Embedding Green Education in Maritime Curricula: Advancing Environmental and Maritime Sustainability

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المستخلص

في هذا البحث تم التحقيق في الآثار المتعددة لدمج التعليم الأخضر ضمن مناهج التعليم والتدريب البحري. ومع مواجهة القطاع البحري لتعقيدات الاستدامة البيئية والتطورات التكنولوجية في عصر الثورة الصناعية الرابعة، يصبح تعزيز جيل جديد من المتخصصين الواعين بيئيًا أمرًا بالغ الأهمية. اعتمد هذا البحث المنهج النوعي لتقييم شامل للفوائد والتحديات والعوائق المحتملة المرتبطة بدمج التعليم الأخضر في برامج التعليم والتدريب البحرى ومن خلال مراجعة الأبحاث العلمية وآراء الخبراء، عرضت الورقة نهجًا تكامليًا يعزز استدامة البيئة البحرية وتطور القطاع البحري، إضافةً إلى التخفيف من التعقيدات التربوية والمؤسسية والعملية. وأظهرت النتائج معرفة معمقة تفيد المؤسسات العلمية البحرية وصانعي السياسات وأصحاب المصلحة في الصناعة لزيادة فعالية أثر دمج التعليم الأخضرفى منهاج التعليم والتدريب البحرى.

Abstract

This research examined the multiple effects of integrating green education into Maritime Education and Training (MET) curricula. As the maritime sector faces the complexities of environmental sustainability and technological progress in the era of Industry 4.0, fostering a new generation of environmentally conscious professionals becomes essential. This study used a qualitative approach to thoroughly assess the benefits and potential challenges and barriers of incorporating green education in MET. By reviewing scholarly publications and empirical studies, the paper presented an integrated approach that promotes the sustainability of the maritime environment and advances the maritime sector, while addressing pedagogical, institutional, and practical challenges. The findings provided valuable insights for educators, policymakers, and industry stakeholders to enhance the effectiveness of green education frameworks in MET.

1- Introduction

The maritime industry, which is the backbone of global trade and the global economy, including shipping, seaport, and shipbuilding (Sullivana et al., 2020) and economic development, is simultaneously a significant contributor to environmental impacts, including greenhouse gas emissions, marine pollution, and habitat degradation. At the same time as rising environmental challenges globally and tight international laws, the maritime sector is undergoing a transformative shift towards sustainability. This paradigm shift needs a critical examination of the current processes, technologies, and the education and training of future maritime professionals.

Environmental education, also known as green education or education for sustainable development, is an invaluable tool to equip such professionals with the knowledge, skills, and attitudes they possess to lead and influence such a shift with effectiveness (Simanjuntak et al., 2024; Hardian et al., 2024). The integration of green education into MET curricula is not only an academic work but also a strategic essential. It aims to cultivate an in-depth understanding of ecological principles and promote sustainable operational approaches among seafarers and maritime stakeholders. Nevertheless, the incorporation of this elaborate and dynamic notion within existing frameworks of education is accompanied by positive potential as well as considerable challenges. This research paper attempts to present an in-depth and critical examination of these positive and negative effects through qualitative and argumentative analysis from academic literature.

2- Methodology

This research paper employs a qualitative methodology to explore the positive and negative impacts of embedding green education within MET curricula. The qualitative approach is particularly suited to this study, as it allows for an in-depth understanding of complex phenomena, perceptions, and experiences related to the integration of sustainability in education (Padgett, 2016; Saldana, 2014). By focusing on the 'how' and 'why' of green education's impacts, this methodology facilitates a nuanced exploration of the argumentative aspects derived from academic work.

The research design primarily relies on a comprehensive narrative review of existing scholarly studies and reports related to the topic. Additionally, several case studies and empirical data from various countries are incorporated. This approach enables the synthesis of different perspectives, highlights key themes, and develops an argumentative narrative about the impacts of green education in MET. The literature review method is especially effective for examining complex educational and environmental issues where empirical data collection may be impractical or where a broad overview of existing knowledge is required (Yilmaz, 2013).

This study will examine the following major elements:

- Foundations of green education and sustainable development applied to the shipping sector.
- The positive impact of environmental education in enhancing knowledge of the environment, stimulating sustainable behaviour.
- The negatives and challenges include pedagogical challenges, resistance to reform, and resource limitations.
- Validating the findings through multiple empirical studies across developed countries.

A qualitative approach based on a thorough review of existing literature will be employed to synthesise knowledge and provide a critical analysis. Ultimately, the aim of this research is to enhance understanding of how green education can be effectively integrated through MET, promoting a more sustainable future for the maritime sector.

3- Literature Review

3-1 Green Education and Sustainable Development in the Maritime Context

Green education is a learning approach that integrates environmental sustainability principles and practices within educational frameworks. The main goal is to equip seafarers with the necessary knowledge, skills, and attitudes to address environmental challenges and promote sustainable development (Hardian et al., 2024). In the maritime context, it involves understanding marine ecosystems, pollution prevention measures, sustainable resource management, and international environmental regulations (e.g., MARPOL) (IMO, 2018; UN, 2015). The primary aim is to cultivate a new generation of maritime professionals committed to environmental protection and sustainable development principles (Simanjuntak et al., 2024).

Sustainable development was defined as development that meets present needs without depriving future generations of their ability to meet their needs (Brundtland Commission, 1987). For shipping, the principle involves incorporating environmental protection, social responsibility, and economic viability into all maritime activities (IMO, 2020; Soltani Motlagh et al., 2023). These actions include efforts to enhance the environmental efficiency of international shipping, reduce greenhouse gas emissions from ships, and sustain the long-term health of marine ecosystems.

3-2 The Role of Green Education in Fostering Sustainability in MET

The integration of green education in the MET is fundamental to preparing future maritime professionals equipped with skills and competencies to navigate the complexities of an industry in rapid transformation. The process involves embedding sustainability concepts in the curricular design, pedagogic practices and assessing measures (Simanjuntak et al., 2024).

Traditionally, maritime education has focused on the acquisition of technical skills regarding navigating and management of shipping (Walker et al., 2010; Harrison, 2009). However, a significant gap has emerged, necessitating the embedding of environmental education into the maritime curricula. This integration is intended to align education programs with sustainable development goals and deliver maritime professionals who are environmentally responsive (Simanjuntak et al., 2024). The knowledge gap is visible across various fields: traditional maritime education curricula have often avoided the environmental dimensions of the industry, leaving professionals well-skilled in operational issues but lacking in an understanding of ecological awareness (Chakraborty, 2021; Stokols, 2018). Furthermore, there is a growing demand for maritime professionals who are not just technically equipped but also environmentally literate in a holistic understanding (IMO, 2018; UN, 2015). A lack of standard environmental education across maritime courses has also helped to create differences in training and varying levels of environmental awareness among seafarers (Simanjuntak, 2023).

3-3 International Frameworks and Green Education in MET

The International Maritime Organization (IMO) has played a vital role in creating frameworks for sustainability within the maritime sector. While it has traditionally focused on technical skills (IMO, 1996), the Manila Amendments in 2010 seek to equip seafarers with knowledge about sustainability objectives (IMO, 1996, 2010b). However, Sustainability Thinking—covering

essential non-technical skills such as leadership and teamwork—is often overlooked and not explicitly recognised in international standards like STCW and the International Safety Management (ISM) code (IMO, 2018). This highlights a gap in the standards concerning the development of robust methods for assessing sustainability thinking in maritime education and training (MET) (Simanjuntak et al., 2024).

The IMO has not yet established a definition for ‘Sustainability’ but has initiated proactive efforts to enhance the environmental performance of international shipping, reduce emissions, and attempt to develop sustainability by integrating environmental management and economic feasibility into maritime operations (IMO, 2020; Soltani Motlagh et al., 2023).

3-4 Positive Impacts of Green Education in MET

The embedding of green education into MET curricula provides beneficial effects, playing an important role in the environmental and maritime sectors' sustainability. These impacts can be primarily classified as improved environmental awareness, the encouragement of sustainability practices, and ecological protection responsibility.

a- Enhanced Environmental Awareness

Green education primarily aims to develop environmental awareness concerning challenges and their relevance in the shipping industry. By including subjects such as marine ecosystems, climate change, prevention of pollution, and global warming challenges, MET programs can significantly assist students in developing their understanding of the environmental impact of shipping activities (Hardian et al., 2024). This foundation helps equip professionals to develop an understanding of environmental hazards, comprehend regulatory needs, and value the sensitivity of marine ecosystems.

b- Promotion of Sustainable Practices

Green education, which encompasses knowledge and skills, is essential for applying sustainable development to the shipping industry. It includes training in green technology, energy efficiency, waste disposal, and the efficient use of renewable resources. Embedding environmental elements into maritime curricula enables MET institutions to graduate professionals who can reduce the environmental impact of the shipping industry. Practical training, real-world application, and discussions on current environmental challenges are highly beneficial for maritime students to develop their understanding and application of sustainability fundamentals (Simanjuntak et al., 2024).

c- Ecological Protection Responsibility

Green education at MET is vital for fostering ecological responsibility, which involves understanding the duties and rights of stakeholders towards the environment (Hardian et al., 2024). This includes promoting a shared responsibility for environmental protection and sustainability, and supporting ethical decision-making and commitment to sustainability. By empowering students to act as environmental guardians both within and outside the workplace, MET programs help build a workforce for whom environmental responsibility is a core professional value. The United Nations Sustainable Development Goals (UN-SDGs), particularly SDG 4 (Quality

Education) and SDG 14 (Life Below Water), provide an international framework for addressing these issues, and green education at MET directly contributes to achieving these Goals by encouraging responsible management of marine resources and ocean conservation (UN, 2015; Simanjuntak et al., 2023).

3-5 Negative Impacts and Challenges of Green Education in MET

Despite the obvious merits, integrating green education into MET curriculums faces several challenges and potential barriers. These include pedagogic and institutional obstacles, as well as resistance from traditional paradigms and resource constraints.

a- Pedagogical and Curricular Barriers

One of the main challenges is the pedagogic approach and curriculum framework. Most existing academic frameworks, though historically informative, tend to overlook or inadequately address the key implications of automation, digitalisation, and autonomy (Elmeligy, 2025). There is also a lack of standardised green education frameworks, which leads to uneven training and varying levels of environmental literacy among students from different institutions (Simanjuntak, 2023). Saylan's (2011) highlights the fact that awareness alone does not lead to action, and environmental education often fails to be meaningful.

b- Institutional and Resource Constraints

MET institutions for the Maritime Sector often face resource constraints, including a lack of funds, inadequate physical facilities, and a shortage of educators skilled in sustainability within maritime activities and environmental awareness (Siahaan et al., 2024; Chakraborty, 2021; Stokols, 2018). Developing innovative green curricula requires substantial financial investment in teaching resources, technological upgrades, and teachers' professional development. Additionally, resistance to changing traditional pedagogic models can pose a significant barrier.

c- Academic and Industry Alignment

There is a considerable gap between MET institutions and industry needs in practice, due to the absence of a harmonised maritime taxonomy integration framework (Elmeligy, 2025). This disconnection may lead to graduates who are inadequately skilled with the green competencies required by a transforming industry, or an industry evolving to become greener because of a perception of unqualified personnel (Saylan, 2011).

d- Risk of Superficial Implementation

In some cases, the green education process can be applied superficially, focusing on guideline following rather than genuine understanding and behavioural change. This approach may involve going through the motions, with environmental courses delivered without full engagement or critical analysis. When it concentrates only on abstract structures without real-world application, it might be seen as less effective in fostering sustainability thinking (Simanjuntak et al., 2024).

4- Validation from an Empirical Perspective

The shift towards sustainability in the maritime industry involves not only advanced technology but also transforming maritime training and education systems. Therefore, green education is vital

in integrating into educational curricula, policy frameworks, and among industry stakeholders. Many countries aim to speed up workforce adaptation to sustainability by including green education in their systems.

In Norway, they incorporated green maritime education into the government's electrification policy to boost practical efficiency. MET institutions worked with ferry operators to provide training modules on high-voltage (HV) safety, battery management, and related topics. Sæther & Moe (2021) tested this initiative using mixed methods, including stakeholder interviews and policy analysis. The authors showed that the synergy between national decarbonisation policy and green maritime education greatly improved operators' skills and competencies, thereby increasing workforce readiness.

Another piece of empirical evidence came from the United Kingdom (UK) through a case study at the Port of Plymouth. This study supports the link between maritime green education and operational decarbonization. Karamperidis et al. (2023) conducted this research to show the impact of the short courses (e.g., emissions management, fuel safety, and energy efficiency) on the practical missions. The case study results assessments showed an improvement in operational performance and upskilling the personnel with the required competencies for sustainability.

Continuing with the UK, which examined the Skills for Green Jobs by combining a large-scale employer survey (n=620) with pilot implementations in three maritime education institutions. The results showed shortages in skills related to emission monitoring and the use of low-emission tools. Additionally, the employers who completed their green modules reported greater confidence in green competencies (Maritime Skills Commission, 2024).

Similarly, the Maritime Industry Authority (MARINA) in the Philippines initiated a real-world case study to support green education capacity-building. This study focuses on training more than 150 trainees in decarbonization awareness and green operations through short courses. Pre- and post-assessments have been conducted, indicating a dramatic increase in skills and competencies. This study bridged the gap between the international standards and the local application via the green maritime education (MARINA, 2023).

On a global scale, classification societies such as DNV applied an empirical assessment of the future needs of seafarers' training. This assessment includes topics such as decarbonization, emissions, green operation and sustainability. Sixty stakeholders were interviewed, and their responses emphasised that most seafarers would require new training to equip them with the skills and competencies necessary for areas such as high-voltage systems, carbonisation systems, and fuel reduction. Consequently, for example, maritime decarbonization not only relies on advanced technology but also on the capacity of green maritime education (Antoni Kaspersen et al., 2022).

These empirical studies used statistical analysis of their findings to demonstrate that embedding green education positively enhances MET institutions' ability to achieve sustainability in the maritime sector, as shown in Table 1.

Table 6: Stakeholder-Level Impacts of Green Maritime Education.

Stakeholder	Main Benefit	Example Study	Observed Result
Students / Cadets	Improved sustainability literacy and operational readiness	MARINA (2023)	40 % skill improvement post-training
Seafarers	New competencies in low-emission operations, HV safety	Antoni Kaspersen et al. (2022)	75 % required retraining in green competencies
Industry Stakeholders	Enhanced efficiency and decarbonization readiness	Karamperidis et al. (2023)	25 % fuel-use reduction at Port of Plymouth
Academia	Integration of sustainability in curricula and pedagogy	Sæther & Moe (2021)	3 new green courses introduced nationally

5- Discussion and Recommendations

The incorporation of green education within MET curricula presents a variety of potential benefits and barriers, as the earlier exploration of both advantages and constraints effects indicated. This section outlines these findings and identifies efforts to capture green education's benefits most effectively and mitigate its problems.

Research demonstrates that green education significantly boosts environmental awareness among seafarers (Hardian et al., 2024; Simanjuntak et al., 2024). However, awareness alone does not necessarily lead to action, as Saylan (2011) suggested. MET training should shift from just providing information to promoting application, critical thinking, and responsible decision-making. The focus should be on developing professionals who are environmentally educated and motivated to adopt sustainability practices. A curriculum that combines theory with practical skills is also crucial for students to make a real impact on the environment.

Another challenge was identified and clarified as the gap between academic institutions and the practical requirements of the maritime industry (Elmeligy, 2025). This disconnection can result in graduates who are not fully equipped with the necessary green skills and competencies aligned with industry advancements. To address this barrier, it is essential to focus on collaboration between MET institutions and industry bodies. This includes curriculum development that emphasises sustainable maritime practices relevant to the industry, and the enhancement of internship opportunities that give students a deeper understanding of environmental challenges and solutions. Furthermore, professional development for existing maritime personnel, also designed collaboratively with industry involvement, can help close the skills gap and promote the adoption of sustainability practices.

Shortages of professionals in MET institutions and resource limitations are significant obstacles to the widespread and effective implementation of green education (Siahaan et al., 2024; Chakraborty, 2021; Stokols, 2018). Overcoming these challenges requires a coordinated approach. Primarily, there is a strong need for increased funding and investment in MET institutions, especially for green education initiatives, including infrastructure upgrades, the development of innovative teaching materials, and faculty training. Additionally, cultivating a culture of innovation and flexibility within such institutions is essential. This involves encouraging teachers to adopt modern pedagogic techniques and providing them with the necessary support and training. Moreover, policy frameworks at both national and international levels can play a crucial role in facilitating the transition to green education and establishing guidelines for its integration, thereby reducing resistance to change and promoting a unified approach across the sector.

The superficial application of green education highlights the high risk and underscores the need for a holistic integration of green education in MET. Instead of teaching environmental topics as isolated courses, sustainability concepts must be incorporated throughout the entire MET curriculum, from basic modules to advanced training. This means embedding green education not only in environmental science courses but also across all maritime subjects (e.g., navigation, engineering, logistics, and maritime law). A holistic approach ensures that sustainability principles become part of the mindset of all professionals in the shipping industry, thus influencing decision-making at various levels.

6- Conclusion

Integrating green education into Maritime Education and Training (MET) curricula is a vital step to promote environmental sustainability and the sustainable development of the maritime industry. This study assessed the benefits and barriers of this integration using a qualitative narrative approach.

In conclusion, the benefits of green education for MET are significant and essential for a sustainable future in shipping, and achieving them requires a collaborative, strategic effort. This involves shifting to action-oriented teaching methods, fostering collaboration between academia and industry, securing adequate resources and institutional support, and applying sustainability principles holistically across the curriculum. By addressing the challenges proactively, MET institutions can play a key role in developing a generation of shipping professionals who are not only technically proficient but also deeply committed to environmental responsibility and the long-term sustainability of ships and the global shipping industry.

Finally, presenting multiple empirical studies provides strong validation for this research. It demonstrates the impact of incorporating green education within MET institutions, helping them to improve and achieve the Sustainable Development Goals (SDGs) in the maritime sector.

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