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Sustainability Guide for Schools and Clubs Implementing SailingIntoSTEAM course

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DELIVERABLE DATA SHEET

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Deliverable summary
This document provides practical tools and strategies to reduce the environmental impact of sailing activities and cultivate environmental responsibility among educators and students. It was created following D2.2 - SailingIntoSTEAM Methodology and Syllable. That is, it follows the developed curriculum and gives concrete proposals for implementing the course per sustainability and nature conservation principles.

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Sustainability Guide for Schools and Clubs Implementing SailingIntoSTEAM course

Introduction

The SailIntoSTEAM project aims to design, develop, and conduct a pilot test of a sailing course adapted for children aged 7 to 12. The goal is to use sailing as an excellent testbed to teach science, technology, engineering, art, and mathematics (STEAM) subjects. Besides bridging the gap between theory and real-life by introducing a series of hands-on activities, the project also aims to educate young minds about the need to better understand and protect nature, an indispensable component of sailing. Such a course should provide technological and environmental skills for all participants, preparing young people for the future.

This deliverable will focus on promoting sustainability in sailing education, providing practical tools and strategies to reduce the environmental impact of sailing activities and cultivate environmental responsibility among educators and students. First, it will give a brief overview of the important relationship between sailing and sustainability, including STEAM subjects that should also have a sustainable component. After that, it will explain the basic concepts of sustainability and environmental protection, called here sustainability labels, which will later be linked to the course modules developed within D2.2 - SailingIntoSTEAM Methodology and Syllable. The main aim of this document is to provide concrete recommendations and advice for piloting and implementing the SailingIntoSTEAM course in a way that is sustainable and respects the basic principles of nature conservation.

Sailing, STEAM, and Sustainability

Sailing has long been associated with a harmonious relationship between humans and the natural world. As a practice deeply rooted in the use of wind and water, sailing inherently promotes a connection with the environment, encouraging respect for and stewardship of the ecosystems that make it possible. This activity, often seen as a sustainable form of transportation and recreation, offers a unique lens through which we can explore the principles of environmental protection and sustainability.

One of the most significant aspects of sailing is its reliance on renewable energy sources. By harnessing the power of the wind, sailboats eliminate the need for fossil fuels, reducing greenhouse gas emissions and contributing to a cleaner atmosphere. This starkly contrasts motorized vessels, which often depend on diesel or gasoline and can emit harmful pollutants into the air and water. Sailing exemplifies how renewable energy sources can be effectively utilized in transportation and recreation, serving as a model for other industries to adopt sustainable practices.

Furthermore, sailing promotes a minimal-impact approach to the marine environment. The design and operation of sailboats often prioritize efficiency and simplicity, which align with the principles of low-impact living. Sailors tend to be mindful of their waste and resource use, as the constraints of life aboard a vessel naturally foster conservation habits. This mindfulness extends to protecting marine ecosystems, as sailors are acutely aware of the importance of clean and healthy waters for navigation and enjoyment.

Sailing also serves as an excellent platform for environmental education. Many sailing programs incorporate lessons on marine biology, oceanography, and conservation, fostering a greater understanding of the interconnectedness of aquatic ecosystems. Participants often learn about the effects of pollution, overfishing, and climate change firsthand, gaining a deeper appreciation for the need to protect our oceans.

Moreover, sailing communities frequently engage in activities that directly support environmental protection, such as beach clean-ups, monitoring marine life, and advocating for protected areas. These initiatives not only benefit the environment but also cultivate a culture of responsibility and action among sailors and their communities. By participating in these efforts, individuals develop a stronger commitment to sustainable practices both on and off the water.

Despite its inherent sustainability, sailing is not without its challenges. The production of modern sailboats often involves materials like fiberglass and resins, which can have significant environmental impacts. Additionally, antifouling paints used to prevent biofouling can release toxic substances into the water. Addressing these challenges requires innovation and a commitment to integrating sustainable materials and technologies into boat manufacturing and maintenance.

Opportunities for sustainable sailing are expanding with advancements in green technologies. Solar panels, wind turbines, and energy-efficient systems are increasingly being integrated into sailboat designs, enhancing their eco-friendly credentials. Additionally, initiatives promoting sustainable boating practices, such as waste reduction and the use of biodegradable products, are gaining traction within the sailing community. These efforts highlight the potential for sailing to become an even more sustainable activity, setting an example for other sectors to follow.

The intersection of sailing, sustainability, and STEAM (Science, Technology, Engineering, Arts, and Mathematics) sciences offers immense potential for innovation and education. STEAM disciplines play a crucial role in advancing sustainable sailing practices, from developing eco-friendly materials for boat construction to designing cutting-edge renewable energy systems that power sailboats. Engineering and technology, in particular, are driving the creation of smarter, more efficient sailing vessels that minimize environmental impact.

Science and mathematics are essential for understanding the complexities of weather patterns, ocean currents, and navigation—knowledge that is vital for successful and sustainable sailing. The integration of arts within STEAM further enriches the experience, fostering creativity and a deeper connection to the natural world through design, storytelling, and environmental advocacy. By leveraging STEAM sciences, sailing can continue to evolve as a sustainable activity that inspires innovation and environmental stewardship.

In addition, the relationship between sailing and sustainability offers a dynamic platform for engaging young minds in STEAM education. Programs that combine sailing with lessons in environmental science and renewable energy can ignite a passion for sustainable development in future generations. These initiatives not only prepare individuals for careers in green industries but also instill a lifelong commitment to protecting our planet.

Sailing embodies the principles of sustainability and environmental protection, showcasing how humans can coexist harmoniously with nature. By embracing renewable energy, promoting conservation, and leveraging the power of STEAM sciences, sailing offers a model for a more sustainable future.

Sustainability and Environmental Protection Concepts

Environmental protection encompasses a series of measures, strategies, and practices designed to safeguard the natural environment from degradation. These efforts aim to ensure a balance between human activities and ecological systems, promoting the health and sustainability of the planet for present and future generations.

Energy Efficiency



One of the most critical components of environmental protection is energy efficiency, which emphasizes using less energy to achieve the same results. This approach reduces energy consumption, lowers greenhouse gas emissions, and conserves natural resources. Energy efficiency can be implemented in various ways, such as optimizing energy use, minimizing energy losses, and designing sustainable infrastructure. For example, energy-efficient buildings with proper insulation, LED lighting, and advanced heating systems reduce energy needs. Similarly, adopting electric vehicles and hybrid technologies minimizes energy use in transportation. These practices lead to significant environmental benefits, including a reduced carbon footprint and conservation of non-renewable resources like coal and oil. However, implementing energy efficiency often involves overcoming challenges such as high initial costs for advanced technologies and resistance to changing traditional systems.

Pollution Prevention



The principle of pollution prevention focuses on reducing or eliminating pollutants at their source. Unlike traditional methods that manage pollution after it occurs, prevention emphasizes cleaner production techniques, non-toxic materials, and eco-friendly product design. Examples include green chemistry, zero-waste manufacturing, and biodegradable packaging. These approaches minimize environmental contamination, improve public health by reducing exposure to toxins, and lower costs associated with pollution cleanup. Yet, transitioning to pollution prevention often requires investments in technology, regulatory support, and public education.

Water Conservation



The conservation of water resources is another critical concept. Efficient use and management of freshwater resources are essential for ensuring their availability in the future. Practices like rainwater harvesting, smart irrigation, and water-saving technologies in households and agriculture help reduce water waste. For instance, drip irrigation systems optimize water use in farming, while low-flow fixtures decrease household consumption. By preserving aquatic habitats, supporting water availability during droughts, and reducing the energy required for water treatment, these practices enhance environmental sustainability. However, water conservation faces challenges such as population growth, increasing industrial demands, and climate change-induced water scarcity.

Preserving Biodiversity

The concept of preserving biodiversity emphasizes protecting the variety of life on Earth, including different species, ecosystems, and genetic diversity. Biodiversity is essential for maintaining ecosystem balance and providing services such as pollination, climate regulation, and nutrient cycling. Practices like creating protected areas, restoring degraded ecosystems, and promoting sustainable land use help conserve biodiversity. For example, wildlife corridors enable species to migrate safely, while community-based conservation programs engage local populations in protecting their natural environment. Preserving biodiversity ensures ecosystem resilience, supports food security, and mitigates the effects of climate change. However, threats like habitat destruction, pollution, and overexploitation pose significant challenges to biodiversity conservation.

Minimizing Waste

Minimizing waste focuses on reducing the amount of waste generated and managing it in an environmentally responsible manner. This concept includes reducing waste at the source, recycling materials, and promoting composting. For instance, zero-waste initiatives encourage the design of products and systems that eliminate waste entirely. Minimizing waste helps conserve resources, reduce pollution, and decrease the environmental impact of landfills. However, achieving this goal requires changing consumer habits, improving waste management infrastructure, and fostering a circular economy.

Mitigating Climate Change

The concept of mitigating climate change involves reducing greenhouse gas emissions and enhancing carbon sinks to limit global temperature rise. Strategies include transitioning to renewable energy, improving energy efficiency, and adopting sustainable agricultural practices. Reforestation and afforestation projects also play a vital role in absorbing CO₂ from the atmosphere. Mitigating climate change reduces the severity of extreme weather events, protects ecosystems, and ensures the well-being of vulnerable communities. Despite these benefits, implementing climate change mitigation strategies requires overcoming barriers such as financial constraints, political resistance, and lack of global coordination.

Guidelines for modules' sustainable implementation

In this section, a brief overview of the 8 modules developed for the implementation of the SailingIntoSTEAM course will be given. After the description of each module, there will be recommendations for the most sustainable implementation of it. The goal is that each module, and all interactive and practical exercises that make up the modules, will be implemented in a way that protects the environment and respects the principles of nature conservation, to the extent possible. Also, each module will be connected to the corresponding concepts of environmental protection, which will be indicated by circles of appropriate colors - sustainability labels, which were explained in the previous section.

Module 1: Nature of the wind



Summary:

This module introduces students to the science of wind and its application in sailing, with a focus on understanding wind energy, its measurement, and how it propels sailboats. Students will engage in hands-on activities to explore these concepts, integrate maths and science skills, and connect their learning to real-world applications and environmental impact.

Activities of this module include the following exercises: Understanding Wind Formation (Water Tank Experiment); Measuring Wind; Exploring Bernoulli's Principle (Ping Pong Ball and Hairdryer); Exploring Wind Energy; Wind Propulsion in Sailing.

For the first exercise, the recycled or repurposed materials should be used (a second-hand or repurposed glass or plastic tank instead of purchasing a new one). Only the necessary amount of water for the demonstration should be used, and single-use items should be avoided.

For the second exercise, it is necessary to use a material that can be recycled in our country: cardboard boxes (without styrofoam, adhesive tape, plastic, and cellophane), brown cardboard, cardboard and paper bags, notebooks, printed paper, copy paper, magazines, envelopes, packaging from juices and milk. transparent plastic beverage bottles, transparent edible oil bottles and caps, and aluminum beverage cans.

Example: <https://www.youtube.com/watch?v=eBPSfU-ZH-s>

For the third exercise, if possible, collect ping pong balls that have already been used, and do not throw the ones used for the experiment in the garbage, but find a new purpose for them.

For the fourth exercise, it is also necessary to use material that is recycled, such as cardboard, thin trees that can be found somewhere on the side of the road, some old wires, an LED light bulb, and glue, avoid using adhesive tape because the material with it cannot be recycled. Example: <https://www.youtube.com/watch?app=desktop&v=JXYkjHKakGE&t=0s>

For the last exercise, here are examples of sustainable materials for each model: <https://www.youtube.com/watch?v=tIMenzVJFjQ>

Module 2: Buoyancy



Summary:

This module focuses on the principles of buoyancy and density, exploring how these concepts are crucial for understanding and designing sailboats. Through hands-on activities, students will learn about floating and sinking, water displacement, and the role of ballast in maintaining stability. The module also integrates creative and engineering challenges to enhance learning.

Activities of this module include the following exercises: Exploring Buoyancy; Cartesian Diver Activity; Applying Archimedes' Principle; Model Ship Construction.

For all these exercises, it is recommended to use materials that are not new but have already been used for something, as well as materials that have a high decomposition potential or can be recycled.

Module 3: Sails, Sailing, and Bearings



Summary:

This module introduces students to the exciting world of sails, sailing, and navigation using bearings. Through a variety of engaging and interactive activities, students will learn about sail design, how sails work, and the basics of navigation. The module integrates STEAM concepts with practical sailing applications to spark a love for sailing and a deeper understanding of the science behind it.

Activities of this module include the following exercises: Sail Design and Functionality; Using Wind for Propulsion; Practicing Basic Maneuvering Skills; Navigation Basics.

For the first exercise, it is suggested to use recycled paper, old fabrics (e.g., T-shirts, curtains, or cloth bags), or reusable plastic bags. For decorations, natural or non-toxic, biodegradable paints would be ideal.

For the second exercise, to simulate wind propulsion, small, energy-efficient fans (e.g., USB-powered fans) and boat models made from repurposed materials such as cardboard, plastic bottles, or similar items, should be used.

For the third exercise, it is proposed to simulate tacking and jibing maneuvers using chalk-drawn boat outlines, cardboard, or natural branches for sail handles. This approach reduces material waste while fostering teamwork.

For the fourth exercise, existing compasses or mobile apps should be used. Treasure maps could be drawn on the back of already-used paper or created digitally to reduce waste.

Additionally, there is a possibility for an exercise combining modules 3 and 4, which would be carried out if there is access to the water body, and would involve making a functional sailboat out of recyclable materials (for both boat and sail).

For this exercise, recyclable materials such as plastic and paper should be used. The activity would also include a discussion about leaving no waste behind to protect the environment.

Module 4: Simple machines and mechanisms on the Sailboat



Summary:

This module introduces students to various machines and mechanical systems used on sailboats. Through practical activities and demonstrations, students will learn about simple machines, their functions on sailboats, and their importance in sailing. The module also emphasizes the engineering principles behind these machines and their real-world applications. Special focus is placed on the safety aspects of using these machines and mechanisms, ensuring that students understand how to safely operate and maintain a sailboat.

Activities of this module include the following exercises: Introduction to Simple Machines; Mechanical Systems on Sailboats: Pulley and Block System; Rudder and Torque Demonstration; Engineering the Winch System.

For the first exercise, it is suggested to use sustainable materials (wooden planks made from reclaimed or recycled wood instead of newly sourced materials; replace plastic pulleys with metal or wooden alternatives), to ensure all components, such as springs and ropes, are durable and stored properly for reuse in future workshops, and to conduct the experiments outdoors whenever possible to connect participants with nature while minimizing artificial setups.

For the second exercise, for the frame mimicking the mast, bamboo or recycled aluminum can be used. Also, natural fiber rope should be used, like jute or cotton instead of synthetic materials. The pulley system should be built to last multiple workshops and demonstrations to reduce material waste.

For the third exercise, utilize old cardboard, recycled plastics, or salvaged wood to craft the rudder and pivot point. Any discarded materials should be either composted (if biodegradable) or recycled properly.

For the fourth exercise, discarded spools, wires, or rods should be used, instead of purchasing new components. Metal or wooden crank handles are more sustainable than plastic ones. During the exercise, it should be highlighted how winch systems conserve human energy and reduce reliance on motorized systems, drawing parallels with renewable energy sources.

Module 5: Water and Its Nature



Summary:

This module explores the various aspects of water, focusing on its properties, quality, and significance in both the environment and sailing. Through hands-on activities, students will understand the physical and chemical properties of water, learn about water quality testing, and recognize the importance of clean water for marine life and human use. Additionally, students will connect these concepts to sailing, emphasizing the impact of water quality on sailing activities and marine ecosystems.

Activities of this module include the following exercises: Exploring Water's Properties; Water Quality Testing; Hands-On Water Filtering Activity; Investigating Water Sources.

For the first exercise, instead of single-use plastic cups, glass or metal containers that can be reused are preferred. Also, avoid using disposable ice cube bags and instead use reusable ice cubes or mold trays. Instead of synthetic dyes for demonstration, use natural dyes, such as those derived from vegetables (e.g., red cabbage for pH tests). This helps minimize the use of chemicals and plastics.

For the second exercise, for pH strips and other instruments, make an effort to use recycled or long-lasting devices, such as digital meters instead of disposable strips. Instead of purchasing bottled water, encourage the use of eco-friendly bottles or even containers from local water sources. If bottled water is necessary, choose products with recycled packaging, if possible.

For the third exercise, instead of plastic bottles, consider using glass containers. If necessary, use the same plastic bottle over and over. Additionally, use natural materials such as sand, gravel, and activated charcoal, rather than synthetic filters, to reduce the use of artificial materials. Whenever possible, reuse materials for multiple experiments. For example, activated charcoal or sand can be reused for future demonstrations.

For the fourth exercise, plastic should be avoided (use recycled paper or digital resources for maps). If a field trip is organized, encourage the use of eco-friendly transportation (cycling, walking, or carpooling) to reduce the carbon footprint.

Module 6: Environment and sustainable sailing



Summary:

This module will help participants to gain an understanding of the importance of preserving aquatic habitats, identify the factors that put these habitats at risk, and learn methods for protecting these ecosystems. By examining ecosystem services, participants will develop an ecological perspective on sailing. The module will explore the potential negative impacts of sailing and investigate ways to mitigate these impacts, ultimately defining sustainable sailing practices.

Activities of this module include the following exercises: Find Yourself in Nature; Pollution Hunters; Sailboats for Nature.

Given that this module directly addresses the connection between sailing and its potential environmental impact, all exercises within it are designed to be conducted sustainably. The exercises are digitized where

possible, and to the greatest extent include being in nature and active discussion of the participants about the positive and negative impacts of certain activities on various environmental mediums. If the exercise requires the use of certain materials, the use of materials that the EcoHub team has used for many years to conduct various environmental workshops is provided.

Module 7: Understanding and Creating Technology



Summary:

This module shows students how technology works. What needs to be done so that computer games work and robots move autonomously and a 3D printer makes objects? Starting with coding without computers then moving to coding with blocks and other objects (e.g. arrows) and finishing with physical computing and 3D design, children will get a crash course in dealing with technologies “behind the scenes” - they will be beamed from being merely the users of technology to its creators.

Activities of this module include the following exercises: ‘Navigate Me’ game; Open coding and game scenarios; 3D Desing.

For the first exercise, when creating the matrix outdoors, prioritize natural and reusable materials like branches, stones, or leaves instead of chalk or disposable items. If the game is conducted indoors, use reusable boards, markers, or laminated materials that can be reused for future activities instead of paper or plastic boards. Also, ensure the scenarios used in the game promote environmental themes such as recycling, energy conservation, biodiversity preservation, navigating through polluted areas to collect waste or promoting renewable energy solutions. Use the game development process to discuss resource-efficient design and the environmental impact of digital media.

For the second exercise, encourage participants to design coding projects centered on pressing environmental challenges like marine pollution, renewable energy solutions, or habitat restoration, such as tracking carbon footprints or optimizing resource use. Conduct coding exercises on devices set to energy-saving modes, minimizing processing power and energy consumption, and ensure that all devices are shut down properly after use.

For the third exercise, if possible, use 3D printers that support recycled plastic filament to minimize resource consumption and align with circular economy principles. Encourage designs that address sustainability, such as reusable tools, eco-friendly sailing equipment, or devices that promote conservation efforts. Also, prioritize the use of digital resources, such as e-manuals, online tutorials, and simulation tools, to reduce reliance on printed materials.

Module 8: Marine robotics and applications to sailing



Summary:

This module will introduce the general field of marine robotics and applications using practical examples. The focus will be in the robots and technologies that can be applied to sailing such as Remotely Operated Vehicles (ROVs), buoys and Autonomous Surface Vehicles (ASVs). As well, and given the sustainability component of the project, examples of marine robots engaged in environmental protection will be provided. Participants will be able to learn how to pilot an ROV and perform inspections in a similar fashion to what can be done for a sailing boat hull inspection.

Activities of this module include the following exercises: Using marine robots for environmental monitoring and protection; Remote piloting an ROV.

For the first exercise, use case studies that demonstrate how marine robots have positively impacted ecosystems, such as oil spill mitigation or underwater clean-ups. Where possible, simulate environmental monitoring tasks (e.g., virtual garbage collection) to minimize additional environmental impact while fostering learning. Highlight the role of energy-efficient designs and renewable power sources (e.g., solar or wind energy) in marine robotics and encourage participants to explore these options in their projects. Use modular and reusable parts for robotics to align with the principles of the circular economy, ensuring minimal waste during assembly, testing, and maintenance.

For the second exercise, highlight the ROV's use of long-lasting, rechargeable batteries, emphasizing sustainable energy practices as part of the learning process. Combine technical skill development (e.g., piloting ROVs) with discussions on how these tools can support marine conservation efforts, such as removing underwater debris or studying climate change impacts on marine life. Prioritize the use of digital resources, such as e-manuals, online tutorials, and simulation tools, to reduce reliance on printed materials.

Conclusion

The "Sustainability Guide for Schools and Clubs implementing SailingIntoSTEAM course" document provides a detailed insight into the modules developed to implement the course and the ways for their sustainable implementation. Both sailing and STEAM sciences have a strong connection with sustainability and sustainable development. The aim of the course itself is to, among other things, teach participants about the importance of environmental protection and compliance with rules related to reducing pollution and the negative consequences of climate change. This document provides that the course itself be maximally sustainable and that all exercises within it are implemented in a way that preserves nature and the environment that the necessary resources are rationally used.

This document primarily serves to sustain the implementation of the SailingIntoSTEAM course, but given its comprehensive approach and detailed guidelines and recommendations, it can also inspire courses with a similar theme and structure and adapt them following the principles of sustainability.