# Innovative Teaching Methods for Environmental Awareness in Maritime Vocational Education, A Qualitative Study of Green Technology Integration in Indonesia

Junaidi
*Research and Community Science Department*
*Maritime Institute of Jakarta, Sekolah Tinggi Ilmu Pelayaran Jakarta*
North Jakarta, Indonesia
sulthanssk0824@gmail.com

Siska Yoniessa
*Research and Community Science Department*
*Maritime Institute of Jakarta, Sekolah Tinggi Ilmu Pelayaran Jakarta*
North Jakarta, Indonesia
sulthanssk0824@gmail.com

Achmad Basori
*Research and Community Science Department*
*Maritime Institute of Jakarta, Sekolah Tinggi Ilmu Pelayaran Jakarta*
North Jakarta, Indonesia
sulthanssk0824@gmail.com

Cempaka
*Port and Shipping Management*
*Maritime Institute of Jakarta, Sekolah Tinggi Ilmu Pelayaran Jakarta*
North Jakarta, Indonesia
sulthanssk0824@gmail.com

Sulthan Saladin Syah Koswara
*Port and Shipping Management (KALK)*
*Maritime Institute of Jakarta, Sekolah Tinggi Ilmu Pelayaran Jakarta*
North Jakarta, Indonesia
sulthanssk0824@gmail.com

*Abstract*— The increasing environmental challenges faced by the maritime industry necessitate a shift towards sustainability in vocational education. This study analyzes the effectiveness of innovative teaching methods and green technology integration in enhancing environmental literacy within maritime vocational institutes in Indonesia. While previous research has explored sustainability in maritime education, this study adds original value by focusing on the practical application of green technologies and experiential learning approaches. The key research questions examined how current teaching practices prepare graduates for real-world environmental challenges and how green technology can be further integrated into curricula. A qualitative research design was used, gathering insights from three groups: maritime professionals, lecturers, and graduates. Data were collected through interviews and descriptive analysis to explore the effectiveness of curriculum design in achieving environmental awareness goals. Results showed a high effectiveness score (9/10), indicating that project-based learning, case studies, and simulations are instrumental in developing students' understanding of sustainability. Graduates are well-prepared to implement environmental management systems and lead green initiatives in maritime operations. The study concludes that continuous curriculum development, including further integration of green technologies and international collaboration, is essential for maintaining the relevance of maritime education in an evolving industry.

*Keywords*— Maritime education, environmental literacy, green technology, vocational training, innovative teaching methods

## INTRODUCTION

The global maritime industry plays a critical role in international trade and commerce, forming the backbone of many national economies, including Indonesia's. With over 17,000 islands and a strategic position along major shipping routes, Indonesia's maritime sector is particularly crucial for the nation's economic development. However, as the industry continues to grow, so do its environmental impacts, including pollution, emissions, and resource depletion. These issues have given rise to the urgent need for sustainable practices in maritime operations, particularly in port management, shipping, and export-import activities. To address these environmental challenges, it is imperative to equip future maritime professionals with the knowledge and skills to implement sustainable practices effectively (Barasa & Simanjuntak, 2024). This highlights the need for a reorientation of maritime education, with a strong emphasis on environmental awareness and green technology integration.

In response to this need, the role of maritime education has evolved significantly, especially in vocational institutes that train seafarers, port managers, and shipping professionals. Traditionally, maritime education has focused on imparting technical and operational skills necessary for shipping and logistics. However, as sustainability becomes a global priority, educational institutions must now adapt their curricula to reflect these new demands. The integration of green technology and environmental literacy into maritime education is no longer an option but a necessity. For Indonesia, this shift is particularly important given the country's reliance on the maritime sector and its commitment to international environmental agreements.
The focus on sustainability in maritime education requires more than just curriculum changes; it demands a fundamental transformation in teaching practices and techniques. As education moves towards addressing complex environmental issues, innovative teaching methods become essential tools for fostering deeper understanding and critical thinking among students (Simanjuntak, et al, 2024) Methods such as project-based learning, case studies, and simulations allow students to engage with real-world scenarios, encouraging them to apply theoretical knowledge to practical environmental problems. By employing such approaches, educators can instill a greater sense of environmental responsibility and equip students with the skills needed to contribute to greener shipping and port operations.

The maritime industry is heavily intertwined with export-import operations, which form a significant portion of global trade. As environmental concerns increase, the need for sustainable practices in export-import logistics becomes more pressing. Maritime professionals who manage these operations must not only focus on efficiency and cost-effectiveness but also on reducing the environmental footprint of trade activities. This includes implementing strategies to reduce carbon emissions, minimize waste, and optimize resource use in transportation and logistics. Therefore, vocational education in maritime institutes must include sustainability-focused modules that address the specific challenges of export-import operations. This ensures that future professionals are equipped to make environmentally conscious decisions in their roles within the industry (Simanjuntak, et al, 2024).

Our research focuses on examining teaching practices and techniques in maritime environmental education, with a particular emphasis on innovative methods for fostering environmental awareness. The goal of the study is to explore how maritime educational institutions can effectively incorporate sustainability into their curricula and teaching methods. In doing so, the research aims to contribute to the ongoing discourse on how vocational education can prepare students for the environmental challenges facing the maritime industry (Barasa & Simanjuntak, 2021).

Through a qualitative and descriptive analysis approach, our research examines the perspectives and experiences of key stakeholders in the maritime education system. We conducted interviews with three distinct groups: maritime professionals, lecturers, and graduates. The inclusion of professionals working in port and shipping industries provides practical insights into how environmental practices are being implemented in the field. These professionals, including entrepreneurs, officers, and managers, offer valuable perspectives on the current gaps in environmental literacy among the maritime workforce and the skills they believe are necessary for future professionals to meet sustainability challenges.
In addition, we engaged with lecturers and researchers who are responsible for teaching maritime science and vocational programs for seafarers. These educators play a pivotal role in shaping the curriculum and teaching methods that future maritime professionals will encounter. Their expertise and experiences provide insights into the challenges and opportunities associated with incorporating green technology and environmental awareness into existing educational frameworks. The lecturers' perspectives on innovative teaching methods are crucial in understanding how education can evolve to meet the environmental demands of the industry (Barasa, et al, 2024).

Finally, we explored the views of graduates who have transitioned from academic training to professional roles in the maritime sector. Their experiences in applying the knowledge and skills gained during their education to real-world maritime operations provide a unique lens through which to assess the effectiveness of current teaching practices. These graduates work in various sectors of the maritime industry, including port offices, shipping companies, and maritime industries, offering a broad view of how well prepared they were to tackle environmental challenges in their professional roles.

Our research focuses on identifying the gaps and opportunities within current educational practices in maritime institutes. It is evident that while sustainability is becoming an increasingly important aspect of maritime operations, there is still much work to be done in embedding these principles into vocational education. Through the qualitative analysis of expert, lecturer, and graduate perspectives, the research highlights the importance of interdisciplinary curriculum development. A comprehensive curriculum that integrates green technology across various maritime disciplines is necessary to prepare students for the environmental challenges they will face in the industry (Simanjuntak, et al, 2024).

Furthermore, the study emphasizes the importance of export-import operations in the context of environmental sustainability. Export-import activities, which are fundamental to the global economy, often have significant environmental impacts due to the large volumes of goods transported across long distances. Educating future maritime professionals on how to manage these operations sustainably is crucial for reducing the industry's overall environmental footprint. By incorporating environmental literacy into the vocational training of export-import managers, maritime institutes can play a key role in promoting sustainable trade practices (Barasa & Purba, 2024).

The novelty of this research lies in its focus on the intersection of maritime education, green technology, and environmental literacy. While much of the existing literature focuses on the technical aspects of green shipping and port management, this study brings a unique perspective by emphasizing the role of education in driving sustainability in the industry. By exploring innovative teaching methods and examining the experiences of professionals, educators, and graduates, the research provides new insights into how vocational maritime education can evolve to meet the industry's environmental challenges (Barasa & Simanjuntak, 2024).

The study also contributes to the field by addressing the need for English language education as a tool for enhancing environmental literacy. English is the dominant language in international maritime operations, and proficiency in the language is essential for understanding and implementing global environmental standards and regulations. By integrating English language education with environmental literacy training, vocational maritime institutes can better prepare students for the international nature of their future roles and responsibilities. This interdisciplinary approach not only enhances students' technical skills but also equips them with the communication skills necessary for engaging with global sustainability initiatives (Simanjuntak, et al, 2024).

The urgency of this research is underscored by the increasing international pressure on the maritime industry to adopt more sustainable practices. Organizations such as the International Maritime Organization (IMO) have introduced stringent regulations aimed at reducing emissions and promoting greener shipping operations. Indonesia, as a key player in global maritime trade, must align its educational and operational practices with these international standards to remain competitive and environmentally responsible (Simanjuntak & Barasa, 2024). As such, the need to train a new generation of maritime professionals who are well-versed in sustainability and environmental literacy is more pressing than ever.

The maritime industry is a dynamic and vital sector that is central to global trade and economic growth. However, the increasing demand for shipping services has brought with it significant environmental challenges, including air and water pollution, greenhouse gas emissions, and the depletion of marine ecosystems. As a result, the need for sustainable management practices within maritime operations has become paramount (Simanjuntak, 2024). Within this context, applied maritime management studies have emerged as a critical field of research, focusing on the integration of environmental sustainability into the management of ports, shipping, and related activities.

At the core of applied maritime management studies is the recognition that traditional management practices, which prioritize efficiency and cost reduction, must be adapted to address the pressing environmental concerns of the 21st century (Malau & Simanjuntak, 2024). This shift in focus from purely operational metrics to include sustainability goals has driven significant changes in both academic research and practical applications within the maritime sector. One of the key areas where this shift is most apparent is in port management. Ports, as major hubs of international trade, are significant contributors to environmental degradation, particularly in terms of emissions from ships, machinery, and cargo-handling equipment. Applied maritime management studies have increasingly emphasized the importance of green port practices, which involve the adoption of technologies and strategies aimed at reducing the environmental impact of port activities.

One important aspect of this is the implementation of green technology in port operations. This includes the use of cleaner energy sources, such as renewable energy or alternative fuels, to power port machinery and reduce reliance on fossil fuels. Additionally, ports are exploring the use of energy-efficient equipment and technologies that minimize waste and emissions. The application of green technology is not only an environmental imperative but also a strategic management decision that can enhance the competitiveness of ports by aligning them with global sustainability standards. Studies in maritime management have demonstrated that ports that adopt green practices are better positioned to attract environmentally conscious customers and partners (Malau, et al, 2024), thereby gaining a competitive edge in the global market.

In the shipping sector, applied maritime management studies have similarly focused on the integration of environmental sustainability into shipping operations. Shipping, as the primary mode of transporting goods across the world, is

responsible for a significant share of global greenhouse gas emissions. The International Maritime Organization (IMO) has introduced regulations aimed at reducing emissions from ships, which has led to the development and implementation of cleaner fuel technologies and more energy-efficient vessel designs (Malau, et al, 2024). Applied maritime management research explores the implications of these regulations for shipping companies and how they can adapt their operations to meet the new environmental standards. This includes the use of low-sulfur fuels, liquefied natural gas (LNG), and other alternative energy sources that reduce emissions and contribute to more sustainable shipping operations.

Moreover, ship design and retrofitting have emerged as important areas of study within applied maritime management. Research has shown that improving the energy efficiency of ships, through better hull design, propulsion systems, and energy-saving devices, can significantly reduce their environmental impact. The adoption of such technologies is increasingly viewed not only as a regulatory requirement but also as a critical aspect of modern shipping management. Shipowners and managers are tasked with balancing the cost of retrofitting or acquiring new vessels with the long-term benefits of operating more environmentally friendly ships. In this sense, maritime management studies highlight the need for a holistic approach that considers both the economic and environmental dimensions of shipping operations.

In addition to technological advancements, applied maritime management studies also focus on the role of sustainability-oriented management practices in the day-to-day operations of shipping and port companies. This includes the adoption of environmental management systems (EMS), which provide a structured framework for managing and reducing environmental impacts across all aspects of maritime operations. EMS can be applied to various components of the maritime supply chain, from shipping and cargo handling to port management and logistics. By implementing such systems, companies can monitor their environmental performance, identify areas for improvement, and ensure compliance with environmental regulations. Maritime management studies have demonstrated that companies that adopt comprehensive environmental management systems not only reduce their environmental footprint but also benefit from improved operational efficiency, reduced costs, and enhanced corporate reputation.

A key area of focus within applied maritime management studies is export-import operations, which are integral to international trade. Export-import logistics involve the movement of goods across borders, often requiring multiple modes of transportation, including ships, trucks, and trains. Each of these transportation modes has its own environmental impact, and managing these impacts is a central concern of maritime management. Research in this area has explored strategies for optimizing export-import operations to reduce their environmental footprint, such as improving the efficiency of transportation routes, reducing idle times at ports, and implementing sustainable packaging practices. By focusing on these areas, applied maritime management studies provide valuable insights into how companies can reduce the environmental impact of their international trade activities while maintaining the efficiency and profitability of their operations.

In the context of vocational maritime education, applied management studies take on an additional layer of complexity, as the focus shifts from operational management to the training and development of future maritime professionals. Maritime education has traditionally centered on technical training and skills development, preparing students for careers in ship operations, port management, and logistics. However, as the industry faces increasing pressure to adopt sustainable practices, there is a growing recognition that maritime education must also incorporate environmental literacy and green technology training. Applied maritime management studies in education explore how vocational training programs can be adapted to include sustainability as a core component of the curriculum.

One of the key challenges in this area is ensuring that maritime students are not only technically proficient but also capable of thinking critically about environmental issues and making decisions that prioritize sustainability. Research has shown that innovative teaching methods, such as project-based learning, simulations, and case studies, are particularly effective in fostering this type of critical thinking. By engaging students in real-world scenarios, these methods allow them to apply theoretical knowledge to practical problems, thereby deepening their understanding of how environmental considerations intersect with maritime operations. Applied management studies in maritime education emphasize the importance of integrating such teaching methods into vocational programs to prepare students for the environmental challenges they will face in their professional careers.

The role of lecturers and educators in this process is also a focus of applied maritime management studies. Educators are not only responsible for imparting technical knowledge but also for shaping the mindset of the next generation of maritime professionals. As such, their ability to effectively teach sustainability and environmental awareness is critical to the success of maritime education programs. Research in this area has explored the competencies that lecturers need to effectively teach environmental literacy, as well as the challenges they face in doing so. Studies have highlighted the importance of providing educators with the necessary training and resources to stay up to date with the latest developments in green technology and environmental management (Barasa, 2024).

Moreover, the perspectives of maritime professionals and graduates offer valuable insights into the practical application of environmental education in the industry. Research has shown that professionals who have received training in sustainability and environmental management are better equipped to implement green practices in their organizations. Graduates

of maritime vocational programs who have been exposed to environmental literacy are more likely to advocate for sustainable practices in their workplaces and take on leadership roles in driving environmental initiatives. This underscores the importance of applied maritime management studies in shaping the future of the industry by ensuring that education programs produce professionals who are not only skilled in maritime operations but also committed to sustainability.

The applied maritime management studies provide a comprehensive framework for understanding the integration of environmental sustainability into the maritime sector. From port management and shipping operations to export-import logistics and maritime education, this field of research highlights the critical role that sustainability plays in modern maritime management. As the industry continues to evolve in response to environmental challenges, applied maritime management studies offer valuable insights into how companies and educational institutions can adapt their practices to meet these challenges. By focusing on both technological advancements and management strategies, this field of study ensures that the maritime industry is well-positioned to contribute to global sustainability goals while maintaining its vital role in international trade and commerce.

## RESEARCH METHOD

This research utilizes a qualitative approach, with a focus on exploring the perspectives and experiences of key stakeholders in maritime education and the maritime industry. The qualitative methodology was selected to provide a deep, descriptive analysis of the phenomena under study, particularly the integration of environmental literacy and innovative teaching methods into maritime vocational education (Simanjuntak, et al, 2024). The goal is to understand how these teaching methods can enhance students' understanding of sustainability and how well these concepts are applied in professional maritime operations. Through interviews and descriptive analysis, the research seeks to capture the nuanced views of maritime professionals, educators, and graduates, providing a comprehensive picture of the current state of environmental education in the maritime field.

The study sample consists of three distinct groups: maritime professionals, lecturers, and graduates. These participants were chosen purposively, as they offer direct insights into both the educational and operational aspects of the maritime industry. The professionals included in the study are entrepreneurs, officers, and managers working in port and shipping industries. Their inclusion allows for an examination of how environmental awareness is applied in the real-world management of maritime operations, including port management, shipping logistics, and export-import activities. Their experiences provide critical insights into the current gaps in environmental literacy among the workforce and the importance of integrating green technologies into maritime practices.

The second group of participants consists of lecturers, trainers, and tutors who are involved in teaching maritime science and vocational training for seafarers. These educators were selected based on their competencies and experience in teaching at maritime institutes, as well as their roles as researchers in the field. The perspectives of these lecturers are essential in understanding the challenges and opportunities of incorporating sustainability into maritime curricula. Their input offers valuable insights into the effectiveness of current teaching methods and the potential for adopting more innovative approaches to instill environmental awareness among students. The role of lecturers is especially critical, as they are the primary facilitators of knowledge transfer, and their ability to engage students in meaningful discussions on environmental sustainability is central to the research.

The third group comprises graduates who have recently completed their studies in maritime education and have entered professional roles within port offices, shipping companies, and maritime industries. This group was included to assess the effectiveness of their educational experiences in preparing them for real-world challenges related to environmental management in the maritime sector. Graduates offer a unique perspective, as they bridge the gap between education and professional practice. Their insights help to evaluate how well current teaching methods prepare students to implement sustainable practices and address environmental concerns in their daily operations.

Data collection was conducted through semi-structured interviews with participants from each of the three groups. This method was chosen because it allows for flexibility in exploring the participants' experiences and insights while still maintaining a structured approach to ensure that key research questions are addressed. The interviews were designed to elicit detailed responses about the participants' experiences with environmental education and sustainability in maritime operations. For maritime professionals, the focus was on how they apply environmental awareness in their management practices and the challenges they face in implementing green technologies. For lecturers, the interviews explored their teaching methods, the content of their curricula, and their views on the effectiveness of current educational practices in promoting sustainability. The interviews with graduates focused on how well their education prepared them for professional roles that require an understanding of environmental issues and sustainability practices.

The data analysis followed a thematic approach, where recurring themes and patterns were identified across the interviews. This approach was chosen to systematically capture the key ideas and insights shared by the participants, allowing for an in-depth understanding of the challenges and opportunities related to teaching and learning about sustainability in maritime education. Themes such as the integration of green technologies, the effectiveness of innovative teaching methods,

and the gaps in current educational practices were explored in detail. The thematic analysis also helped to highlight areas where further improvements could be made in the curriculum to better prepare students for the environmental demands of the maritime industry.

The research also includes a descriptive analysis of the findings, providing a detailed narrative of how environmental awareness is currently being taught and applied within maritime vocational education and professional practice. This analysis aims to identify both strengths and weaknesses in the current approach, offering practical recommendations for enhancing environmental education in maritime institutes. The qualitative nature of the study allows for a rich exploration of the complex relationship between education, sustainability, and professional practice, providing a foundation for future research and curriculum development (Barasa, 2024).

## RESULTS AND DISCUSSION

This research aimed to explore the effectiveness of Innovative Teaching Methods for Environmental Awareness within maritime vocational education, specifically in the context of port and shipping management. By analyzing the perspectives of maritime professionals, lecturers, and graduates, this study assessed how well environmental literacy is incorporated into the curriculum, the effectiveness of these methods, and the extent to which graduates are prepared to handle environmental challenges in their professional roles. Based on qualitative analysis of the interview data, the results reveal significant insights into the effectiveness of these teaching practices, scoring 9 out of 10 for effectiveness, with varying degrees of success across different indicators.

### *Indicator 1: Effectiveness of Teaching Methods in Enhancing Environmental Literacy*

The first key area of focus was the effectiveness of the innovative teaching methods employed in the vocational programs for enhancing environmental literacy among students. This was measured through feedback from graduates, lecturers, and maritime professionals on the practical applications of these teaching techniques in real-world settings. The qualitative data revealed a high level of satisfaction with these methods, with an overall score of 9/10 across all groups.

**Table 1**: Effectiveness of Teaching Methods in Enhancing Environmental Literacy

| Participant Group | Score (out of 10) | Comments |
|---|---|---|
| Maritime Professionals | 9 | Practical applications of green technology were well understood. |
| Lecturers | 8.5 | Teaching methods were effective, though some suggested deeper integration of technology. |
| Graduates | 9.5 | Graduates felt well-prepared for handling environmental issues in industry. |
| Overall Score | 9 | The overall impact of teaching methods was positive across participant groups. |

In-depth analysis of the interviews suggests that the use of project-based learning, case studies, and simulation exercises were the most effective in enabling students to develop a deep understanding of environmental concepts. Graduates, in particular, highlighted how these methods helped them to apply theoretical knowledge to practical challenges in their workplace, specifically in green port management and sustainable shipping operations.

The lecturers acknowledged that while most methods were highly effective, more technological tools could be integrated into the curriculum to simulate real-world scenarios further. Despite these recommendations, the overall results demonstrate a successful enhancement of environmental literacy among students, as reflected in the 9/10 effectiveness score.

### *Indicator 2: Integration of Green Technology in Curriculum Development*

The second indicator focused on how effectively green technology was integrated into the curriculum, and whether students were adequately trained to manage green technology applications in the maritime industry. The professionals and graduates expressed that the introduction of modules on renewable energy, clean fuel technologies, and energy-efficient systems were key factors in improving environmental awareness and operational efficiency.

**TABLE 2**: INTEGRATION OF GREEN TECHNOLOGY IN CURRICULUM DEVELOPMENT

| Participant Group | Score (out of 10) | Comments |
|---|---|---|
| Maritime Professionals | 8.5 | Green technology modules were useful, but more industry-specific training needed. |
| Lecturers | 9 | Curriculum incorporated green tech well, but with potential for more practical training. |
| Graduates | 9.5 | Graduates appreciated hands-on experience with green technologies. |
| Overall Score | 9 | The integration of green technology was seen as a strength, with graduates particularly benefitting. |

The graduates expressed confidence in applying green technologies in their workplaces, particularly in port machinery, ship retrofitting, and alternative fuel use. Maritime professionals also praised the curriculum but suggested further industry-specific courses, such as those focusing on retrofitting aging fleets and greener port infrastructure.

The lecturers confirmed that the green technology modules introduced in recent years had improved significantly, allowing students to engage with state-of-the-art developments in sustainable shipping and port management. Practical workshops on low-sulfur fuels, LNG, and renewable energy sources were particularly beneficial, providing students with hands-on experience that would be directly transferable to their professional roles.

*Indicator 3: Preparation of Graduates for Environmental Challenges in Maritime Operations*

The third indicator assessed how well the educational programs had prepared graduates to tackle environmental challenges in their daily maritime operations. This aspect focused on the application of environmental management systems (EMS), sustainable logistics, and export-import regulations. The research found that graduates were well-prepared, as shown in their ability to take leadership roles in implementing green port practices and cleaner shipping operations.

**TABLE 3**: PREPARATION OF GRADUATES FOR ENVIRONMENTAL CHALLENGES IN MARITIME OPERATIONS

| Participant Group | Score (out of 10) | Comments |
|---|---|---|
| Maritime Professionals | 9 | Graduates demonstrated strong environmental knowledge and leadership in green initiatives. |
| Lecturers | 9.5 | Educational programs were designed to thoroughly prepare students for real-world environmental challenges. |
| Graduates | 9 | Graduates felt confident in their ability to implement green practices in their workplaces. |
| Overall Score | 9.2 | Graduates were well-prepared, with strong feedback on their ability to address environmental challenges. |

Graduates reported that the vocational training programs provided a solid foundation in understanding environmental regulations, such as those mandated by the International Maritime Organization (IMO), as well as practical skills for implementing energy-efficient solutions in both shipping and port management. Maritime professionals echoed these sentiments, observing that graduates were proactive in introducing sustainable solutions, such as adopting waste reduction measures, fuel efficiency programs, and cleaner port operations.

Lecturers were particularly proud of how the curriculum had evolved to include comprehensive training on environmental management systems and sustainable supply chain management, equipping students with both the theoretical and practical tools they need to succeed in the environmentally-conscious maritime industry of the future.

*Analysis of Results*

The research reveals that the overall effectiveness of the current innovative teaching methods and curriculum integration of green technology is notably high, with all indicators scoring an average of 9/10. This suggests that the educational programs are successfully preparing students to understand and apply environmental sustainability practices in their professional roles.

The results reflect a positive correlation between the educational practices implemented in vocational maritime institutes and the preparedness of graduates to address environmental challenges in the industry. Maritime professionals validated the effectiveness of these programs by highlighting the initiatives led by graduates in green port management and shipping operations.

Graduates themselves expressed confidence in applying the knowledge and skills gained from their education, particularly in managing environmental compliance, improving energy efficiency, and promoting sustainable operations. Lecturers were also optimistic about the success of the innovative teaching methods, although some suggested the need for further practical training and integration of new technologies to keep pace with industry developments.

*Discussion of the Results*

The findings indicate that the maritime institutes have made significant strides in integrating environmental sustainability into their curricula, particularly through innovative teaching methods and the adoption of green technologies. The 9/10 overall score signifies the effectiveness of these efforts in fostering environmental literacy and preparing students for the environmental challenges they will face in the maritime sector.

However, the results also suggest areas for further development. While the integration of green technology into the curriculum is robust, there is still room for improvement in ensuring that the training aligns with the latest industry trends. Maritime professionals recommended more focus on specific green technologies relevant to different sectors of the industry, such as ship retrofitting, port electrification, and the reduction of port emissions.

The findings also highlight the importance of continuing education for lecturers. Providing lecturers with regular professional development opportunities to stay updated on the latest environmental technologies and teaching methods is crucial. Doing so would ensure that vocational education programs remain at the forefront of sustainability education, equipping students with the most relevant and cutting-edge skills.

*Comprehensive Table Summarizing Key Results*

| Indicator | Professionals' Score | Lecturers' Score | Graduates' Score | Overall Score |
|---|---|---|---|---|
| Effectiveness of teaching methods for environmental literacy | 9 | 8.5 | 9.5 | 9 |
| Integration of green technology into curriculum | 8.5 | 9 | 9.5 | 9 |
| Graduate preparedness for environmental challenges | 9 | 9.5 | 9 | 9.2 |
| Average Score | 8.83 | 9 | 9.33 | 9.05 |

The findings of this research provide significant insight into the current state of environmental literacy and sustainability education within maritime vocational training. The effectiveness of the innovative teaching methods and curriculum development implemented in the maritime institutes of Indonesia are demonstrated through the results, which show an overall score of 9 out of 10. This high level of success, as perceived by professionals, lecturers, and graduates, reflects the positive impact that contemporary teaching methods, including green technology integration, have had on enhancing environmental awareness and preparing graduates for real-world challenges in the maritime industry.

***Effectiveness of Innovative Teaching Methods for Environmental Literacy***

The first key outcome, regarding the effectiveness of teaching methods, indicates that the innovative educational practices implemented in maritime institutes are instrumental in fostering environmental awareness among students. This finding is supported by the qualitative insights from graduates and professionals, who consistently highlighted the importance of practical, hands-on learning in developing a deep understanding of sustainability issues.

Project-based learning, case studies, and simulation exercises emerged as particularly successful strategies in this context. These methods allow students to engage with real-world scenarios and apply theoretical knowledge to practical challenges in maritime operations. Such an approach aligns with the broader pedagogical shift toward experiential learning, which has proven effective in developing critical thinking and problem-solving skills. By simulating situations such as managing green port operations or addressing shipping emissions, students are able to better understand the environmental impact of maritime activities and the importance of sustainable practices.

The high satisfaction among graduates regarding these methods underscores the critical role that active learning plays in vocational education. Graduates reported feeling well-prepared to address environmental challenges in their professional roles, whether in port management or shipping logistics. This sense of preparedness is vital, as the maritime industry faces

increasing pressure to comply with international environmental regulations and adopt sustainable practices to reduce the sector's carbon footprint.

However, while the feedback was overwhelmingly positive, the results suggest room for improvement in terms of further technological integration. Several lecturers expressed the need for enhanced use of digital tools and simulations to provide more detailed and up-to-date training on environmental issues. Although project-based learning is effective, the dynamic nature of the maritime industry—particularly in terms of rapidly advancing green technologies—necessitates continual updates to the educational content and methodologies to remain relevant. Incorporating more sophisticated tools, such as virtual simulations of port operations or fuel efficiency calculators, could bridge this gap and further enhance the learning experience.

***Integration of Green Technology in Curriculum Development***

The second significant finding relates to the integration of green technology into the maritime education curriculum. With an overall score of 9/10 for this indicator, it is clear that maritime institutes have successfully introduced green technologies into their educational programs. This is a critical development, as the adoption of sustainable technologies is essential for the future of the maritime industry, particularly in meeting global sustainability goals and adhering to international environmental regulations.

The study revealed that modules covering renewable energy, low-sulfur fuels, and energy-efficient ship design were particularly impactful in preparing students for the technological shifts currently taking place within the industry. Professionals noted that graduates who had received training in these areas were well-equipped to lead green initiatives in their companies, such as implementing energy-saving measures or introducing cleaner fuel alternatives in port operations.

This finding aligns with the broader trends in the maritime industry, where green port management and sustainable shipping technologies are becoming increasingly central to operations. As international organizations such as the International Maritime Organization (IMO) introduce stricter regulations on emissions and environmental performance, the maritime workforce must be prepared to implement and manage these technologies effectively. The inclusion of practical workshops on green technology applications ensures that students are not only familiar with the theoretical aspects of sustainability but are also able to apply this knowledge in their professional environments.

However, as noted by maritime professionals and lecturers, there remains an opportunity to further tailor the curriculum to address sector-specific needs. While general training on green technologies has proven effective, certain sectors of the maritime industry—such as ship retrofitting, green infrastructure development, and advanced waste management systems—require more specialized training. To address this, vocational programs could introduce specialized courses that focus on sector-specific green innovations, such as retrofitting older ships to meet new environmental standards or developing smart ports that leverage renewable energy and digital technologies for cleaner operations.

Additionally, continuous curriculum updates are essential to keep pace with the rapid advancements in green technology. The industry is continually evolving, with new innovations such as zero-emission vessels and carbon-neutral ports gaining momentum. Therefore, maritime institutes must ensure that their curricula remain agile, incorporating the latest developments in sustainability technology and regulatory frameworks. This ongoing evolution of the curriculum will help ensure that graduates remain at the forefront of green maritime practices.

***Preparation of Graduates for Environmental Challenges***

The third key result concerns the preparation of graduates to tackle environmental challenges in the maritime industry. With a score of 9.2/10, the findings demonstrate that graduates feel confident and capable of managing environmental sustainability initiatives in their workplaces. This is a particularly positive outcome, as it indicates that the vocational training programs are effectively equipping students with the knowledge and skills required to succeed in a rapidly changing industry.
One of the most significant aspects of this preparation is the focus on environmental management systems (EMS) and sustainable logistics. The research showed that graduates were well-versed in the operational aspects of sustainability, such as implementing waste reduction measures, energy-saving strategies, and environmental compliance protocols. This training is crucial, as the maritime industry continues to face increasing pressure from regulatory bodies and stakeholders to adopt more sustainable practices.

The positive feedback from maritime professionals further supports this finding, with several professionals noting that graduates played key roles in driving green initiatives within their companies. This highlights the broader impact that environmentally conscious graduates can have on the industry, particularly in terms of leading efforts to reduce emissions, optimize fuel use, and improve port efficiency. It also underscores the importance of fostering a workforce that not only understands environmental regulations but is also capable of innovating and implementing solutions to address these challenges proactively.

Moreover, the findings highlight the importance of long-term preparation for environmental challenges. While the current curriculum is effective in preparing graduates for immediate challenges, the industry is continuously evolving, and the environmental challenges of tomorrow may differ significantly from those of today. To ensure graduates remain relevant, maritime institutes must continue to emphasize lifelong learning and professional development, encouraging graduates to stay updated on new environmental policies, technologies, and practices.

Additionally, lecturers and graduates highlighted the potential benefits of international collaboration in education. As the maritime industry becomes more globalized, there is a growing need for standardized training and shared knowledge on environmental issues. By fostering partnerships with international maritime institutes and industry leaders, educational programs can broaden their scope, providing students with a more comprehensive understanding of global environmental challenges and the innovative solutions being implemented around the world.

***Enhancing Environmental Literacy Through English Language Education***

An interesting aspect of the research findings is the role of English language education in enhancing environmental literacy. As the global language of the maritime industry, English serves as a critical tool for both communication and learning. The ability to access international research, global best practices, and multinational regulations is greatly enhanced when students are proficient in English. This not only improves their ability to understand and apply environmental concepts but also prepares them for working in multinational teams or pursuing opportunities in international maritime companies.

Moreover, English language education also facilitates the exchange of ideas and collaboration with experts from different parts of the world. As maritime institutes in Indonesia seek to further develop their curricula, enhancing students' proficiency in English will ensure that they are able to engage with the latest environmental research and global maritime policies, thereby improving their capacity to implement innovative solutions in their home country.

***Addressing the Need for Continuous Curriculum Development***

Finally, one of the overarching themes that emerged from the research is the need for continuous curriculum development. As environmental challenges and green technologies evolve, so too must the educational programs that prepare students to meet these challenges. The maritime industry, in particular, is at the forefront of this transformation, with global regulatory changes, technological innovations, and industry-specific developments occurring at an unprecedented pace.

To remain relevant and effective, maritime institutes must prioritize flexibility and agility in their curriculum design. This could include regular consultations with industry professionals, periodic curriculum reviews, and the incorporation of emerging trends in both environmental science and maritime technology. By doing so, educational programs will be better equipped to anticipate the needs of the industry and ensure that graduates continue to be leaders in sustainability.

## CONCLUSION

This research has demonstrated the significant impact of innovative teaching methods and green technology integration on enhancing environmental literacy within maritime vocational education in Indonesia. The overall effectiveness, scored at 9/10, indicates that the curriculum in these institutes successfully prepares graduates to address environmental challenges in the maritime industry. Key elements such as project-based learning, practical case studies, and simulations have proven highly effective in fostering a deep understanding of sustainability concepts and their real-world applications.

The integration of green technologies into the curriculum, specifically in areas like energy-efficient ship design and renewable energy usage, equips students with the necessary skills to lead sustainability initiatives in the industry. Moreover, the qualitative insights from maritime professionals, lecturers, and graduates emphasize the importance of continuous curriculum development, particularly in the face of rapidly advancing technologies and evolving global regulations.

The research highlights that graduates are well-prepared to implement environmental management systems and drive green initiatives in port management and shipping operations. However, ongoing curriculum updates and international collaboration are essential to ensure that maritime education remains agile and responsive to emerging industry trends. Ultimately, this research underscores the critical role of environmental literacy in shaping the future of sustainable maritime operations.

## RECOMMENDATION AND SUGGESTION

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