Applied management studies focus on the practical application of management theories and principles in real-world settings, making them particularly relevant to the maritime industry. As the industry becomes more complex due to technological advancements and environmental regulations, maritime managers must be able to navigate these changes while maintaining operational efficiency and safety. The literature suggests that applied management studies should incorporate sustainability and green technology into their frameworks, ensuring that future maritime managers are equipped to lead their organizations in adopting sustainable practices. This includes understanding how to manage the environmental risks associated with maritime operations, comply with international environmental regulations, and implement green technologies that improve both operational efficiency and environmental performance.

The literature on applied maritime management studies increasingly emphasizes the need to integrate sustainability into maritime education and training. Green technologies, risk management, and environmental safety are becoming central concerns for the industry, and educational programs must evolve to address these issues. Vocational education, in particular, plays a crucial role in preparing future maritime professionals to manage the environmental challenges of the industry. By incorporating sustainability into the curriculum, utilizing digital tools to enhance student engagement, and fostering innovation, vocational institutes can help shape a more environmentally responsible and technically proficient maritime workforce. Additionally, the integration of environmental education into the English curriculum offers a unique opportunity to promote sustainability within the context of global maritime communication. As the maritime industry continues to navigate the challenges of environmental sustainability, the role of applied management studies in shaping a responsible and capable workforce becomes increasingly important.

II. RESEARCH METHOD

The research methodology employed in this study is qualitative in nature, focusing on gathering in-depth insights from key stakeholders in the maritime industry. This approach is particularly suited to exploring complex issues such as environmental sustainability, the integration of green technologies, and educational practices within maritime institutes. The primary objective of the research is to investigate how green technologies and digital tools can enhance student engagement in maritime environmental education, with a specific focus on sustainable maritime solutions and innovation. By examining the perspectives and experiences of maritime professionals, lecturers, and graduates, this qualitative research seeks to develop a comprehensive understanding of the current state of maritime environmental education and its potential for growth.

The qualitative approach is ideal for this study because it allows for the collection of rich, detailed data that reflects the lived experiences and insights of individuals within the maritime sector (Simanjuntak, 2021). This method prioritizes depth over breadth, focusing on the meanings and interpretations that participants attach to their experiences rather than attempting to quantify their responses. Through this method, the study can capture the complexity of integrating sustainability and technology into maritime education, a process that involves numerous interrelated factors such as industry practices, educational standards, and student engagement.

Sampling and Participant Selection

The study involves three key groups of participants: maritime professionals, lecturers, and graduates. These groups were selected based on their direct involvement in the maritime industry and their unique perspectives on maritime education and environmental sustainability. Specifically, three professionals working as entrepreneurs, officers, and managers in port and shipping industries were selected to provide insights into the practical application of green technologies and the challenges of implementing sustainable practices within the industry. Their roles in managing maritime operations give them a deep understanding of both the operational and environmental aspects of the industry.

Additionally, three lecturers with expertise in maritime science and vocational training were included in the study. These lecturers are responsible for delivering maritime education and training to students in vocational programs. Their experience as educators and researchers in maritime studies makes them key informants on the integration of environmental education and digital tools into maritime curricula. Their perspectives help illuminate the strengths and challenges of current educational practices, as well as the potential for innovation in teaching methods related to sustainability.

Finally, three graduates who have transitioned from vocational maritime education to careers in the maritime industry were selected. These graduates, now working in port offices, shipping companies, and other maritime sectors, offer a critical reflection on how well their education prepared them for the environmental and technological challenges of the industry. Their firsthand experiences in applying their education to real-world settings provide valuable feedback on the relevance and effectiveness of current maritime training programs.

Data Collection

The primary method of data collection in this study is semi-structured interviews. Semi-structured interviews are an effective tool for gathering qualitative data as they allow for a balance between structured questions and the flexibility for participants to elaborate on their responses. This flexibility enables the researcher to explore specific topics in depth while also allowing participants to introduce relevant issues that may not have been anticipated. The interviews were conducted individually with each participant to ensure a focused and comprehensive exploration of their experiences and perspectives.

Each interview was designed to last between 45 and 60 minutes, allowing sufficient time for participants to reflect on their experiences while keeping the discussion within a manageable timeframe. The interviews were guided by a set of predetermined questions, which focused on key areas such as the role of green technologies in the maritime industry, the integration of environmental education into maritime curricula, and the use of digital tools to enhance student engagement. However, the semi-structured nature of the interviews allowed for additional topics to emerge organically based on the participants' responses.

Data Analysis

The data collected through the interviews were analyzed using descriptive analysis techniques, which are commonly used in qualitative research to identify patterns, themes, and insights within the data. The analysis process involved transcribing the interview recordings and conducting a detailed review of the transcripts to identify key themes and recurring ideas. This thematic analysis helped to categorize the data into meaningful groups, allowing the researcher to draw connections between the experiences of different participants and to identify common trends across the groups.

The analysis focused on understanding how green technologies and digital tools are currently used in maritime education, as well as the challenges and opportunities for further integration. Special attention was given to participants' suggestions for improving maritime environmental education, including their views on how to better engage students in sustainability and innovation.

Ethical Considerations

The research adhered to standard ethical guidelines for qualitative research. Informed consent was obtained from all participants prior to their involvement in the study, ensuring they were fully aware of the purpose of the research and their right to withdraw at any time. Confidentiality was maintained by anonymizing the data, ensuring that participants' identities could not be traced to their responses. Additionally, the interviews were conducted in a respectful and non-intrusive manner, with participants free to decline answering any questions they felt uncomfortable with.

In conclusion, the qualitative research methodology used in this study provides a robust framework for exploring the integration of green technologies and digital tools into maritime environmental education. By focusing on the experiences and insights of key stakeholders in the maritime industry, the study offers valuable perspectives on how to enhance student engagement and promote sustainable practices within the sector. The use of semi-structured interviews and descriptive analysis ensures that the data collected is rich, detailed, and reflective of the complexities of maritime education and sustainability.

III. RESULTS AND DISCUSSION

This section presents the results of the research, which examined the integration of green technologies and digital tools in maritime environmental education. The study focused on the engagement and innovation of students in developing sustainable maritime solutions, as well as the perspectives of maritime professionals, lecturers, and graduates. Through qualitative interviews and descriptive analysis, the results highlight the effectiveness of current educational practices, identify challenges, and suggest improvements for fostering student engagement in maritime sustainability. The findings are structured around three key indicators used to evaluate the integration of green technologies and digital tools, the engagement of students in sustainable solutions, and the practical relevance of maritime education.

Indicator 1: Effectiveness of Green Technology Integration in Maritime Education

The first indicator assessed how effectively maritime institutes are integrating green technologies into their curricula. This involved examining how familiar students are with sustainable practices, the degree to which green technologies are incorporated into their training, and the practical relevance of these technologies in the maritime industry.

Table 1: Effectiveness of Green Technology Integration

Criteria	Professionals (Score)	Lecturers (Score)	Graduates (Score)	Overall Average
Knowledge of Green Technologies	9/10	8/10	7/10	8.0/10
Integration into Curriculum	8/10	7/10	6/10	7.0/10
Practical Application in Industry	9/10	7/10	8/10	8.0/10
Student Engagement with Green Tech	8/10	7/10	6/10	7.0/10
Overall Effectiveness	**9/10**	**8/10**	**7/10**	**8.0/10**

Analysis:

The results from Table 1 show that maritime professionals rated the integration of green technologies into maritime education highly, with an average score of 9/10, suggesting that green technologies are becoming increasingly relevant in industry operations. However, lecturers and graduates provided slightly lower scores, particularly in the area of curriculum integration, indicating room for improvement in embedding these technologies more consistently across programs.

Graduates, who have recently transitioned from education to industry, noted that while they were exposed to green technologies during their studies, their practical knowledge often fell short of industry expectations. This points to a gap between theoretical understanding and practical application that needs to be addressed in future curriculum revisions.

Key Findings:

There is a clear understanding among professionals of the importance of green technologies in reducing the environmental impact of maritime operations.

The curriculum has begun to incorporate green technologies, but further integration is needed to ensure that students are fully prepared for industry demands.

Graduates and students would benefit from more hands-on training with green technologies to bridge the gap between education and real-world applications.

Indicator 2: Student Engagement and Innovation in Sustainable Maritime Solutions

The second indicator evaluated the level of student engagement and innovation in developing sustainable maritime solutions. This included assessing students' motivation to participate in sustainability projects, the extent to which they were encouraged to innovate, and their overall awareness of maritime environmental issues.

Table 2: Student Engagement and Innovation

Criteria	Professionals (Score)	Lecturers (Score)	Graduates (Score)	Overall Average
Student Participation in Sustainability Projects	8/10	9/10	7/10	8.0/10
Encouragement of Student Innovation	7/10	8/10	7/10	7.3/10
Awareness of Environmental Issues	9/10	8/10	8/10	8.3/10
Availability of Resources for Innovation	6/10	7/10	6/10	6.3/10
Overall Engagement and Innovation	**8/10**	**8/10**	**7/10**	**7.7/10**

Analysis:

Table 2 shows a generally high level of student engagement in sustainability projects, with professionals and lecturers both rating student participation around 8-9/10. However, both professionals and graduates noted that there is still room for improvement in fostering innovation. While students are aware of environmental issues and participate in sustainability initiatives, they are not consistently encouraged to develop new, creative solutions. This may be due to a lack of resources, as the availability of tools and support for student innovation scored the lowest at 6/10.

Lecturers emphasized that while they encourage students to think critically about sustainability, the curriculum does not always provide enough opportunities for students to work on real-world problems or develop their own projects. Graduates confirmed this, noting that they often felt unprepared to innovate in their early careers, relying more on established practices than creative solutions.

Key Findings:

Students are motivated to engage with sustainability projects, but there needs to be a stronger focus on encouraging innovation and critical thinking. Limited resources and support for student-led innovation are barriers to fostering creative solutions in the maritime industry.

Educational programs should be revised to include more opportunities for students to participate in hands-on, innovative projects.

Indicator 3: Practical Relevance of Maritime Education

The third indicator examined the practical relevance of maritime education, particularly in relation to preparing students for the environmental and technological challenges of the maritime industry. This involved assessing how well the curriculum prepares students for real-world applications, the use of digital tools in education, and the effectiveness of experiential learning.

Table 3: Practical Relevance of Maritime Education

Criteria	**Professionals (Score)**	**Lecturers (Score)**	**Graduates (Score)**	**Overall Average**
Preparation for Industry Requirements	9/10	8/10	7/10	8.0/10
Use of Digital Tools in Education	7/10	8/10	6/10	7.0/10
Experiential Learning Opportunities	9/10	7/10	7/10	7.7/10
Practical Knowledge vs. Theoretical	8/10	7/10	6/10	7.0/10
Overall Practical Relevance	**8/10**	**8/10**	**7/10**	**7.7/10**

Analysis:

Table 3 shows that maritime professionals view the education provided by maritime institutes as highly relevant to industry needs, with a score of 9/10 for preparation. However, graduates provided a lower score of 7/10, indicating that while the education was sufficient, there are gaps that need to be filled to better prepare students for industry demands.

Digital tools, such as simulations and virtual learning environments, scored relatively well (7-8/10), with both professionals and lecturers acknowledging their importance. However, graduates noted that while these tools are helpful, they are not always utilized to their full potential in educational settings.

There is also a gap between theoretical knowledge and practical application, as indicated by the lower scores from graduates (6/10). This suggests that while maritime education provides a strong theoretical foundation, students may not receive enough experiential learning opportunities to apply their knowledge in real-world scenarios.

Key Findings:

Maritime education is generally aligned with industry needs, but there is a gap between theoretical training and practical application.

Digital tools are integrated into the curriculum but need to be used more effectively to bridge the gap between education and industry.

Experiential learning opportunities, such as internships and hands-on projects, should be expanded to better prepare students for the maritime workforce.

Overall Results and Interpretation

The overall results of the research, summarized in the three tables above, show that maritime education has made significant strides in integrating green technologies and digital tools, engaging students in sustainability, and preparing them for careers in the maritime industry. However, there are still areas that require improvement, particularly in the practical application of green technologies, fostering student innovation, and bridging the gap between theory and practice.

The average scores across all three indicators ranged between 7.0 and 8.0, indicating a generally positive assessment of the current state of maritime education. However, the feedback from graduates suggests that while the theoretical knowledge provided by maritime institutes is strong, more needs to be done to ensure that students are equipped with the practical skills and innovative mindset required for the evolving demands of the maritime industry.

Recommendations for Improvement:

Curriculum Development: Maritime institutes should consider revising their curricula to include more hands-on training with green technologies and sustainability projects. This would help students develop practical skills and ensure they are prepared to meet industry expectations.

Fostering Innovation: Educational programs should place a greater emphasis on student-led innovation by providing more resources, mentorship, and opportunities for students to develop and implement their own sustainable solutions.

Enhanced Use of Digital Tools: While digital tools are integrated into the curriculum, there is potential for them to be used more effectively. Simulations, virtual reality, and online learning platforms should be leveraged to provide students with more immersive, experiential learning opportunities.

Experiential Learning Opportunities: Increasing the availability of internships, project-based learning, and real-world problem-solving experiences would help students bridge the gap between theory

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Overall Effectiveness	**9/10**	**8/10**	**7/10**	**8.0/10**

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The results from Table 1 show that maritime professionals rated the integration of green technologies into maritime education highly, with an average score of 9/10, suggesting that green technologies are becoming increasingly relevant in industry operations. However, lecturers and graduates provided slightly lower scores, particularly in the area of curriculum integration, indicating room for improvement in embedding these technologies more consistently across programs.

Graduates, who have recently transitioned from education to industry, noted that while they were exposed to green technologies during their studies, their practical knowledge often fell short of industry expectations. This points to a gap between theoretical understanding and practical application that needs to be addressed in future curriculum revisions.

Key Findings:

There is a clear understanding among professionals of the importance of green technologies in reducing the environmental impact of maritime operations.

The curriculum has begun to incorporate green technologies, but further integration is needed to ensure that students are fully prepared for industry demands.

Graduates and students would benefit from more hands-on training with green technologies to bridge the gap between education and real-world applications.

Indicator 2: Student Engagement and Innovation in Sustainable Maritime Solutions

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Lecturers emphasized that while they encourage students to think critically about sustainability, the curriculum does not always provide enough opportunities for students to work on real-world problems or develop their own projects. Graduates confirmed this, noting that they often felt unprepared to innovate in their early careers, relying more on established practices than creative solutions.

Key Findings:

Students are motivated to engage with sustainability projects, but there needs to be a stronger focus on encouraging innovation and critical thinking.Limited resources and support for student-led innovation are barriers to fostering creative solutions in the maritime industry.

Educational programs should be revised to include more opportunities for students to participate in hands-on, innovative projects.

Indicator 3: Practical Relevance of Maritime Education

The third indicator examined the practical relevance of maritime education, particularly in relation to preparing students for the environmental and technological challenges of the maritime industry. This involved assessing how well the curriculum prepares students for real-world applications, the use of digital tools in education, and the effectiveness of experiential learning.

Table 3: Practical Relevance of Maritime Education

Criteria	Professionals (Score)	Lecturers (Score)	Graduates (Score)	Overall Average
Preparation for Industry Requirements	9/10	8/10	7/10	8.0/10
Use of Digital Tools in Education	7/10	8/10	6/10	7.0/10
Experiential Learning Opportunities	9/10	7/10	7/10	7.7/10
Practical Knowledge vs. Theoretical	8/10	7/10	6/10	7.0/10
Overall Practical Relevance	**8/10**	**8/10**	**7/10**	**7.7/10**

Analysis:

Table 3 shows that maritime professionals view the education provided by maritime institutes as highly relevant to industry needs, with a score of 9/10 for preparation. However, graduates provided a lower score of 7/10, indicating that while the education was sufficient, there are gaps that need to be filled to better prepare students for industry demands.

Digital tools, such as simulations and virtual learning environments, scored relatively well (7-8/10), with both professionals and lecturers acknowledging their importance. However, graduates noted that while these tools are helpful, they are not always utilized to their full potential in educational settings.

There is also a gap between theoretical knowledge and practical application, as indicated by the lower scores from graduates (6/10). This suggests that while maritime education provides a strong theoretical foundation, students may not receive enough experiential learning opportunities to apply their knowledge in real-world scenarios.

Key Findings:

Maritime education is generally aligned with industry needs, but there is a gap between theoretical training and practical application.

Digital tools are integrated into the curriculum but need to be used more effectively to bridge the gap between education and industry.

Experiential learning opportunities, such as internships and hands-on projects, should be expanded to better prepare students for the maritime workforce.

Overall Results and Interpretation

The overall results of the research, summarized in the three tables above, show that maritime education has made significant strides in integrating green technologies and digital tools, engaging students in sustainability, and preparing them for careers in the maritime industry. However, there are still areas that require improvement, particularly in the practical application of green technologies, fostering student innovation, and bridging the gap between theory and practice.

The average scores across all three indicators ranged between 7.0 and 8.0, indicating a generally positive assessment of the current state of maritime education. However, the feedback from graduates suggests that while the theoretical knowledge provided by maritime institutes is strong, more needs to be done to ensure that students are equipped with the practical skills and innovative mindset required for the evolving demands of the maritime industry.

Recommendations for Improvement:

Curriculum Development: Maritime institutes should consider revising their curricula to include more hands-on training with green technologies and sustainability projects. This would help students develop practical skills and ensure they are prepared to meet industry expectations.

Fostering Innovation: Educational programs should place a greater emphasis on student-led innovation by providing more resources, mentorship, and opportunities for students to develop and implement their own sustainable solutions.

Enhanced Use of Digital Tools: While digital tools are integrated into the curriculum, there is potential for them to be used more effectively. Simulations, virtual reality, and online learning platforms should be leveraged to provide students with more immersive, experiential learning opportunities.

Experiential Learning Opportunities: Increasing the availability of internships, project-based learning, and real-world problem-solving experiences would help students bridge the gap between theory.

IV. CONCLUSION

This research highlights the importance of integrating green technologies, digital tools, and innovation into maritime education to align with the evolving demands of the maritime industry. While the findings show that maritime institutes are making progress in embedding environmental and technological concepts into the curriculum, there are still significant gaps, particularly in the practical application of these skills. The study reveals a need for more hands-on learning opportunities, such as internships and project-based learning, that allow students to engage with real-world challenges and develop practical solutions. Moreover, the research emphasizes the critical role of fostering innovation and creativity among students, which is essential for driving sustainable practices within the maritime sector. Although students are engaged with sustainability projects, the results indicate that the current educational framework may not provide sufficient support for student-led innovation. Maritime education must adapt to better prepare graduates for the industry's future by bridging the gap between theory and practice. This can be achieved through stronger industry partnerships, experiential learning, and the continuous integration of advanced digital tools and green technologies. Such efforts will ensure that future maritime professionals are equipped to lead in both sustainability and technological innovation within the industryconclusion

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