

From awareness to action: The SUDEMAR project for teaching the SDGs

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Abstract. The entire maritime sector and all industries are increasingly being challenged to contribute to the achievement of the SDGs through being green and socially sustainable. The SDGs in the maritime sector cannot be achieved by technology and regulation alone. They require education, awareness, implementation and behavioral change. In this context, maritime education and training institutions form a key link in the chain between awareness and action. The SUDEMAR Project aims at developing digital resources and tools for the teaching and implementation of sustainability, the SDGs, and their integration into workplaces and organizational cultures of maritime professionals. The Project will pursue its objective by creating three main outputs: a Repository of Good Sustainable Development Practices, an E-learning Course on Sustainable Development in the Maritime Sector, and a Mobile Application to ease SDG-oriented learning and engagement. The educational model and expected outputs of the SUDEMAR Project on maritime education and training, as well as the implementation of digital learning ecosystems on sustainability education for lifelong and competency development, sustainable behavior, and behavioral change are presented. The results also contribute to the long-term achievement of the SDGs in the maritime context by showing that learner-centered digital learning tools can turn sustainability awareness into action and implementation.

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Keywords: Sustainable Development Goals (SDGs), Maritime Education and Training, Sustainability education, Digital learning, Behavioral change

1. Introduction

Achieving sustainability in the maritime sector requires more than technology and regulations [1, 2]. It also involves creating an awareness of sustainability issues, responsible decision-making, and developing long-term behavioral change with respect to sustainability among maritime

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stakeholders [3]. Maritime education and training institutes, therefore, have an important role to play in preparing the maritime workforce of the future with this perspective [4,5, 6] .

Approaches to maritime education and training have not kept pace with the evolving sustainability and flexible lifelong education and training requirements, yet they currently focus on student-centered pedagogies, competence-based approaches to learning, digital learning environments, and lifelong learning opportunities for seafarers [7, 8]. Digital resources, ranging from e-learning platforms to mobile learning applications, could support the wider delivery of sustainability education to maritime professionals and students through increased access and engagement.

While the focus on maritime sustainability and marine education and training is increasing, existing initiatives and curricula mainly target regulatory and technical compliance. Behavioral change, sustainability culture, and practical implementation of SDG-oriented thinking are comparatively underrepresented [9, 10]. In addition, accessible and structured digital educational ecosystems for raising awareness and long-term engagement with sustainability in maritime contexts are lacking.

The SUDEMAR Project was developed to address these educational and professional needs by supporting the teaching, dissemination, and implementation of SDGs in maritime education and training. The project combines repository-based learning, online education, and mobile learning technologies to create an integrated digital educational ecosystem promoting sustainability awareness, implementation-oriented learning, and continuous engagement. .

This paper discusses the rationale, pedagogy, outcomes, and evaluation of the SUDEMAR Project. Starting from the challenge of integrating sustainability into the maritime training and career and competency frameworks, the paper discusses how the digital pedagogical tools employed within the project were able to influence behavior and integrate the SDGs into the professional culture and practices.

2. Sustainability, Education, and Behavioral Change in the Maritime Sector

2.1 Sustainable Development Goals and Maritime Industry

The maritime sector is connected to all three dimensions of the sustainable development concept, namely environment, economy, and society [11, 12]. Sustainability in the maritime sector has been increasing due to environmental consciousness, international agreements, and technological advancements. This sustainability transformation is reflected in several SDGs relevant to the maritime sector.

SDG 13 Climate Action seeks to reduce greenhouse gas emissions and decarbonize the maritime transport sector, and SDG 14 Life Below Water covers the protection of marine ecosystems and the sustainable use of the oceans, seas, and marine resources. These aspects are reflected in SDG 5 (Gender Equality) which calls for equal opportunity for everyone in the maritime industry, as well as SDG 8 (Decent Work and Economic Growth), which calls for safe and decent working conditions on board ship and ashore. Achieving these sustainability goals, however, requires not only technological and regulatory measures but also education and behavioral change.

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Furthermore, as a cross-cutting issue, SDG 4 (Quality Education) should play an important role in the general maritime sustainability transformation through lifelong learning, the development of sustainability-related competencies and educational institutions as an important means to further sustainability literacy and responsible professional behavior.

2.2 Education for sustainable development

Education for Sustainable Development (ESD), as a more recent strand or model, seeks to empower individuals with the knowledge, understanding, skills, values, and attitudes necessary to create sustainable societies. ESD, in contrast to other knowledge-based education models, is about transformational learning: critical and reflective thinking, active participation, ethical responsibility, and behavioral change.

Within the maritime context, these principles provide a foundation for integrating sustainability into professional decision-making and practice. Education for sustainability, therefore, goes beyond an environmental perspective to include social responsibility, ethical conduct, resource management, and long-term thinking.

Accordingly, transformative sustainability education is seen as learning resulting in action, rather than the theoretical study of sustainability frameworks and concepts. Participatory, reflexive, and continuous forms of learning are thus important ingredients of maritime sustainability education.

2.3 Digital learning in maritime education

Digital learning technologies are affecting instructional practices across a range of maritime workplaces [13, 14]. E-learning systems and applications, mobile learning, and online learning environments are examples of pedagogic digital learning technologies being employed to support the educational needs of maritime practitioners who operate under challenging, often distributed working conditions.

From the perspective of maritime professionals and seafarers, digital education has some benefits such as location-independent learning, self-paced learning, continuous professional development, and allowing students to constantly update their skills and competencies in a flexible way to keep up with constantly changing regulatory, environmental, and technological requirements. Several forms of digital teaching and learning, such as multimedia, interactive and scenario-based learning, and social learning environments, can be used to further strengthen the learner's engagement, specifically in the field of sustainability education.

2.4 Behavioral Change and Sustainability Culture

One of sustainability education's major challenges is the difficulty in sustaining behavior change, as merely informing students is not enough to promote sustainable behavior without continued engagement, practice, and organizational support [15].

To achieve sustainability-oriented behavioral change, principles should become part of day-to-day activities and decisions in the workplace. The emphasis of education changes from passive information dissemination to action-oriented and participatory approaches aimed at fostering personal involvement and individual responsibility. In this context, education plays a central role in enabling such behavioral change.

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Digital learning ecosystems can also contribute directly to sustainability culture: students can be exposed to sustainability information repeatedly with mobile learning technologies, which can continuously reinforce relevant sustainable practices in the sustainability domain within and beyond the physical boundaries of the learning environment. Against this background, the SUDEMAR Project was developed to operationalize these principles in maritime education.

3. The SUDEMAR Project

3.1 Project Overview

The project aims to increase awareness of the SDGs among maritime stakeholders, support sustainability-oriented behavioral change, ease the implementation of sustainable practices, encourage lifelong learning and continuous professional development, improve the accessibility of sustainability education, and strengthen sustainability culture within maritime education and industry [16]. The project targets maritime students, cadets, educators, seafarers, maritime professionals, and training institutions.

Based on the assumption that sustainability education is not just about raising awareness, SUDEMAR pursues an implementation-oriented, learner-centered, and participatory approach to education that focuses on reflection, accessibility, and the implementation of sustainability in practical settings. Beyond raising awareness, the project intends to involve learners via practical implementation work, by presenting good examples, hands-on tools for active learning, and through a continuous process of exploring digital communication strategies. In doing so, the project seeks to connect sustainable knowledge with professional behavior and everyday practice in the maritime sector.

3.2 Core Outputs of the SUDEMAR Project

The SUDEMAR Project has three core outputs. One of them is the repository of good sustainable practices in the maritime sector. Next is an e-learning course aiming at the sustainable development of the maritime sector, and finally, a mobile application that supports the implementation of SDGs in the maritime sector. In the following part, the core outputs of the project are explained.

- *Repository of Good Sustainable Development Practices [17]*

The Repository of Good Sustainable Development Practices is a web-based information system designed and developed in the scope of the SUDEMAR Project, easing the operationalization of the Sustainable Development Goals in the maritime domain. The Repository is a digital information repository for the classification, storage, and retrieval of information and knowledge, related to relevant EU and UN policies and evidence-based good practices in the environmental, economic, and social domains.

The system's multi-dimensional classification structure indexes all entries in the database based on their alignment with SDGs and their particular maritime sub-sector - such as shipping operations, port management, and sustainable fisheries - within a taxonomy-based hierarchy, to ease information retrieval, data filtering, and cross-referencing across entries in the repository.

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The system is a multilingual user interface addressing several stakeholder groups, and follows a user-centered, open, interoperable architecture, enabling a structured access to a standardized body of sustainability knowledge.

Besides being a passive database, the repository is also a functional knowledge management tool that enables knowledge sharing, evidence-based decision making, and sustainability learning processes. It can be used as an independent database or as part of other SUDEMAR learning and training environments. The repository contains:

- sustainable operational case studies,
- green port management practices,
- environmental protection initiatives,
- energy efficiency applications,
- digital transformation examples,
- socially inclusive organizational practices,
- gender equality initiatives within maritime workplaces.

The repository supports experiential and practice-oriented learning by showing how sustainability principles and concepts can be turned into practice and at the same time enabling learners and institutions to think implementation-oriented by seeing and studying practical examples.

- *E-learning Course on Sustainable Development in the Maritime Sector [18]*

The e-learning course of the SUDEMAR Project provides a Moodle-based digital learning environment, which seeks to ease the incorporation of the SDGs in maritime education and training, in maritime practice, and in the research community. The e-learning course comprises a set of modules and lessons that are supported by relevant learning materials and digital resources. Learning resources within the system can include quizzes, tests, assessments, cases, exercises, simulations, videos, infographics, and other multimedia resources that can engage learners and provide active, rich, and practice-based learning. Instructors can also use built-in assessment and evaluation tools to track participants' progress and retention of information learned.

Accessibility and usability are key principles for the platform. In this respect, the course is designed to be accessible for a wide range of learners. Course facilitators are provided with guidance and training materials to deliver the course and ensure the course is delivered in a pedagogically consistent manner across learning environments.

Upon completion, the course enables participants to develop both conceptual understanding and practical competencies related to sustainability in the maritime sector. The course will also support behavioral change and the development of sustainable practices in the workplace, contributing to the long-term implementation of the maritime sector with a sustainable development perspective. In this way, the course has the potential to influence broader institutional awareness and policy-oriented thinking across the sector.

The course consists of the following modules:

- Introduction to SDGs,
- Sustainability Challenges in the Maritime Sector,
- Sustainable Development Goals

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- Best Practices for Sustainable Maritime Operations,
- Applying, Measuring and Reporting Sustainability,
- Industry Trends & the Future of Maritime Sustainability

Each module has sub-sections addressing significant topics it covers. For example, the first module, Introduction to Sustainable Development Goals (SDGs), has three subsections, which are Understanding the SDGs, Priorities for the Maritime Sector, and Quiz.

The second module, Sustainability Challenges in the Maritime Sector, covers Environmental, Social, and Economic Challenges, followed by Case Studies and the Quiz part.

The module about Sustainable Development Goals is the longest one since it covers all 17 SDGs with four subsections, which are the General Introduction, Targets, Significance for the Maritime Sector, and Implementation and Good Practices in Maritime. At the end, there is a quiz part for self-evaluation.

The fourth module, Best Practices for Sustainable Maritime Operations, has two subsections. First, Sustainable Shipping and Alternative Fuels, and the second is Greenport Management and Sustainable Logistics, followed by a quiz.

The next module is Collapse Applying, Measuring and Reporting Sustainability, which consists of the following parts: Introduction to Applying, Measuring and Reporting Sustainability, Implementing & Measuring Sustainability, ESG Reporting Standards, ESG in the Maritime Sector, Creating a Sustainability Report - Case Study Simulation, and Case Study Simulation. It also covers a quiz like the others.

The last module, Industry Trends & the Future of Maritime Sustainability, has two parts followed by a quiz: Emerging Technologies in Maritime Sustainability, Challenges & Opportunities in the Future of Sustainability, and Future Trends – Decarbonization & The Green Shipping Revolution.

The online format of the course permits flexibility and accessibility, fostering lifelong learning for marine professionals engaged in diverse working conditions. Upon the completion of all modules and quizzes successfully, participants are issued their certificates online.

- *Mobile Application for SDG Engagement [19]*

As part of the SUDEMAR Project, a mobile application was developed that promotes the uptake of the SDGs in the maritime sector and provides mobile access to related publications, tools, services, and available information on maritime sustainability. The app acts as a mobile extension of the project's software repository and e-learning platforms.

The application is a structured repository of good practices, case studies, learning tools, and other materials about sustainability in a maritime context. It is designed to be simple to use and accessible to stakeholders in the maritime sector, including maritime professionals, students, educators, and industry representatives. It is designed to be compliant with accessibility standards. The application also has interactive components such as quizzes, interactive maps, forums, and discussion boards that aim to encourage user engagement and provide the maritime community with opportunities to share knowledge and best practices.

The main part of the system is offline, so that the necessary data can still be accessed when the application is not connected to the internet. This is particularly important for seafarers who are often on ships where the internet is not available. It also supports multiple languages.

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The app is a knowledge repository that focuses on knowledge transfer by encouraging users to share their experiences and practices. It is a practical implementation support system that connects knowledge to e-learning, transforming knowledge into practice, helping close the divide between theory and practice, and taking SDG standards from the repository into actual implementation by maritime organizations.

The application provides:

- practical sustainability guidance,
- SDG-related educational content,
- sustainability reminders and updates,
- microlearning opportunities,
- access to repository and course materials.
- interactive sustainability engagement tools.

5. Educational and Social Contributions of the SUDEMAR Project

One of the challenges of education and training about sustainable development noted by the SUDEMAR Project is the gap between awareness, knowledge, understanding of social and environmental issues developed through education, and actual behavior of individuals and organizations. Although many forms of education in sustainable development have led to increased knowledge and awareness of social and environmental issues, they have not supported individuals to incorporate this knowledge into everyday work and organizational processes. As a result, sustainability continues to be conceptualized and not operationalized in workplace behaviors and decisions, and it ultimately remains unimplemented.

On the other hand, SUDEMAR structures its educational concept based on an approach that focuses on implementation. This means that learning for SUDEMAR should support the process of transferring knowledge into action to ease behavioral change among the maritime community. Therefore, SUDEMAR offers structured learning programs, tools and means for implementation that can be used directly. Sustainability in this sense is not merely a conceptual notion but a series of actionable competencies that can be developed, learned and applied in maritime contexts.

To address this challenge holistically, SUDEMAR implements an integrated digital learning ecosystem. It consists of three components: a knowledge base, technical vocational education e-learning module, and a mobile application for supportive implementation on the job. It combines a multi-layered approach to learning, including knowledge acquisition, practice-oriented application, and workplace integration.

This ecosystem can be said to support iterative and lifelong learning, for example by revisiting the sustainability topics at different moments and/or using different media, and by promoting repetition, interaction, and application. In doing so, it not only develops the individual competence of participants but can also support the wider organizational learning process, and potentially lead to the gradual integration of sustainability into the maritime professional culture.

The ultimate goal of SUDEMAR is to improve the maritime industry's capacity to implement the Sustainable Development Goals, by transforming sustainability education from

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awareness-raising to lifelong learning, behavioral changes, and institutional changes within organizations and higher education institutions.

6. Discussion

As sustainability issues gain in importance in the maritime sector, there is an expectation that maritime education and training organizations should not only address technical and regulatory aspects, but also develop competencies on sustainability. The long-term solution lies in education models that integrate learning and practice, organizational culture, and the decision-making process

In this direction, the SUDEMAR Project's digital learning ecosystem, as described above, with its publication of guidelines, e-learning course, mobile app, and good-practice repository, presents a multi-layered context for learning that interlinks the providing of structured knowledge with the providing of learning opportunities in an applied and professional context. This structure allows users to engage with the multiplicity of sustainability in varied contexts of use.

In addition, the project contributes to the continuity of learning beyond school. By utilizing mobile and digital formats to support STS learning, the skills acquired in school can be further practiced and reinforced outside the formal school setting, such as through the learners' own professional activities. This allows for a gradual development of sustainability competencies and willingness to apply them in maritime practice.

Factors such as (i) user engagement, (ii) institutional embedding, (iii) potential technological scalability, and (iv) sustainability of continuing participation may influence the design of digital sustainability education systems, as well as their application and evaluation in real-world contexts.

Future developments in digital sustainability education are likely to incorporate new technologies such as artificial intelligence, adaptive learning platforms, gamification techniques, and experiential simulation environments for students.

7. Conclusion

Sustainable capacity in the maritime sector involves not only technological and regulatory advancements but also the development of competencies, behaviors, and organizational practices that support and align with the SDGs. To meet this challenge, the SUDEMAR Project proposes an integrated digital learning ecosystem, which includes an online repository of best practices, an e-learning platform, and a mobile application. Together, these digital tools are designed to ease the dissemination of knowledge, and its application to professional contexts within the field of sustainability.

Overall, the project shows how digital and accessible learning environments can contribute to mainstreaming sustainability in maritime education and operations as well as other continuing digital and green transitions in the maritime sector.

Future research could build on this work to investigate the longer-term effects of such systems as well as their effects on behavioral change, learner engagement, and organizational adoption of sustainability practices.

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