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DELIVERABLE D2.3

Teacher's guide for implementing SailingIntoSTEAM course

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DELIVERABLE DATA SHEET

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Deliverable summary
The Teacher's Guide for implementing the SailingIntoSTEAM course provides a comprehensive roadmap for educators to deliver effective and engaging STEAM-based sailing instruction. The guide includes detailed lesson plans, teaching strategies, and assessment methods that align with the SailingIntoSTEAM methodology and syllabus, enabling teachers to optimize the learning outcomes of their students. It is written in Serbian and English for better dissemination.

Table of content:

Teacher's Guide for Implementing the SailingIntoSTEAM Course

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Introduction: Why Sailing and STEAM?

Welcome to the **SailingIntoSTEAM Teacher's Guide**—a hands-on and flexible resource designed to help you bring science, technology, engineering, arts, and mathematics (STEAM) to life through the exciting world of **sailing**.

This guide is meant for anyone teaching children between the ages of **7 and 12**—whether you're in a school classroom, a sailing club, a youth center, or anywhere in between. You don't need to be a scientist or a sailor. You just need curiosity, creativity, and a willingness to explore and guide.

So why sailing? Sailing is more than a sport. It's a real-world adventure filled with STEAM learning opportunities. When a boat floats, catches the wind, turns, or follows a course—it's putting science, engineering, math, and creativity into action. Sailing connects children to nature, fosters teamwork, and builds confidence through active, hands-on discovery.

Each aspect of sailing naturally links to core STEAM subjects, creating opportunities for hands-on exploration and discovery.

- **Science** – understanding wind, water, weather, and ecosystems
- **Technology** – using navigation tools, experimenting with coding, or exploring marine robotics
- **Engineering** – designing, building, and testing boats, pulleys, and mechanical systems
- **Art** – expressing ideas through sail design, drawing wind maps, and storytelling
- **Math** – measuring wind speed, calculating sail angles, and reading coordinates
- **Environmental Awareness** – observing nature, learning to care for aquatic environments, and promoting sustainability

This course is all about learning by doing. It invites students to experiment, move, discuss, build, and reflect. The modules are tailored to how young learners engage best: by playing, testing ideas, asking questions, and making sense of the world around them in a joyful way.
Whether students are experimenting with simple models in the classroom or exploring full-sized sailboats on the water, the goal remains the same: to discover the science behind sailing, deepen their connection to nature, and inspire thoughtful, sustainable action.

How Do I Use This Guide?

The guide is made to be flexible. You can adapt it to:

- A **formal classroom setting**
- A **sailing club environment**
- A **hybrid format** combining both (which is often ideal)

You don't have to use every module or activity. Instead, select the parts that best suit your learners, your location, and the time you have available. Each module includes **ideas for shorter or longer sessions**, **indoor or outdoor adaptations**.

The course is modular—meaning the units can stand alone or be combined in sequence. Each module builds toward more advanced understanding, blending basic physical science with applied engineering, creativity, and student independence.

Learning Through Exploration

This course is designed around the way children learn most effectively: through active engagement and meaningful experiences. Rather than simply receiving information, students are encouraged to:

- Observe and explore real-world phenomena
- Reflect on their observations and ask thoughtful questions
- Test ideas, adapt their thinking, and try again
- Work together and share what they discover

This inquiry-based approach develops both subject knowledge and essential skills such as communication, collaboration, and creative problem-solving. It fosters a strong sense of involvement and responsibility, helping students connect what they learn to their environment, their interests, and their everyday lives.

How It Works in Different Settings

In a Classroom

You might use this guide to supplement your lessons on nature and society, math, science, or geography—or as a full STEAM enrichment project. Most modules can be delivered indoors with simple materials. Outdoor experiments, mini-boat testing, or local field trips can add extra impact.

At a Sailing Club

You can use the modules during regular sailing sessions, for "no-wind days," or as part of a structured youth sailing curriculum. If you have access to boats, docks, and real sailing environments, you can integrate land-based learning with on-the-water experiences.

In Collaboration

The strongest outcomes come from **joint programs between schools and clubs**, where students can explore the same topic both in class and in the field. For example, a school might introduce the science of wind and then visit a club to see how sails use it. Or a club might introduce compass bearings, and the school follows up with map work and reflection.

Connecting Modules to Sustainability

Each module in the SailingIntoSTEAM course is thoughtfully linked to key concepts of environmental protection—such as energy efficiency, water conservation, biodiversity preservation, and pollution prevention. To help educators recognize these connections at a glance, we use **color-coded sustainability labels** beside relevant activities throughout the guide. These small circles correspond to specific sustainability themes and make it easier to identify how each lesson contributes to environmental awareness and action.

The sustainability labels include:

- **Energy Efficiency** – using less energy to achieve the same goals, reducing emissions and saving resources
- **Pollution Prevention** – avoiding the creation of waste and contaminants at the source
- **Water Conservation** – protecting and using water wisely
- **Preserving Biodiversity** – safeguarding species, ecosystems, and their balance
- **Minimizing Waste** – reducing, reusing, and recycling materials
- **Mitigating Climate Change** – reducing greenhouse gases and promoting carbon sinks

If you wish to learn more about these sustainability concepts and how they are integrated into the course activities, you can find the **Sustainability Guide for Schools and Clubs Implementing the SailingIntoSTEAM Course (Deliverable D2.5)** on the official project website.

This EU-funded document offers detailed recommendations for making each module environmentally responsible and fostering sustainable habits in students.

MODULE 1: NATURE OF THE WIND

Subjects: Nature and Society, Environmental Studies, Physics, Science and Technology, Mathematics, Technical Education, Visual Arts
Sailing Concepts: Wind formation, Wind measurement, Lift and air pressure, Sail and hull design, Wind energy

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. Through hands-on activities, learners will investigate how wind forms, how it behaves, and how it can be harnessed as a renewable energy source. Activities integrate mathematics, science, and engineering concepts, offering a rich, interdisciplinary approach.

Whether students are building wind-measuring tools for testing wind-powered models or exploring how different surfaces interact with wind, they are encouraged to think critically about real-world sustainability challenges and the role wind plays in our future.
Each activity aligns with the core educational philosophy of SailingIntoSTEAM: active engagement, collaborative learning, and environmental awareness.

Learning Objectives

Upon completion of this module, students will:

- Understand the nature and behaviour of wind.
- Learn how to measure wind speed and direction.
- Explore the principles of wind energy and its applications.
- Understand the basic principles of sailing physics.
- Develop awareness of the impact of wind on ecological sustainability and its role in renewable energy sources.

Key Concepts

- The nature of wind and the processes of its formation.
- Wind measurement techniques and instruments.
- Principles of using wind to propel various types of aircraft and vessels
- Wind energy and its practical applications.

Lesson Plan & Activities

Activity 1: Understanding Wind Formation

In this foundational activity, students will model how wind forms using a water tank experiment that simulates convection currents. By introducing hot and cold elements into the tank, students will visually observe how temperature differences cause movement in fluids—mirroring the way warm air rises and cool air sinks in the atmosphere. This hands-on demonstration forms the basis for understanding the invisible forces behind wind.

By the end of this activity, students will be able to:

- Explain how temperature differences cause fluid movement.
- Describe the concept of convection currents and relate it to wind formation.
- Observe and reflect on a physical model of atmospheric behavior.
- Connect their observations to real-world phenomena like wind, sailing, and weather.

Materials Needed

Educators are encouraged to use repurposed and recyclable materials in line with sustainability guidelines.

For the Mini-Demonstration – “Land vs. Water Heating” (Sea Breeze Setup):

- A desk or table lamp (with an incandescent bulb or warm LED)
- Two shallow containers (repurposed food containers or transparent bowls)
  - One filled with water
  - One filled with sand, pebbles, or dry soil
- Two small thermometers (alcohol-based or digital)
- Timer or stopwatch (optional, or use a clock)

For the Main Demonstration – “Wind in a Jar” (Convection Currents):

- Transparent water tank or repurposed aquarium
- Food coloring (preferably natural or water-based)
- Droppers or pipettes for controlled color placement
- Mesh or sieve to hold ice in place
- Ice cubes
- Large stone or heat-retentive object (preheated in hot water)
- Warm and cold water (as needed)

Sustainability Note: Use minimal water and ensure that the tank and tools are reused. Choose eco-friendly dyes and avoid single-use plastics.

- **Tip :** Reuse household containers, and limit water usage for sustainability.

Theoretical Introduction

This short discussion sets up the activity by helping students understand that wind is caused, partly, by differences in temperature. The aim is to build on their everyday experiences and guide them toward the key concept: **when warm air rises and cool air moves in to replace it, wind is created**.

1. Start with what students already know

Begin by asking a few open-ended questions:

- "Have you ever felt wind on your face? What was happening around you?"
- "What kinds of things move when there's wind?"
- "Can we see wind, or only its effects?"

Encourage a few students to share examples — like flying a kite, sailing, walking in a storm, or watching tree branches sway. You can even ask one student to blow across the paper to show air in motion.
Use this as a way to highlight that **wind is invisible, but we experience it all the time.** It's something we feel, see the effects of, and sometimes rely on — especially when sailing.

2. Introduce the core idea: warm air rises, cool air sinks

Ask:

- "Do you think the air above the sea on a sunny day is the same temperature as the air in the shade?"

Let students respond, then explain:

> "When the sun shines, it heats up land and water—but not in the same way. The land gets hot faster. The air above it becomes warm and rises. The air over the water stays cooler and heavier, so it moves in to take the place of the rising warm air. That moving air is what we call wind.."

Reinforce the concept by using a short demonstration:

Steps**:**

1. Place both containers under the lamp at the same distance.
2. Insert one thermometer in each container.
3. Leave them under the lamp for **5–10 minutes**.
4. Have students **record the temperature** from each thermometer.
5. Compare the results and ask:
    - "Which one warmed up faster?"
    - "Why do you think that happened?"

Explain**:**

"The sand and stones heat up faster than the water—just like land and sea. This is why, during the day, the air above land gets warmer, rises, and is replaced by cooler air from over the water. That creates a *sea breeze*."

3. Explain what wind really is

Help students form a working definition. Write or say:

> **Wind is air moving from high-pressure (cooler, heavier air) to low-pressure (warmer, rising air) areas.**

You might add:

> "So when we feel wind, we're actually feeling the air moving in to fill space left by rising warm air."

This is also a good moment to make a link to why the Earth's surface doesn't heat up evenly — due to things like sunlight, shade, water, or land — which sets these movements in motion.

4. Frame the experiment as a way to see the invisible

Tell the class that in the upcoming activity, they'll use a water tank to make this invisible process visible.

> "Because we can't see air, we're going to use water and food coloring to model what happens when warm and cool air masses meet. Water behaves in a similar way to air when it comes to temperature."

Ask students:

- "What do you think will happen when we place something hot and something cold in opposite parts of the tank?"
- "Where do you think the colored water will go — up or down?"

Let students share ideas or draw simple sketches of their predictions.
Encourage them to think and observe like young scientists — watching the movement of colors in the tank and trying to connect it to how wind works in nature and in sailing.

Experiment: Visualizing Air Currents Using Water

This activity can be carried out in both classroom and sailing club settings with simple adaptations. The steps below walk you through the core process. Allow space for students to observe carefully, describe what they see, and connect the results to what they've learned.

Estimated Total Time: 35–40 minutes

Step 1: Setup and Predictions (5–10 minutes)

Before starting, make sure the tank is filled with room-temperature water and placed on a stable surface where everyone can see. If possible, elevate the tank slightly or use a projector or camera to make the view accessible for all students.

Ask students to revisit their earlier predictions:

- "What do you expect to happen when warm and cold objects are placed on opposite sides of the tank?"
- "Which color do you think will rise? Which one will sink?"
- "What might this tell us about how wind begins?"

Invite a few students to briefly share their predictions out loud or draw them in their notebooks.

Step 2: Conduct the Experiment (10–15 minutes)

Begin by calmly and clearly walking the students through each step as you demonstrate it — or assign the steps to small student groups if doing it in parallel setups.

1. **Place the ice cubes in a mesh or sieve** on one side of the tank. Explain this represents a *cold air mass* or a *cold front*.
2. **Carefully place the preheated stone** on the opposite side. Let students know this simulates a *warm air mass* or *warm front*.
3. **Use droppers to add a few drops of food coloring**:
    - One color near the cold side (e.g., blue)
    - A different color near the warm side (e.g., red or yellow)

Encourage the students to stay quiet for a moment and **watch carefully**. Let the movement of the colored water speak for itself.

Step 3: Observation and Discussion (10–15 minutes)

Once the colors begin to move, invite students to describe what they notice.

Ask guiding questions:

- "Which color started to rise? Which one sank?"
- "Can you see any circular movement forming in the water?"
- "What does this show us about how warm and cold air behave in the atmosphere?"
- "How does this relate to wind?"

Allow students to compare their predictions to the actual outcome. Some may revise their thinking. Encourage open discussion and don't rush to correct—help them reason through their observations.

Teacher tip: Reinforce vocabulary as students speak — e.g., "Yes, what you're seeing is a convection current!" or "Exactly — that's the denser, cooler water sinking."

Activity 2: Exploring Bernoulli's Principle (Ping Pong Ball and Hairdryer)

In this engaging demonstration, students will explore **Bernoulli's Principle**—the scientific explanation behind how air pressure changes with the speed of airflow. Using everyday objects like a ping pong ball and a hairdryer, this activity helps students visualize how faster-moving air creates areas of lower pressure, which plays a key role in how sails generate lift and move a sailboat forward. This principle is foundational not only to sailing but also to flight and fluid dynamics.

By the end of this activity, students will be able to:

- Explain that faster-moving air results in lower air pressure.
- Observe how airflow can cause lift and movement.
- Relate Bernoulli's Principle to sailing and how sails work.
- Develop curiosity about the invisible forces that influence movement and direction in nature and sports.

Materials Needed

- Thin paper strips (about 1 cm wide, 10–15 cm long) — one per student
- Ping pong balls (preferably used or repurposed)
- Hairdryer (preferably with a "cool" setting or low heat)
- Optional: Funnel or tube attachment for hairdryer to focus the airflow
- Wooden beam with attached circular metal clamps simulating an obstacle course

Sustainability Note

Encourage reuse of materials:

- Use old ping pong balls or lightweight alternatives.
- Choose hair dryers that are already available at the club or school.
- Avoid waste by storing the setup for repeated demonstrations.

Theoretical Introduction

Engage Students' Experience
Ask:

- *"Have you ever stuck your hand out of a moving car window?"*
- *"What happens when the wind blows over a curved sail?"*
- *"How do airplanes or boats seem to 'lift' when the wind catches them?"*

These questions help spark recognition of air movement and its impact on real-world objects.

Start with a simple experiment:
Hand out a thin paper strip to each student.

Say:
"Hold the paper strip just below your mouth, let it hang freely, and gently blow across the top of the strip. What do you think will happen?"

Let them try it. They will see the strip **lift upward** instead of falling down.

Ask:
"Why do you think the paper moves up even though you're blowing air over it?"

Introduce the Concept:
Explain that **air moves from high pressure to low pressure**. Bernoulli discovered that when air moves faster, it creates a zone of lower pressure. That means an object can be 'pushed' into the low-pressure zone—even if gravity tries to pull it down. When you blow across the top of the paper strip, the fast-moving air creates lower pressure above the strip, so the higher pressure below pushes it upward

Say:

- *"When wind moves quickly around a curved sail or a wing, it creates lower pressure. The higher pressure from the opposite side pushes the sail or wing into motion. That's how boats and planes move through the air!"*

Tell students they'll now see this invisible force in action.

Experiment: Ball Levitation and Navigating Airflow

Timing and Steps of the Activity

Estimated Total Time: 20–30 minutes

1. Introduction and Prediction

- Show the hair dryer and ping pong ball.
- Ask students what they think will happen if you blow air straight up and place the ball in the stream.
- Encourage them to draw or describe their predictions.

2. Demonstration

- Turn on the hairdryer and point it straight upward.
- Gently place the ping pong ball in the airstream.
- The ball should float, suspended in the fast-moving air.
- Slowly tilt the hairdryer and let students observe how the ball stays inside the airflow, even at an angle.
- Ask follow-up questions:
  - *“Why doesn’t the ball fall?”*
  - *“Where is the pressure higher: inside or outside the fast-moving air stream?”*

3. Hands-On Challenge: Navigating the Polygon (10 minutes)

Invite students to apply what they’ve learned by guiding the ping pong ball through a simple obstacle course.

- Show the wooden beam with attached circular metal clamps simulating an obstacle course (polygon).
- Challenge students to use the hairdryer’s airflow to move the ping pong ball through the clamps without letting it fall.
- Allow them to take turns adjusting the angle and distance of the hairdryer to steer the ball.

Ask guiding questions as they experiment:

- *“How do you need to tilt the hairdryer to move the ball left or right?”*
- *“What happens if you move the hairdryer closer or farther away?”*
- *“How does the speed of the air affect control?”*

This challenge encourages critical thinking, experimentation, and teamwork as students apply Bernoulli’s Principle to solve a playful, hands-on problem.

4. Observation and Reflection (5–10 minutes)

- Discuss what students saw.
- Link the behavior of the ping pong ball to wind moving over sails:
  - *“When wind moves quickly along one side of the sail, it lowers the pressure on that side. The pressure difference helps push the boat forward.”*

Learning Focus

- Understand that faster-moving air creates lower pressure.
- Connect airflow and pressure to lift and movement.
- See Bernoulli's Principle in action with simple, relatable materials.

Safety Considerations

- Always supervise the use of electrical equipment.
- Use the "cool" setting on the hairdryer where possible.
- Ensure students do not place fingers near the airflow intake or grill.
- Maintain a clear area around the demonstration space.

Adaptation Tips

General Recommendations:

- Make this a quick, high-impact demo between two longer activities.
- Encourage students to test other lightweight objects and compare behavior.

Activity 3: Measuring Wind (Wind Vanes and Anemometers)

In this hands-on activity, students will build simple tools to measure wind direction and speed—two essential skills for sailors and scientists alike. By constructing wind vanes and anemometers using recycled materials, students will develop a functional understanding of how wind is observed and recorded, and why this information is important for navigation, safety, and environmental awareness.

By the end of this activity, students will be able to:

- Build and use a wind vane to determine wind direction.
- Build and use an anemometer to estimate wind speed.
- Describe how wind direction and wind speed are measured and why both are important for sailing.
- Recognize how sailors and meteorologists use wind data in decision-making.

Materials Needed

Encourage the use of recycled and low-impact materials wherever possible:

- Cardboard (e.g., cereal boxes, packaging)
- Plastic straws
- Paper cups or small yogurt containers
- Push pins, thumbtacks, or paper fasteners
- Pencil with eraser or wooden dowel
- Plastic bottles or aluminum cans (cut with care)

- Scissors
- Markers for labeling
- Compass (optional for orientation)
- Stopwatch (for counting spins)

Optional materials for advanced anemometer variant:

- Small DC motor
- 3D-printed blades (or lightweight plastic blades)
- Voltmeter or multimeter
- 9V battery
- plastic tube/handle

Theoretical Introduction

Engage Students' Experience Begin with a few thought-provoking questions:

- *“How do we know which way the wind is blowing?”*
- *“Why might it be useful to measure how fast the wind is moving?”*
- *“What would happen if sailors couldn’t tell the wind direction?”*

Invite students to share experiences feeling wind or using weather apps. Explain that being able to measure wind direction and speed is essential for predicting weather and planning safe, efficient sailing.

Introduce the Concept
Explain that a **wind vane** shows the direction the wind is coming from, while an **anemometer** is used to measure how fast it is blowing. These tools are critical for sailors and scientists. In this activity, students will learn how to build and use both.

Clarify the Purpose
Let students know they will become “wind detectives,” using their homemade tools to gather and interpret wind data. Ask them:

- *“What do you think will make the anemometer spin faster?”*
- *“How could you tell where the wind is coming from just by looking at a flag or your hair?”*

Experiment: Measuring Wind with Handmade Tools

This activity can be conducted in both classroom and sailing club settings with minimal adjustments. The instructions below apply universally, but recommendations for adapting the activity to each environment are listed after the main steps.

Estimated Total Time: 45–60 minutes

1. Introduction and Setup (5–10 minutes)

- Review learning goals and materials.
- Brainstorm how wind affects sailing and why sailors need to understand wind direction and speed.

2. Wind Vane Construction (15–20 minutes)

- Cut out an arrow and tail from cardboard.
- Attach to a straw or stick with a push pin so it spins freely on a pencil eraser or wooden dowel.
- Insert the pencil into a stable base (bottle, can, or cup filled with sand or pebbles).
- Label the cardinal directions (N, S, E, W) using a compass or local landmarks.

3. Anemometer Construction (Basic and Advanced Options) (20–25 minutes)

Option A: Basic Cup Anemometer

- Attach four small paper cups to the ends of two crossed straws.
- Pin the straws through the center to spin freely atop a pencil or dowel.
- Blow across the cups, in front of the fan or place in a breezy area and count rotations in 10 seconds.
- This version allows students to estimate wind speed by counting rotations over a set period of time (e.g., RPM – rotations per minute).

Option B: Advanced Anemometer with DC motor

- Attach lightweight 3D-printed blades to a 3D-printed shaft to a small DC motor.
- As wind turns the blades, the motor produces voltage that can be displayed on an LED screen of the voltmeter .
- As the wind turns the blades, the motor generates voltage, which is then translated into wind speed using a scale calibrated in RPM. This version introduces basic electronics and connects physical wind movement to digital output.

4. Testing and Observation (10–15 minutes)

- Take the tools outside.
- Use the wind vane to determine wind direction.
- Use a stopwatch to count anemometer spins and estimate wind speed.
- Compare results across student groups and note variation.

Tip: Rebuild and reuse instruments for ongoing wind observations throughout the module.

Optional - Activity 4: Wind Tunnel Experiment

In this activity, students explore how wind flows around different shapes using a pre-built wind tunnel. This experiment makes airflow visible and connects aerodynamic principles to real-life sailing, allowing students to see why the shape of sails and hulls matters in both performance and energy efficiency.

By the end of this activity, students will be able to:

- Observe how wind interacts with objects of different shapes.
- Describe airflow patterns such as lift, drag, and turbulence.
- Recognize how shape influences speed, movement, and stability in sailing.
- Apply their observations to real-world sailing and design thinking.

Materials Needed

- **Prebuilt wind tunnel** (small classroom-sized or DIY model)
- **Variety of test objects**, such as:
    - Cubes, pyramids, spheres, cones, and rectangular prisms
    - Flat paper sails in different angles or curves
    - Student-made shapes from cardboard, foil, or recycled materials

Sustainability Note: Use scrap cardboard, bottle caps, foil, reused paper, and packaging to create test shapes.

Theoretical Introduction

Before starting the experiment, guide students through a short discussion to help them understand the **why** behind the activity.

Start with a question:

- “Have you ever stuck your hand out of a moving car or felt the wind push against you when biking?”

Let students describe how it felt:

- “Was the wind pushing back?”
- “Was it easier to hold your hand flat or turned sideways?”

Explain:

- “That feeling is called drag — the wind is pushing against your hand.”
- “If you tilt your hand a bit, it feels different — sometimes it lifts. That’s called lift.”

These two forces — **drag** and **lift** — are what make sails work.
When wind moves smoothly around a sail (or any shape), it can push it forward, lift it up, or slow it down.

Designers of sailboats and airplanes study this carefully using something called a **wind tunnel** — a machine that shows how air flows.

Tell them:

- "Today, we'll use our own wind tunnel to see how wind behaves with different shapes. We'll test which shapes 'cut' through the wind easily and which ones create more resistance."

Make the connection to sailing:

- "The shape of a sail or a boat's hull changes how fast and how smoothly it moves through the water and air. This is why sail design is such a cool combination of science and creativity!"

Experiment: Testing Shapes in a Wind Tunnel

Step 1: Introduce the Wind Tunnel
Show students how the wind tunnel works. Turn on the fan and let them see the air current.
Explain that the tunnel helps us see invisible air using streamers.

Step 2: Make Predictions
Let students pick a shape to test.
Ask:

- "What do you think will happen when the wind hits this shape?"
- "Will the air move smoothly around it or get stuck?"
- "Will it wobble, fly, or stay still?"

Step 3: Run the Experiment
One at a time:

- Place the test shape inside the tunnel.
- Turn on the fan and observe what happens.
- Use streamers or tissue to show airflow.
- Ask students to watch carefully and describe what they see.

Step 4: Record Observations
Have students draw or write what they noticed:

- Which shape had the smoothest airflow?
- Which shape stayed still?
- Which shape created a lot of drag or wobbling?

Step 5: Group Reflection
Bring the group together and ask:

- **"Which shape worked best?"**
- **"Why do you think that happened?"**
- **"How would you design a good sail now?"**

Assessment Ideas

- Ask students to choose the best-performing shape and explain why.
- Have them draw airflow around two shapes.
- Let them suggest a new shape to test next time and predict how it might behave.

Real-World Sailing Connection

- "When wind flows over a curved sail, it creates **lift** — helping the boat move forward."
- "If a sail is flat or too loose, it can create **drag** — slowing the boat down."
- "Sailors adjust the sail shape depending on the wind direction — just like we adjusted our objects today!"

Optional - Activity 5: Exploring Wind Energy (Wind Turbine Model)

In this practical and creative activity, students will explore how wind can be harnessed and transformed into usable energy. By building a simple wind turbine model using recycled materials, they will witness how moving air can generate electricity to power a small device—like an LED light in a model house. This activity introduces core concepts in renewable energy, mechanical-to-electrical energy conversion, and sustainability, while inviting students to become young inventors and energy explorers.

By the end of this activity, students will be able to:

- Explain how wind energy can be converted into electricity.
- Build a functioning model of a wind turbine.
- Understand the basic mechanics of how blades turn a motor.
- Recognize wind as a renewable energy source and its importance in sustainable development.

<u>Materials Needed</u>

Use recycled and repurposed materials wherever possible to align with sustainability goals:

- Cardboard (for turbine blades)
- Small DC motor (from old toys or electronics)
- Wires and clips
- LED light or small light bulb
- Recycled plastic bottle or sturdy cardboard tube (for the turbine tower)
- Skewers or wooden sticks (for support)
- Bottle caps or plastic lids (for mounting)

- Glue or eco-friendly adhesive
- Scissors or craft knife (with adult supervision)
- Small fan or natural wind source

Theoretical Introduction

Engage Students' Experience
Ask students:

- *"Have you ever seen a wind turbine in real life or in pictures?"*
- *"What do you think it does?"*
- *"How do we make electricity without plugging into the wall?"*

Let them brainstorm ways wind can be useful. Emphasize that wind isn't just for sailing—it can also power homes and even cities.

Introduce the Concept
Explain that when wind turns the blades of a turbine, it spins a small generator (like the motor we'll use). That spinning motion creates electricity, just like in large wind farms. The faster the blades spin, the more energy is produced. Today, they'll get to build their own version of a wind turbine.

Clarify the Purpose
Tell students the goal is to turn wind into electricity they can actually see—by lighting up a small LED. Ask:

- *"What shape of blade do you think will work best?"*
- *"Do you think more wind means more electricity?"*
- *"Can we use this power to do useful things?"*

Let them know they'll be experimenting, testing, and improving their own models just like real engineers.

Experiment: Building and Testing a Wind Turbine

Estimated Total Time: 45–60 minutes

1. Introduction and Planning (5–10 minutes)

- Review the purpose and show examples of wind turbines.
- Let students sketch or plan their design first.

2. Building the Turbine (20–25 minutes)

- Cut blades from cardboard and attach to a bottle cap or disk that fits the motor shaft.
- Mount the motor at the top of a tower made from a bottle or tube.
- Connect the wires from the motor to an LED.

- Secure the turbine on a base so it can stand upright.
- Ensure the blades are angled slightly for catching wind.

3. Testing and Observation (10–15 minutes)

- Use a fan or natural wind source to spin the turbine.
- Observe whether the LED lights up.
- Adjust blade shape or angle to improve performance.

4. Reflection and Sharing (5–10 minutes)

- Discuss what worked well and what could be improved.
- Compare different designs and results across student groups.

Learning Focus

- Understand how kinetic energy (wind) becomes electrical energy.
- Learn basic circuitry and mechanical principles.
- Foster creativity in design and experimentation.
- Explore sustainability through renewable energy sources.

Sustainability Note

Use recycled materials whenever possible. Encourage students to dismantle and store their turbines for future use or repurpose the components into other projects.

Tip: Use motors and LEDs from broken toys or discarded electronics to reinforce a circular approach to materials.

Implementation of the Activities Based on Available Time

This module can be completed over **2–3 sessions of 45–60 minutes** each. It is best to do it in sequence, but activities can stand alone if needed.

- 45 minutes
  Begin with Activity 1: Understanding Wind Formation. Include both the land/sea heating comparison and the convection tank demo. This forms a strong conceptual foundation.
- 90 minutes
  Add Activity 2: Exploring Bernoulli's Principle. This reinforces understanding of airflow and pressure in a fun and interactive way. Optionally begin building simple wind vanes from Activity 3.
- 3 hours
  Complete all five activities. Begin with theory and core demonstrations (Activity 1 and 2), then move on to tool-building (Activity 3), wind tunnel exploration (Activity 4), and end with the wind turbine challenge (Activity 5). Conclude with a short class discussion or exhibition of results.

MODULE 2: BUOYANCY

Subjects: Nature and Society, Environmental Studies, Nature, Physics, Mathematics, Technical Education, Visual Arts
Sailing Concepts: Floating and sinking, Water displacement, Boat design, Boat stability

This module dives into the fascinating forces that make boats float. Students will investigate why some objects sink while others stay afloat, how water pushes back on submerged objects, and how boat designers use weight distribution and shape to keep sailboats steady and safe. Using simple experiments and creative challenges, learners will bring abstract physics concepts to life.

Through building, testing, and redesigning floating models, students will gain a solid grasp of buoyancy, density, and stability—all essential for understanding how sailboats perform on water. The activities also explore the historical roots of Archimedes' Principle and its continued relevance in modern engineering and sailing.
With an emphasis on hands-on discovery and problem-solving, this module encourages students to think like marine engineers and sailors, applying their learning to both real-world sailing and imaginative boat design.

Learning Objectives

Upon completion of this module, students will:

- Understand the principles of buoyancy and density.
- Describe how water displacement determines whether an object floats.
- Explore and apply Archimedes' Principle.
- Investigate how ballast contributes to the stability of a boat.
- Design and test model boats for floating capacity and balance.

Key Concepts

- Buoyancy and the conditions for floating or sinking.
- Density and its effect on an object's ability to float.
- Water displacement and Archimedes' Principle.
- The role of ballast in maintaining sailboat stability.
- Engineering and testing floating structures.

Lesson Plan & Activities

Activity 1: Exploring Buoyancy

In this hands-on activity, students will explore the basic principles of why some objects float while others sink. They will investigate how mass, volume, density, and buoyancy work together, and how shape affects floating. Through prediction, experimentation, and discussion, students will connect real-life observations to scientific concepts.

By the end of this activity, students will be able to:

- Predict whether objects will float or sink and explain why.
- Understand how mass and volume affect an object's density.
- Describe buoyancy as an upward force caused by water displacement.
- Recognize how gravity and buoyancy work as opposing forces.
- Observe how shape can influence an object's ability to float.

Materials Needed

- Clear container or tub filled with water
- Variety of small objects (metal spoon, plastic toy, cork, apple, sponge, stone, etc.)
- Playdooh
- Chart for recording predictions and results
- Towels for spills
- (Optional) Small spring scale to estimate mass

Theoretical Introduction

1. Begin by engaging the class with a discussion

Begin by gathering students around and showing them two wooden chests (or boxes) of different sizes.
Ask:
"Which chest do you think has more volume?"
Let students guess and discuss.

Explain:
Volume is the amount of space something takes up.
Even if a large object is light, it still has a big volume because it takes up more space.
Now, take out two wooden chests of the same size.

Ask:
"Do these chests have the same volume?"
Yes — they are the same shape and size, so they take up the same amount of space.

Now ask:
"Which one do you think is heavier?"
Reveal that one chest is empty and the other is full of coins.

Explain:
This is the concept of mass — how much matter is inside an object.
The chest full of coins has more mass, even though the volume is the same.

Use a simple balance scale or lever to show the difference in mass.

- Place the empty chest on one side.
- Place the full chest on the other.
- Let students observe how the heavier (higher mass) chest lowers the scale.

Next, switch it up:
Place the smaller, full chest on one side.
Place the larger, empty chest on the other.

Ask:
"Which one is heavier now? Which one has more volume?"
Discuss how volume and mass are two separate properties, and you need both to understand whether something will float.

2. Introduce the scientific concepts:

Introduce the following concepts through simple explanations, visuals, or props:

- **Mass -** Mass is the amount of matter in an object. It tells us how heavy something is based on what it's made of. Unlike weight, mass doesn't change depending on location.
- **Volume -** Volume is the amount of space an object takes up. A large object doesn't always weigh more than a small one—it might just take up more space.
- **Density -** Density is how tightly packed the matter in an object is. It is calculated by dividing mass by volume.
  Density = Mass ÷ Volume
  If something has a lot of mass in a small volume, it's dense. If it has less mass in a larger volume, it's less dense.
- **Buoyancy -** Buoyancy is the upward force that water (or any fluid) applies to objects placed in it. This force depends on how much water the object displaces. An object floats if the buoyant force is equal to or greater than its weight.

- **Gravity and Buoyancy Together -** When an object is placed in water, two forces act on it:
    - Gravity pulls it down.
    - Buoyancy pushes it up.

If the object is denser than water, gravity wins, and it sinks. If it's less dense, the buoyant force wins, and it floats. If the forces balance, the object stays suspended.

Emphasize that shape matters—even a dense material like metal can float if its shape displaces enough water (like a boat).

Experiment: How Shape and Density Affect Buoyancy

Step 1: Make Predictions
Show students the objects. Ask: "Do you think this will float or sink?" Record their guesses.

Step 2: Test Objects
One by one, place each item in water. Observe and record whether it floats or sinks.

Step3: Test what happens when shape is changed
Have students make a solid ball using playdough - does it float?
Then, reshape it into a boat — what happens now? They'll see how shape changes buoyancy!

Step 4: Reflect and Discuss
Which predictions were correct? Why did some heavier items float? Introduce the idea that water pushes up (buoyant force), and this force depends on the amount of water moved (displaced).

Activity 2: Cartesian Divers

In this interactive activity, students will explore how changes in pressure affect an object's ability to float by building a simple Cartesian diver. This introduces the relationship between pressure, volume, and buoyancy.

By the end of this activity, students will be able to:

- Observe how pressure affects buoyancy.
- Build a simple Cartesian diver.
- Explain the relationship between air, water, and pressure.

Materials Needed

- Reused plastic bottles with caps (1 per group)
- Small pipettes or eye droppers

- Water

Sustainability Note: Use recycled bottles and reused pipettes.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Ask students:

"Can something sink and float depending on pressure?"

2. Introduce the scientific concepts:
Explain:

- A Cartesian diver floats when its air bubble is big.
- When you squeeze the bottle, pressure increases, compressing the air and making it sink.
- Releasing pressure lets it float again.

Experiment: How Pressure Changes Buoyancy

Step 1: Prepare Divers
Fill a pipette with a little water so it barely floats.

Step 2: Assemble Bottles
Fill the plastic bottle with water, insert the pipette, and close the cap tightly.

Step3: Squeeze and Observe
Squeeze the bottle. Watch the diver sink and float when the bottle is released.

Step 4: Reflect and Discuss
Ask: "What changed when we squeezed the bottle?" Help them understand that air volume changes pressure, and this affects buoyancy.

Activity 3: Archimedes' Principle in Action

In this investigative activity, students will directly test Archimedes' Principle by measuring an object's weight and how much water it displaces when submerged. They will connect theory to real-world understanding of how ships float.

By the end of this activity, students will be able to:

- Understand how displaced water relates to buoyant force.
- Measure and compare weight and water volume.
- Apply Archimedes' principle to real-world objects.

Materials Needed

- Clear measuring cups
- Kitchen scale
- Small objects: toys, rocks, plastic blocks
- Clear tank or container with water
- Ruler or tape measure
- Clear plastic cup (or similar container)
- Waterproof marker or tape

Sustainability Note: Use recycled containers and household objects.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Ask students:

"What is happening to the tub full of water when we enter it?"

Introduce Archimedes: "Long ago, Archimedes figured out that when an object is placed in water, it pushes water out of the way. The amount of water pushed out equals the buoyant force."

2. Introduce the scientific concepts:

Explain:

- Hydrostatic pressure increases with depth. Pressure on the bottom of an object is higher than on the top.
- This pressure difference results in an upward force — the buoyant force.
- The greater the volume of water displaced, the greater the buoyant force.
- If the buoyant force is greater than the object's weight, the object floats. If not, it sinks.

Experiment: Archimedes' Principle in Practice

Step 1: Weigh the Object

Use a kitchen scale to measure the dry weight of a clear plastic cup filled with rocks. Record the value.

Step 2: Measure Initial Water Level
Fill a clear tank with water and mark the starting water level using a waterproof marker or tape.

Step 3: Submerge the Object
Gently place the cup filled with rocks into the tank. Mark how high the water rises. Measure the change in water level and how deep the object is submerged using a ruler.

Step 4: Compare and Reflect
Was the object's weight more or less than the weight of the displaced water? Did it float or sink? What do the submersion depth and water level change tell us about its buoyancy and the forces acting on it?

Optional - Activity 4: Boat Design Challenge

In this creative engineering challenge, students will design and build their own small model boats using recyclable materials, testing which designs stay afloat while carrying cargo (weights). They will explore how shape, balance, and distribution of mass affect a boat's buoyancy and stability.

By the end of this activity, students will be able to:

- Apply principles of buoyancy and density in a design context.
- Experiment with different hull shapes to improve floating capacity.
- Understand how weight distribution affects stability.
- Collaborate, test, and redesign based on results.

Materials Needed

- Aluminum foil sheets
- Corks, popsicle sticks, bottle caps (optional)
- Small coins or marbles (for testing load capacity)
- Shallow tub or large basin of water
- Ruler or measuring tape
- Towels for spills

Sustainability note: use recycled packaging, corks, or reused craft materials.

Theoretical Introduction

1. **Ask students:**
    - *"What makes a boat float even though it's heavy?"*
    - *"Why do some boats tip over or sink more easily than others?"*

2. **Explain briefly:**
    - Boat designers balance weight and shape to make boats float and stay stable.
    - A boat must displace enough water to support its weight, and its shape affects how stable it is when carrying cargo.

Experiment: Build a Cargo-Carrying Boat

Step 1: Design and Build
Challenge students to build a small boat that can carry as many coins/marbles as possible without sinking. Allow them 15–20 minutes to plan and build their boats.

Step 2: Testing
Place each boat in the water and slowly add coins one by one. Count how many coins each boat holds before sinking. Record results.

Step 3: Reflection and Redesign
Ask:

- *"Why did some boats hold more coins than others?"*
- *"How did the shape affect stability?"*
- *"If you could rebuild, what would you change?"*

Optionally allow students to redesign their boats and retest to improve capacity.

Optional - Activity 5: Measuring Keelboat Stability Using a Balance System

In this investigative activity, students explore how adding weight to a keel improves a boat's stability by lowering its center of gravity. A simple model boat is used to demonstrate how increasing keel weight makes the boat more resistant to tipping. A balance system is set up, where a string tied to the mast connects to a small container on the opposite side. By gradually adding weights into the container, the force required to tip the boat is measured. This activity makes visible the relationship between keel weight and tipping force, while also showing the design trade-off between achieving stability and maintaining speed.

By the end of this activity, students will be able to:

- Understand the role of a keel in stabilizing a sailboat.
- Observe how adding weight below the waterline increases righting force.
- Recognize the trade-off between stability (safety) and speed (performance) in boat design.

Materials Needed

- Small wooden, plastic, or foam boat model
- Toothpick, craft stick, or stiff wire (to represent keel fin)
- Small screws, nuts, washers, or playdough (for keel weights)
- String or thin rope
- Pulley or smooth fixed point (to redirect string sideways)
- Small container or cup to hold weights
- Set of small weights (washers, coins, metal nuts)
- Tub or basin filled with water
- Towels for spills

***Sustainability note*:** Reuse boats, hardware, and recycled materials where possible.

Theoretical Introduction

1. Start with a discussion:
   "Have you ever seen the large fin under a sailboat? That fin is called a **keel**. The keel's job is to keep the boat balanced and stop it from tipping over when the wind pushes against the sails."
2. Explain in simple terms:
   "The keel makes the boat more stable because it adds weight below the water. This weight pulls down and helps the boat stay upright, even when the wind or waves try to push it over. It works like a counterweight."
3. Then introduce the key idea:
   "The heavier the keel, the harder it is to tip the boat over. But if the keel is too heavy, the boat becomes slower and harder to move. That's why boat designers have to find the right balance—adding enough weight to keep the boat stable, but not so much that it slows the boat down."
4. End with a clear goal:
   "In this experiment, we'll measure how much force is needed to tip a boat depending on how heavy the keel is. We'll see how adding weight makes the boat harder to tip, and we'll talk about why it's important to balance stability and speed when designing boats."

Experiment: Measuring Keelboat Stability Using a Balance System

Step 1: Prepare the boat
Attach a toothpick, craft stick, or stiff wire under the center of the boat as a keel fin. Attach an initial small nut, washer, or ball of playdough to the bottom of the keel. Place the boat in the tub of water, ensuring it floats upright.

Step 2: Set up the balance system
Tie one end of a string to the top of the boat's mast. Run the string over a pulley or a smooth fixed point positioned to the side of the tub. Tie the other end of the string to a small container that holds weights.

Explain:
"As weights are added into the container, the string pulls sideways on the mast. The amount of weight needed to tip the boat shows how much force the keel is resisting."

Step 3: Measure tipping force
Add small weights gradually into the container. Watch the boat closely. Stop adding when the boat tips over or stays tilted without returning upright. Record the total weight required to reach this tipping point.

Add another nut, washer, or piece of playdough to the keel to increase its weight. Return the boat to an upright starting position. Repeat the process: add weights into the container until tipping occurs. Record the new tipping weight.

Repeat for at least three different keel weights, measuring the tipping force each time.

Implementation of the Activities Based on Available Time

This module can be completed over **2–3 sessions of 45–60 minutes** each. Activities are designed to build on each other for deeper understanding, but they can also be implemented individually depending on time and setting.

- 45 minutes
  Begin with **Activity 1: Exploring Buoyancy**. Through simple experiments using everyday objects and playdough, students will grasp key concepts like mass, volume, density, and buoyancy. This hands-on activity lays the groundwork for understanding why objects float or sink.
- 90 minutes
  Continue with **Activity 2: Cartesian Divers**, which introduces pressure and air compression in a playful, visual way. If time allows, begin **Activity 3: Archimedes' Principle in Action**, focusing on how displaced water creates buoyant force. This pairing helps connect abstract scientific principles with real-world observations.
- 3 hours or more
  For a full and engaging exploration, combine **Activities 1 through 3**, then move on to one of the two design-based challenges—either **Activity 4: Boat Design Challenge** or **Activity 5: Keelboat Stability Experiment**. Each offers a practical application of learned concepts through problem-solving and creativity. Conclude with a class reflection or mini exhibition where students test their models, compare outcomes, and share what they've learned.

MODULE 3: Sails, Sailing and Bearings

Subjects: Nature and Society, Environmental Studies, Physics, Mathematics, Geography, Technical Education, Visual Arts
Sailing Concepts: Sail design and functionality, Wind propulsion, Basic sailing maneuvers (tacking and jibing), Navigation using bearings

This module dives into the fascinating forces that enable sailboats to harness the power of the wind and navigate the waters. Students will explore how different sail shapes capture the wind, how sailors control direction through tacking and jibing maneuvers, and how navigators use bearings to steer a precise course. Using simple experiments and creative challenges, learners will bring abstract physics and engineering concepts to life.

Through building, testing, and navigating model sailboats, students will gain a strong grasp of sail design, wind propulsion, and basic navigation—all essential skills for understanding real-world sailing. The activities also introduce the basic principles behind compass navigation and emphasize environmental responsibility by encouraging the use of recycled materials. With an emphasis on hands-on discovery, creativity, and problem-solving, this module encourages students to think like sailors and engineers, applying their learning to both imaginative challenges and real-world sailing applications.

Learning Objectives

Upon completion of this module, students will:

- Understand how sails capture and use wind energy for boat propulsion.
- Explore the relationship between sail design and sailing performance.
- Learn and simulate basic sailing maneuvers such as tacking and jibing.
- Comprehend the use of bearings and compass navigation.
- Develop practical skills in boat building, maneuvering, and navigation.

Key Concepts

- Principles of sail design and wind propulsion.
- Influence of sail shape and position on boat movement.
- Techniques for basic sailing maneuvers: tacking and jibing.
- Use of bearings and compass for navigation.
- Sustainability and creative reuse of materials in boat and sail building.

Lesson Plan & Activities

Activity 1: Sail Design and Functionality

In this hands-on activity, students will explore how different sail shapes and materials affect a boat's ability to catch the wind and move efficiently. Through design, testing, and refinement, they will develop a practical understanding of aerodynamics and engineering principles.

By the end of this activity, students will be able to:

- Identify how sail shape influences sailing performance.
- Build and test different sail designs.
- Evaluate and refine their designs based on observed outcomes.

Materials Needed

- Recycled paper, old cloth (T-shirts, curtains), reusable plastic bags, old sails
- Scissors, lightweight sticks (e.g., straws, branches)
- Boat bases (plastic bottles, cardboard, wood)
- Tape or eco-friendly glue
- Non-toxic, biodegradable paints (optional for decorating)

Sustainability Note: Use recycled and reusable materials. Encourage students to repurpose previously used items instead of using new ones.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Gather students and show them various images of sails: traditional square sails, triangular modern sails, and curved high-performance sails.

Ask: "Which sail shape do you think captures the most wind?" "Why do you think different boats use different shaped sails?"

Let students share ideas.

2. Introduce the scientific concepts:

Introduce the following concepts through simple explanations, visuals, or props:

- Wind: moving air that can exert force on surfaces.
- Lift and Forward Motion: sails redirect wind to create motion, similar to airplane wings.
- Sail Shape Efficiency: curved and triangular sails maximize efficient movement by optimizing airflow.
- Angle of Attack: the angle between the incoming wind and the sail determines lift and propulsion.

- Pressure Difference: curved sails create low-pressure zones on one side, generating forward motion.

Use diagrams to show how flat vs. curved sails affect airflow and force.

Connect this with knowledge gained in Module 1: Students should recall how wind is formed and behaves, and understand that harnessing wind energy efficiently depends not only on wind strength but also on how surfaces like sails interact with moving air.

Experiment: How Sail Shape Affects Boat Performance

Step 1: Make Predictions
Show sample sail shapes (triangular, square, curved).
Ask: "Which do you predict will move the boat furthest or fastest?"
Record their predictions.

Step 2: Building
Using recycled materials, students build boat bases.
Attach sails of various shapes and materials.
Ensure all boats are similar in size to allow fair testing.

Step 3: Testing designs
Set up a shallow tub of water or a smooth surface with fans blowing consistent air.
Place boats individually in front of the fan.
Observe distance traveled and speed.
Repeat trials for accuracy.

Step 4: Reflect and Discuss
Which sail shape moved best?
Did any surprising results occur?
What changes could improve each design?
Discuss how real-world sailboats adjust sail shapes for different conditions.

Activity 2: Using Wind for Propulsion

In this hands-on activity, students will deepen their understanding of how sailboats harness the power of the wind. They will explore how changing the angle of the sail relative to the wind affects boat speed and direction. By experimenting with model boats and adjustable sails, students will connect scientific principles to practical sailing techniques.

By the end of this activity, students will be able to:

- Explain the concept of apparent wind and its impact on sailing.
- Adjust sail angles to optimize propulsion.

- Recognize how different points of sail affect speed and control.

Materials Needed

- Boat models from Activity 1
- Small, energy-efficient fans
- Water tubs or smooth table surfaces
- Markers or tape for start and finish lines

Sustainability Note: Use recycled materials whenever possible.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Gather students and use a handheld fan or simply blow air gently toward their faces.

Ask:

"What happens when you face directly into the wind?"
"What happens if you turn sideways to the wind?"

Let students describe how the feeling of air pressure changes.

Use this to illustrate that wind's impact depends on how an object is oriented relative to its direction.

Now ask:

"Have you ever stuck your hand out of a moving car or ridden a bike fast on a still day?"
"Did you feel the air pushing against you?"

Explain:

"Even if there was no real wind blowing, moving forward made it feel like there was wind. That's because when we move, we create our own wind."

2. Introduce the scientific concepts:

True Wind:

- True Wind is the natural wind that is blowing outside — even if you are standing still.
- Example: "Imagine standing on the beach and feeling the breeze on your face. That's the True Wind."

Induced Wind

- "Induced Wind" is the wind we create by moving through the air.
- Example: "When you ride your bike on a day with no wind, the air you feel pushing against you is Induced Wind — you made it by moving!"

Apparent Wind:

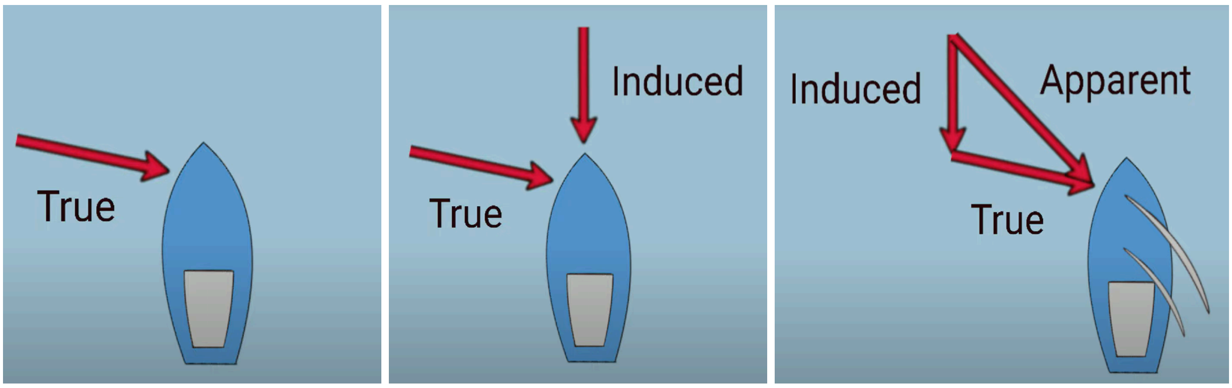
- "Apparent Wind" is what the sail actually feels: it is a combination of the True Wind and the Induced Wind.
- Sometimes the Apparent Wind feels stronger or from a different direction than the True Wind.
- It depends on how fast the boat is moving and which direction it is sailing.

Explain clearly:
- "For a sailboat, the Apparent Wind is a mix of the real wind blowing over the water and the 'wind' created by the boat moving through the air."
- "The faster the boat moves, the stronger and more forward the Apparent Wind feels."
- "That’s why sailors must always adjust their sails not just based on the real wind but based on what the boat feels — the Apparent Wind."

Use simple visuals:

Draw three simple arrows:

- One arrow showing True Wind.
- One arrow showing Induced Wind (opposite the direction of motion).
- One arrow showing Apparent Wind (the result when you combine the two).



3. Introduce Points of Sail:

Explain that depending on how the boat is turned compared to the wind, we call it different "points of sail":

- **Close-Hauled:** sailing almost into the wind (tight angle).
- **Beam Reach:** sailing with the wind hitting from the side.
- **Broad Reach:** sailing with the wind coming from behind the side.
- **Running:** sailing with the wind directly behind.

Use a simple diagram of a boat and a compass rose to show these positions.

Ask students:

- "Where do you think the boat is the fastest?"
- "Where is it the slowest?"

Lead them to discover:

- "When a boat sails slightly sideways to the wind (beam reach), it often goes fastest because it catches the wind most efficiently!"

Experiment: How Sail Angle Affects Boat Speed

Step 1: Make Predictions

Show the students the small boat models and the setup with a fan simulating wind.
Explain that they will test how different sail angles affect boat speed and direction.
Ask:

- "If the sail is facing straight into the wind, do you think the boat will move fast or slow?"
- "What if the sail is turned to the side — will it move better?"

Let students make predictions and write or draw them in their notebooks or on a class chart.
Encourage critical thinking:

- "Remember what we learned about Apparent Wind. It's not just where the True Wind comes from, but also how the boat moves and catches the wind!"
- Ask them to guess which sail position will make the boat travel the furthest.

Step 2: Set Up the Test

Place a shallow water tub (or smooth surface) with a fan positioned at one end.
Mark a starting line and a finish line.
Use boats from Activity 1 — each boat should have an adjustable sail.

Define Three Sail Positions to Test:

- Sail pulled tightly in line with the boat (small angle to the boat — "close-hauled").
- Sail opened halfway (45 degrees from center — "beam reach").
- Sail opened wide (almost 90 degrees — "running").

Explain that they will test the same boat with different sail positions while keeping wind strength constant (same fan setting).

Step3: Conduct the Tests

1. Place the first boat at the starting line with the sail close-hauled (tight to center).
2. Turn on the fan. Observe and time how long it takes to reach the finish line (or note how far it travels in a set time).
3. Repeat the same for the halfway-open sail.
4. Repeat again with the sail fully open.

Observe carefully:

- Speed: Does the boat move fast, medium, or slow?
- Stability: Does the boat sail straight, drift sideways, or spin?
- Distance: How far did it travel?

Important: Encourage students to test each position at least two times to confirm results.

Step 4: Record Observations

Use table from the Students guide

Sail Position	Speed (Fast/Medium/Slow)	Distance Traveled	Stability (Straight/Drifting)
Tight (Close-Hauled)			
Halfway (Beam Reach)			
Open (Running)			

Step 5: Reflect and Discuss

Gather the students together and ask:

- "Which sail position helped the boat move fastest?"
- "Was it easier to move with the sail fully open or halfway?"
- "Why do you think the boat sometimes went sideways or spun?"

Link back to concepts:

- Explain that when sailing close to the wind (tight sail), the boat needs a lot of skill because it fights the wind.

- When sailing with the wind from the side (beam reach), boats often go fastest because the Apparent Wind is strong and well-angled.
- When running (wind from behind), the boat moves more slowly because the Apparent Wind is reduced.

Important teacher tip:

- Reinforce that sailors must trim (adjust) their sails constantly based on Apparent Wind — not just True Wind!
- Highlight how understanding Apparent Wind helps sailors find the best sail angle for speed and control.

Activity 3: Practicing Basic Maneuvering Skills (Tacking and Jibing)

In this hands-on, kinesthetic learning activity, students will simulate tacking and jibing by practicing maneuvers inside stationary Optimist boats placed on land (on dollies, stands, or trailers). Through this practice, they will physically experience how the sail, tiller, and their own body weight work together to control direction.
Beyond sailing skills, this activity invites students to think like engineers and scientists: observing forces, predicting outcomes, testing body mechanics, and reflecting on design and function of the boat and sail. By using the boat as a "learning lab," students apply STEAM principles to real-world challenges.

By the end of this activity, students will be able to:

- Explain the physics of turning a boat (forces acting on sail, rudder, and hull).
- Demonstrate tacking and jibing maneuvers, coordinating tiller, sail, and weight shift.
- Observe and reflect on how forces act differently in tacking versus jibing.
- Collaborate and communicate during maneuvers (engineering teamwork principle).
- Connect sailing maneuvers to mechanical systems and simple machines (leverage, pulleys).

Materials Needed

- Optimist dinghies (secured on dollies, stands, or trailers)
- Fan or arrow marker to indicate wind direction
- Chalk or tape to mark ground diagram (compass rose, no-go zone)
- Whiteboard for diagrams and notes
- Whistle or bell for maneuver calls
- Optional: handheld models or diagrams of sail forces

Sustainability Note: Use existing boats and equipment; reuse chalk/tape; no disposable materials.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Gather the students around the boat.
Ask:

- "If the wind is coming from here, and we want to go over there (point in no-go zone), can we sail straight there?"
- "Why do we have to turn the boat back and forth?"
- "What happens if we turn the front of the boat through the wind? What if we turn our back through the wind?"

Encourage guesses and reasoning.
Visual aid:
Draw a simple diagram on the whiteboard of a boat zig-zagging toward the wind, showing the no-go zone.

2. Introduce the scientific and engineering concepts

Use the boat itself as a demonstration tool. Show the tiller, rudder, and mainsheet.
Explain:

- Forces on the boat:
  "When the wind pushes the sail, it makes the boat move forward, but also sideways."
  "The rudder pushes water to steer, but needs speed to work."
- Tacking:
  "When we turn the bow through the wind, we need to move the tiller, the sail, and ourselves across."
  "We use the tiller like a lever, changing the direction of the boat by redirecting force."
- Jibing:
  "When we turn the stern through the wind, the sail can swing fast, so we need to control the sheet to keep it safe."

Relate this to simple machines:

- "The tiller is like a lever."
- "The mainsheet uses pulleys to reduce force needed to control the sail."

Use diagrams to show:

- Lift on the sail
- Forces during turn
- Torque created by the rudder

STEAM Connection:
Remind students:

- "In Module 1, we learned how wind forms and behaves (science)."
- "In Module 2, we explored how boats float and balance (physics)."

- “Earlier in Module 3, we designed and tested sails (engineering, art, design).”
  “Now, we’re learning how to control a boat’s movement—combining physics, engineering, and teamwork!”

Experiment: Practicing maneuvers

Step 1: Make Predictions

Ask students:

- “Which turn will need more force on the tiller: tacking or jibing?”
- “Which turn moves the sail faster? Why might that matter?”
  Record their predictions on the whiteboard.

Step 2: Practice Tacking

Have a student sit in the boat holding a tiller and mainsheet.

1. Instructor points out wind direction (fan or marker).
2. Instructor calls:
   - “Ready about!” → Student checks surroundings.
   - “Helm’s a-lee!” → Student pushes tiller away and moves sail across.
3. Students shift body weight across the boat (simulating crossing under the boom).
4. Instructor or observer notes:
   - “Was the tiller moved far enough?”
   - “Did they center the tiller after the turn?”
   - “Did they move their weight smoothly?”

Repeat until each student practices 2–3 times.
Between repetitions, discuss what worked or what could improve.

Step 3: Practice Jibing

1. Position boat broad reach (wind behind side).
2. Instructor calls:
   - “Prepare to jibe!” → Student checks surroundings.
   - “Jibe-ho!” → Student pulls tiller toward them and quickly controls the mainsheet as the sail swings across.
3. Student shifts body safely to the new side.

Highlight:

- “Be careful of fast-swinging booms (simulate with hand/rope if no real boom).”
- “Move sail across quickly but controlled.”

Repeat multiple times.

Step 4: Record Observations

Use observation sheets or group discussion:

- How much tiller movement was needed?
- Was timing smooth between tiller, sail, and weight?
- What felt more challenging: tacking or jibing?
- Did the boat's setup (boom length, cockpit space) affect ease of movement?

Step 5: Reflect and Discuss

Gather students.
Ask:

- "What did you notice about the forces acting on the tiller and sail?"
- "Why is teamwork important when sailing a bigger boat?"
- "How does the rudder work as a lever? How does the mainsheet pulley reduce effort?"

Encourage students to connect physical experience to engineering and physics principles.

Optional - Activity 4: Navigation Basics

In this interactive activity, students will learn how to read a simple compass, understand bearings, and apply these skills by navigating a mini "treasure map" course. Through hands-on practice, they will explore the intersection of mathematics, geography, engineering, and problem-solving, developing navigational skills used by sailors and explorers.
This activity builds on earlier modules by connecting understanding of wind and movement (Module 1), balance and floating (Module 2), and sail function (Module 3) with the ability to chart a course and steer toward a goal.

By the end of this activity, students will be able to:

- Explain what a compass does and how to find cardinal directions.
- Understand bearings as angles measured from North.
- Set and follow a bearing to reach a destination.
- Navigate a simple course using a compass and bearings.

Materials Needed

- Simple compasses (or compass apps on devices)
- "Treasure maps" with bearings and distances marked
- Chalk or tape to mark compass rose and course on the ground
- Cones or objects to mark waypoints
- Small tokens or clues to collect at each stop
- Whistle or bell for signaling start/finish

Sustainability Note: Reuse maps, cones, and markers; no single-use materials.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Gather the students together.
Ask:

- "If you were out on a boat, how would you know which way to go?"
- "Have you ever seen a compass or map used together?"
- "Do you know which way is North right now?"

Let them guess or point.
Use a real compass to confirm.

2. Introduce the scientific and engineering concepts

Explain simply:

- Compass Basics:
  "A compass needle always points to the magnetic north. We use it to figure out directions: North, South, East, West."
- Bearings:
  "Instead of just saying 'go east,' sailors use numbers."
  "North is 0°, East is 90°, South is 180°, West is 270°."
  "A bearing tells us how many degrees we turn from North."

Show a simple diagram of a compass rose.

Demonstrate:

- "We line up the compass so the needle points North, then count degrees to face where we want to go."

Connect to earlier modules:

Remind students:

- "In Module 1, we learned how wind moves."
- "In Module 2, we learned how boats float and balance."
- "In Module 3, we learned how sails catch the wind."

"Today, we'll learn how to choose where we're going—and how to get there!"

Experiment: Navigating with a Compass

Step 1: Make Predictions

Ask:

- "If I give you a compass and tell you to walk 10 steps at 90°, where will you end up?"
- "What happens if you turn 180°?"

Let students predict, then test by walking straight lines on the ground.

Step 2: Practice Using the Compass

1. Hand each group a compass or app.
2. Show them how to:
    - Hold it flat.
    - Turn until the needle points North.
    - Set a bearing.
    - Walk in that direction.

Give them simple practice commands:

- "Walk 10 steps at 0°."
- "Now turn 90°—walk 10 more steps."
- "Now 180°—where are you?"

Let them physically experience turning bearings.

Step 3: Navigate a Mini Treasure Map

1. Hand each group a simple map with:
    - Starting point
    - A list of bearings and distances
    - Clues or small objects hidden at waypoints
2. The course leads them across cones or ground markers to "find the treasure."

Students must:

- Set each bearing on the compass
- Walk the distance
- Look for the next clue at the waypoint
- Continue until they complete the course

Celebrate when they complete all waypoints.

Step 4: Reflect and Discuss

Gather students together.
Ask:

- "Was it easy to follow the bearings?"
- "Did you ever drift off course?"
- "How did you figure out where to turn next?"
- "Why do sailors need to know bearings?"

Discuss:

- How wind, current, or obstacles could affect following a straight path in real life.
- How tools (compass, map, GPS) help keep a safe, planned route.

Implementation of the Activities Based on Available Time

This module can be implemented over **2–4 sessions of 45–60 minutes**, depending on your group size, available space, and whether land-based boats or outdoor navigation activities are included. While each activity builds on the previous one, they can also be used independently based on focus and time constraints.

- 45 minutes
  Begin with **Activity 1: Sail Design and Functionality**. Students will explore how sail shape and material affect performance by building simple sailboats using recycled materials. This activity introduces the core concepts of aerodynamics and sail efficiency in a fun, hands-on way.
- 90 minutes
  Combine Activity 1 with **Activity 2: Using Wind for Propulsion**. After testing sail designs, students will adjust sail angles and experiment with different "points of sail" to understand how direction and wind interaction affect speed and movement. This session works well with small fans or as an outdoor exploration on a calm day.
- 3 hours
  For a deeper learning experience, begin with Activities 1 and 2 (sail design and wind propulsion), then add **Activity 3: Tacking and Jibing Practice**. Using stationary Optimist boats or mock setups, students will physically simulate sailing maneuvers, developing coordination and understanding of how sails, rudders, and body weight interact. Finish with a short group reflection on forces and teamwork.
- 4+ hours
  Complete the full module across multiple sessions. Start with sail design and propulsion (Activities 1–2), continue with hands-on maneuvering practice in boats (Activity 3), and conclude with **Activity 4: Navigation Basics**, where students apply compass and bearing knowledge to navigate a course. Wrap up with a creative "Sailor's Challenge" combining boat building, maneuvering, and navigating.

This allows students to apply engineering, geography, and physics in a final collaborative activity or presentation.

MODULE 4: Simple machines and mechanisms on the Sailboat

Subjects: Mathematics, Physics, Engineering, Technical Education
Sailing Concepts: Boat and sailing equipment, sailing safety, tying knots, sails and boat control

Learning Objectives

Upon completion of this module, students will:

- Understand the physics behind mechanisms on the sailboat.
- Test and understand how the basics set of machines (ropes, pulleys, winches) work.
- Investigate and understand how systems could be built or combined.
- Understand how the boats are being steered and controlled.

Key Concepts

- Properties of mechanisms on the boat: purpose, materials, etc.
- Force measurement techniques and instruments.
- Principles behind the pulley and block systems
- Practical application of machines on the Sailboat.

Lesson Plan & Activities

Activity 1: Introduction to Simple Machines

In this learning activity, students will be introduced to the simple machines that exist on the sailing boat. They will investigate how the boat is controlled by using different mechanisms and systems and what force is needed to do that. Through experimentation and discussion, students will connect real-life observations to physics and engineering concepts.

By the end of this activity, students will be able to:

- Understand how physics plays its role in sailing.
- Describe the difference in force needed to lift the objects by using different systems.
- Recognize how sailing systems could be applied in different real-life situations.
- Observe the strength of different materials.

Materials Needed

- Pictures of different systems on sailboats.
- Lever (plank with appropriate support)

Theoretical Introduction

1. Start with what students already know
Begin by asking a few open-ended questions:

- "Have you ever spent time on a boat or sailboat?"
- "What kinds of simple machines or systems exist on the sailboat?"
- "How do the sails get raised?"
- "How does the boat steer?"
- "How is the boat parked and secured?"

Use this activity to get the details on what students know so far.

2. Introduce the scientific concepts:
Introduce the following concepts through simple explanations, visuals, or props:

- **Mass -** Mass is the amount of matter in an object. It tells us how heavy something is based on what it's made of. Unlike weight, mass doesn't change depending on location.
- **Force -** Force is the amount of acceleration applied to the object and its mass in order to move the object and its mass from one place to another.
- **Gravity and Force Together -** Every object have one or multiple forces act on it:
    - Gravity pulls it down.
    - Wind force directs the object into a specific direction.
        - Area of the object influences the strength of the wind force applied to the object.
    - Movement force applied to the object initiates the movement of the object opposed to the gravity and wind.

Explain: If the movement force is lower than the gravity or wind force, one cannot influence the position of the object. If the forces are in balance, then the object has a neutral position and it is not being moved around. If the applied force is higher than the wind or gravity force, then the object is being moved against the direction of the wind / gravity force.

Start from basic examples such as how to move or lift the heavy object from the ground. A lever is a simple machine where we use a bar and a point to move the object. When the force is applied on a longer side of the lever, one can move the object with ease. Ask students if they remember situations from the park when they were playing with the lever and how they influenced whether they were up or down.

Another basic example is the bicycle. Here we use feets to move the object with a significant mass from one place to another. Bicycles are a very good example since children can connect it to their previous experience. This is also a movement where wind can significantly influence the speed of movement depending on the direction of the driving. Bicycles are made out of wheels and axles. This is also a simple machine.

Then explain to the students that due to the nature of the sailboat, certain objects on the boat are either very heavy (keel) or have large areas that in the combination with the wind produce very high force. In order to influence the very high force, you need to have a way to oppose it.
By combining different systems and machines, handling of the sailboat could be much easier.

3. Frame the basic experiment as a way to understand the basic principles

Tell the class that in the upcoming activity, they'll use a lever in the park, or you can improvise the lever by using objects that already exist in the classroom, to lift each other.

> "Because we can't see the force, we're going to use different objects with different mass to see what happens and what kind of force you need to move different objects around."

Ask students:

- "What do you think will happen when we place one heavier and one lighter object on two opposite sides of the lever?"
- "Where do we need to put a lighter object, closer to the center or far away?"

Let students share ideas or draw simple sketches of their predictions. Encourage them to try and play. This will help them connect the required force and how balance is applied in sailing.

Experiment: How a Lever Helps Lift a Load

Step 1: Setup

Take students to the park in front of the classroom where there is a lever or create a similar setup in the classroom. In case this is conducted in a sailing club use plank and appropriate support for it.

Ask students to revisit their earlier predictions:

- "What do you think, what side of the plank will go up and down?"
- "How can a lighter object pull up a heavier one?"

Invite a few students to briefly share their predictions out loud or draw them in their notebooks.

Step 2: Conduct the experiment

One by one, the students should put an object or themself on the lever and compare who will go up and who will stay down. Observe and record the results.

Step3: Reflect and Discuss

Ask guiding questions:

- Which predictions were correct?

- Why were some heavier objects up even though on the other side there were lighter ones?
- How does this relate to other systems on the boat?

Encourage students to compare their notes and findings after the experiment. This exercise should help the student to critically approach their previous thinking. Encourage open discussion and don't rush to correct—help them reason through their observations.

Activity 2: Mechanical Systems on Sailboats : Pulley and Block system

In this hands-on activity students will be introduced to the concept of pulleys and blocks. Use of these are essential for making sailing and life in general easier. Through the system of pulleys and blocks objects that are heavy can be raised or moved with ease by using pure human force. In this exercise students will also get the parts of the pulley so that they can observe and understand how the pulley is being made and how it can be made.

By the end of this activity, students will be able to:

- Use pulleys to lift objects
- Craft and build their own pulleys and blocks
- Describe how pulley and block function
- Calculate what ratio and what kind of block setup is required to lift the object with certain mass

Materials Needed

- Rope
- String and toy pulleys
- Wooden or plastic frame to mimic the mast
- Different weights to simulate objects of different masses (sails, anchor, keel, etc.)
- (Optional) Sailboat pulley systems
  - 1:1, 1:2, 1:4 pulleys.

Theoretical Introduction

1. Start with what students already know

Begin by asking a few open-ended questions:

- "How does the pulley work?"
- "How do the sails get raised?"
- "For what purpose pulley can be used?"

Use this activity to get the understanding of the previous knowledge students may have.

2. Introduce the scientific concepts:

Introduce the concepts of pulleys and blocks through simple explanations, visuals, or props:

- **Pulley/Block -** is a simple machine consisting of a wheel that rotates around an axle, with a rope, cable, or belt running along its groove. It is used to change the direction of force and reduce the effort needed to lift or move heavy objects.
- **Types of pulleys:**
  - **Fixed Pulley:** Changes the direction of force but does not reduce effort.
  - **Movable Pulley:** Moves with the load and reduces the force needed.
  - **Compound Pulley:** A combination of fixed and movable pulleys for greater efficiency.
- **Pulley ratio -** is a ratio between the diameters or rotational speeds of two pulleys connected by a belt or rope. It determines how much the driven pulley will rotate in relation to the driving pulley.

Explain: Repeat the explanation on what force is required to oppose the wind or gravity force. Remember basic examples from previous activity and connect it with this one. This time around focus on how pulleys can be used to lift up the heavy objects and what force is required to do so.

3. Frame the basic experiment as a way to understand the basic principles

Prior to conducting experiments, explain to the students that through these exercises and their personal engagement they will feel the difference and how the pulleys influence the overall force needed to move the object. Force is an invisible thing hence, through the manipulation with ropes they will understand the difference.

Explain that in the first experiment they will see the difference between different ratios and how exactly the same weight that we want to lift off requires different force depending on the pulley system.

Experiment I: Which Pulley Requires the Least Force?

Step 1: Make Predictions

Show students three pulley systems (1:1, 1:2, 1:4). Ask: “Which pulley system will be the easiest one to lift the bucket full of water?” Record their guesses.

Step 2: Test pulley systems

One by one, students should test each system from 1:1 pulley system towards 1:4 system and then backwards to 1:1 to feel the difference. Observe and record what they think is the easiest system to use.

Step3: Reflect and Discuss

Encourage students to provide answer on following questions:

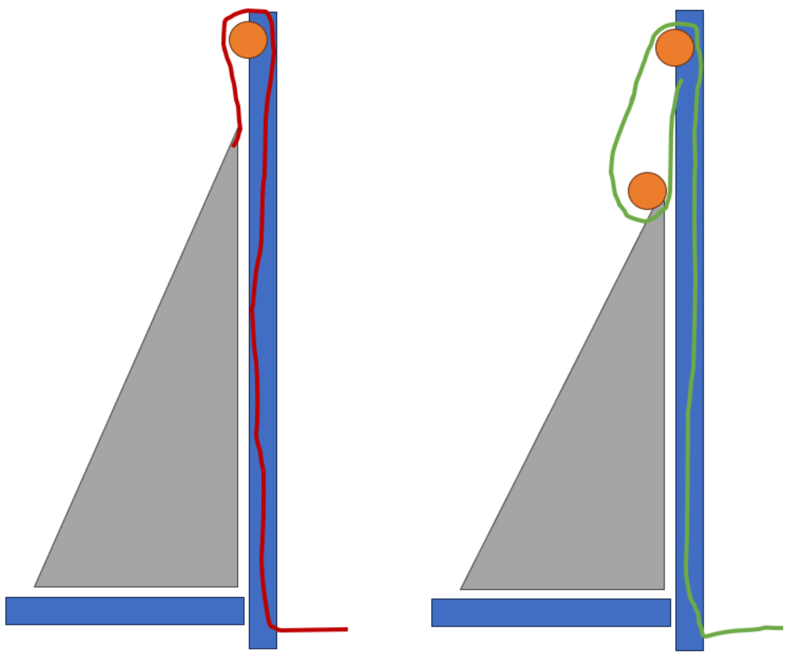
- Which predictions were correct?
- Why do certain systems require less force to raise the object?

Experiment 2: Practical Use Case from the Sailboat

In the second experiment they will see the practical use case of the pulley on the sailboat. Use heavy weight (anchor for an example) and then at least 1:1 and 1:2 systems to raise the weight. Ideally if conducted in the sailing club, the object should be sail and it should be raised to the top of the mast.

Step 1: Prepare 1:1 and 1:2 systems

Have the pulley attached to the top of the long pole. Pass the rope through it and then connect one end against the sail. Have two possibilities, one where rope goes directly from the sail to the top and down, and the other one where we have another pulley attached to the top of the sail so that we have 1:2 system, as described on following pictures:



Step 2: Raise and lower the sails

Ask every student to raise and lower the sails by using both 1:1 and 1:2 system and record the experience in the notebook.

Step3: Reflect and Discuss

Ask students:

- Which system is easier to use? Help them understand why.

Experiment 3: Build Your Own Pulley

By using rope, LEGO or other material try building your own pulley similar to one described on the picture and compare the use of each.

Step 1: Assembly the pulley

Take the two sides of material that you have (with holes on it) and put a wheel between. You should have one screw that goes through the wheel and the other one that goes above the wheel with appropriate amount of nuts between the two sides so that wheel can rotate freely.
First screw will be used as a shaft. The other will be used as distance between the two sides (not to block the wheel) and support that you can use to attach pulley to something.

Step 2: Use the pulley

Test the pulley in some real world scenarios and repeat Experiment I or 2.

Step 3: Reflect and discuss

Encourage students to reflect, discuss and contemplate around what could be improved and how.

Activity 3: Rudder and Torque Demonstration

Through this activity students should understand how the rudder is used to steer the boat. They will connect theory to the real world understanding.

By the end of this activity, students will be able to:
- What is torque
- Understand how rudder works
- How are boats and sailing boats steered

Materials Needed
- Flat cardboard or small ruler to mimic the rudder
- Small plastic container to represent the boat
- Small bassein with water

Theoretical Introduction

1. Begin by engaging the class with a discussion

Ask students:

- “How does the boat move left or right?”
- “Why does that happen?”

Ask the students to remember the answers for further reference.

2. Introduce the scientific concepts:
Explain:

- Rudder Mechanics
  - When the rudder pushes water in one direction, the boat moves in the opposite direction.
  - Angle of Attack: The rudder’s angle determines how sharply the boat turns.
- Torque & Moment of Force
  - Torque: The force applied to the rudder creates rotational movement, steering the boat.
  - The farther the rudder is from the boat’s center, the greater the turning force.

Experiment: How the Rudder and Torque Steer the Boat

In this experiment the idea is to have a small boat with rudder in the water bassein where students can see how the object behaves under which conditions.

Step 1: Make the boat

Take the plastic container and attach the ruler or flat cardboard to it. Fill in the bassein with water.

Step 2: Test the rudder

Position the rudder on the boat to the appropriate position. Set one of the positions and angles (0, 30, 45, 60, 90) of the rudder compared to the side of the “boat”. By using hands mimic the water flow and observe how the boat reacts.

Step3: Test what happens when shape is changed

Observe how the boat reacts to the change of the rudder angle. Ask students prior exercise on what they think behaviour would be and record the answer.

Step 4: Reflect and Discuss

Which predictions were correct? Why in certain case boat went to the right or to the left? Why didn't the boat steer even though we put the rudder in a non neutral position? One more time explain and connect the experiment with torque and how it affects steering:

- The water pushes against the rudder, creating a rotational force (torque).
- Since torque follows, when water is pushed in one direction, the boat moves the other way (Newton's Third Law).

Optional - Activity 4: Engineering the Winch system

In this interactive activity, students will test their engineering and implementational skills. By using toys or real elements they will make a winch system used to lift or move objects (sails, anchors, etc).

By the end of this activity, students will be able to:
- Understand how the winch functions
- Build a simple winch
- Understand for which type of activities winch can be used

Materials Needed
- Set of gears, shafts, cranks:
  - Lego technics 42074
  - items from plywood
  - etc.
- string or rope
- (Optional) two syringe (10ml and 5ml) and plastic tube

Theoretical Introduction

1. Start with what students already know
Begin by asking a few open-ended questions:

- "How does the winch work?"
- "How do the anchors and sails get raised?"
- "For what purpose can it be used?"

Use this activity to get the understanding of the previous knowledge students may have.

2. Introduce the scientific concepts:
Introduce the concepts of winch through simple explanations, visuals, or props. Winch consists out of the:

- **Gear -** toothed mechanical component that is used to transmit motion and torque between machine parts.
- **Crank -** on a winch is a crucial component that allows manual control over the winding and unwinding of the cable or rope. It typically consists of a handle attached to a rotating mechanism that engages the winch drum. When you turn the crank, it transfers rotational force through a gear system, increasing torque while reducing the effort needed to lift or pull heavy loads.
- **Gear ratio -** is a ratio between the diameters or rotational speeds of two gears that are connected. It determines how much the driven gear will rotate in relation to the driving gear.

3. Frame the basic experiment as a way to understand the basic principles

Prior conducting experiments explain to students that through these exercises and their personal engagement they will feel the difference and how the gear ratio influences the overall force needed to move or pull the object. Force is an invisible thing hence, through the manipulation with different gear they will understand the difference.

Experiment: Engineering the Winch System

Step 1: Assembly the winch

Take the two gears of different sizes and two shafts. Use drilled holes on plastic sides to pass through the shaft and connect the gear to it. Connect two gears to each other and on one of the shafts put the crank. On the other one put a drum with a string or rope.

Step 2: Use the winch

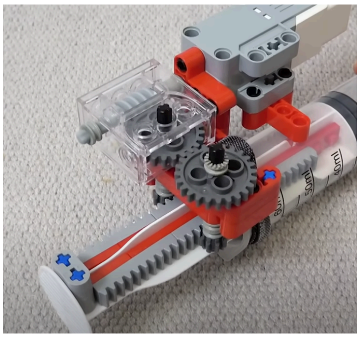
Test the winch in some real world scenarios and try to lift some heavy weight object.

Step 3: Modify gear ration

Either change the place of the drum and crank to see whether it is now easier or harder to lift a heavy weight object. Also use different gears with different ratios to improve the ease of use. Take a look at lego technic 42074 for more ideas.

Step 4: Reflect and discuss

Encourage students to reflect, discuss and contemplate around what could be improved and how.



Step 5: Expand it further and make hydraulic winch (optional)

Connect two syringes with a plastic tube and use one to control the other. It should work like a cylinder. Attach a winch to one end of the syringe so that rotation of it pumps the cylinder. This force is then passed to another syringe / cylinder. More details can be found in the following youtube video with a very interesting exercise on building a submarine: [Building a Lego-powered Submarine 4.0 - automatic depth control].

Implementation of the Activities Based on Available Time

This module is best implemented over **2 to 4 sessions of 45–60 minutes**, depending on access to outdoor spaces or sailing club equipment. While each activity builds on previous knowledge, they can also be conducted as stand-alone STEM explorations depending on your time and setting.

45 minutes
Begin with **Activity 1: Introduction to Simple Machines**. This activity focuses on real-world examples of force and leverage through the use of a lever system. Whether using a playground seesaw or a classroom setup, students will connect everyday experiences to mechanical advantage and how boats use similar systems.

90 minutes
Combine **Activity 1** with **Activity 2: Pulley and Block Systems**. Students test how different pulley configurations (1:1, 1:2, 1:4) affect the force required to lift weight. If conducted at a sailing club, they can observe or replicate real sail hoisting systems. The hands-on comparison deepens their understanding of load distribution and the benefits of mechanical advantage.

3 hours
For a more comprehensive learning session, begin with lever and pulley experiments (**Activities 1–2**) and continue with **Activity 3: Rudder and Torque Demonstration**. Using model boats, students will observe how rudder angles affect movement and understand the concept of torque. This sequence connects concepts of lifting, redirecting force, and steering.

4+ hours
For a full STEAM exploration, complete all four core activities across multiple sessions. After exploring levers, pulleys, and rudders (**Activities 1–3**), conclude with **Activity 4: Engineering a Winch System**. Students will build their own simple winches from LEGO or repurposed materials and test them with real loads. Optionally, expand with a hydraulic winch demo to introduce fluid mechanics and real-world engineering solutions. Wrap up with group reflection or a mini design challenge to test their mechanisms in lifting or moving objects, encouraging critical thinking, creativity, and engineering mindset.

MODULE 5: WATER AND ITS NATURE

Subjects: Nature and Society, Nature, Chemistry, Physics, Geography, Technical Education
Sailing Concepts: Water and sailing safety, Clean water for boats, Pollution and sailing

Learning Objectives

Upon completion of this module, students will:

- Understand the basic physical and chemical properties of water.
- Test and evaluate water samples for pH, clarity, and turbidity.
- Explore how water quality affects ecosystems, human use, and sailing.
- Reflect on environmental responsibility and propose ways to protect water sources.
- Connect water awareness to sailing activities and maritime ecosystems.

Key Concepts

- Properties of water: density, solubility, temperature
- Water quality: clarity, pH, turbidity
- The water cycle and local sources
- Human impact on water ecosystems
- The role of water in sailing and marine navigation
- Environmental stewardship and sustainability

Lesson Plan & Activities

Activity 1: Exploring Water's Properties

In this foundational activity, students will experiment with water's density, temperature, and solubility using common and reusable materials. They will observe how salt, heat, and color affect water behavior.

By the end of this activity, students will be able to:

- Identify and describe the physical properties of water.
- Observe how temperature, salt, and dyes affect water behavior.
- Explain the concepts of density and solubility through hands-on examples.
- Connect these properties to natural bodies of water and their role in sailing.

Materials Needed

- Glass or metal containers (reusable)

- Water
- Reusable ice cubes or ice mold trays
- Salt
- Natural food coloring (e.g., red cabbage)
- Thermometers

Sustainability Note: Use glass or metal containers instead of single-use plastic. Replace synthetic food coloring with vegetable-based dyes like red cabbage (which also works as a pH indicator). Use reusable ice cubes or molds to reduce waste.

Theoretical Introduction

1. Start by discussing the importance of water in everyday life and sailing.

Ask students questions like:

- "Why do you think boats can float on water?"
- "Does water always behave the same way in different conditions?"

2. Introduce the scientific concepts:

- Density: Explain how adding substances like salt can change water's density. Denser water sinks below less dense water.
- Solubility: Describe how some substances dissolve in water (like salt) while others do not.
- Temperature effects: Discuss how temperature affects the movement of particles in water. Warmer water molecules move faster, and cold water is generally denser than warm water.

Connect these ideas to sailing: understanding how water behaves helps sailors predict currents, understand buoyancy, and prepare for different water conditions.

Experiment: Hidden Properties of Water

Before beginning the steps, invite students to act as 'Water Detectives'—scientists who uncover water's hidden behaviors. Tell them they will be observing how water reacts when salt is added, when its temperature changes, or when ice is introduced. Explain that they should take notes or draw diagrams showing what happens in each setup, and compare how water acts under different conditions. This will help them visualize invisible forces like density and solubility and better understand what these properties mean in the real world of nature and sailing.

Step 1: Solubility Test

Fill a container with room-temperature water. Add a spoonful of salt and stir. Ask students to observe what happens. Explain that the salt has dissolved because it's soluble in water. This demonstrates how some substances become part of the liquid while others do not, and introduces the concept of solutions.

Step 2: Density and Temperature Test
Prepare two containers—one with cold water and one with warm water. Add a few drops of natural dye to both. Observe how the dye spreads. In warm water, it spreads quickly due to faster molecular motion; in cold water, it moves slowly and may sink. This illustrates the effect of temperature on molecular movement and diffusion.

Step 3: Ice Cube Test
Place ice cubes in a third container filled with room temperature water. Observe the floating behavior. Ask students why they think ice floats (hint: solid water is less dense than liquid water). This introduces the unique property of water expanding as it freezes.

Step 4: Salt and Ice Test
In a fourth container, dissolve salt in cold water and then add an ice cube. Compare how long the ice lasts compared to freshwater. Salt lowers the freezing point of water, changing how quickly the ice melts. This models how salinity influences freezing and melting in natural waters.

Conclude by discussing how these changes in density, temperature, and solubility affect ocean currents, layering in seas, and sailing—such as in polar regions, rivers, or saltwater seas. in a chart: which water was denser? Where did the dye go faster? How did the ice behave?

Discuss how these changes in density and temperature affect sailing—such as in polar regions or in saltwater seas.

Activity 2: Water Quality Testing

In this activity, students become young scientists as they learn to assess water quality using basic, eco-friendly tools. They will examine different water sources by testing parameters such as pH, turbidity, and conductivity. Students will use their senses and simple instruments to evaluate which water might be suitable for drinking, marine life, or sailing—learning firsthand how these indicators affect both ecosystems and sailing condition

By the end of this activity, students will be able to:

- Test and compare water samples using simple tools.
- Understand the meaning of pH, turbidity, conductivity, and clarity.
- Evaluate water quality and discuss its impact on living organisms and sailing.
- Identify pollution and propose water protection strategies.

Materials Needed

- Water samples from multiple sources
- Digital pH meter (or pH strips)
- Transparent jars or beakers
- Magnifying glass

- Conductivity meter (optional)
- Observation sheets

Sustainability Note: Use refillable containers and digital tools. Avoid bottled water; if needed, use recycled packaging.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Ask students questions like:

- "How do we know if water is clean?"
- "What signs can we look for with our eyes, nose, or tools?"
- "Why might people who live near or use water—like those in cities or at sailing clubs—need to test its quality?"

2. Introduce the scientific concepts:

Explain that in this activity, students will become water scientists—just like professionals who monitor rivers and lakes for safety and health. Introduce the idea of "testing water like scientists do" and present real parameters used by Environmental Protection Agencies:

- **pH level**: acidity or basicity; safe drinking water is between 6.5–8.5.
- **Turbidity**: cloudiness caused by particles. Clearer water lets more light through.
- **Conductivity**: tells how many minerals or salts are present.
- **Color and smell**: unusual color or odor may indicate pollution.

Explain why these are important for ecosystems and sailors: murky water can damage boat parts, and acidic water harms aquatic life.

Experiment: Water Quality Investigation

Before beginning, explain to students that they will be using real scientific tools and methods to analyze the water they encounter in daily life. They can either collect water samples themselves or examine samples the teacher has prepared ahead of time. Make sure to include a variety: tap water, bottled water, rainwater (if available), and river or lake water. Prompt them to observe and compare these sources in terms of safety, cleanliness, and suitability for different uses.

Step 1: Collect and Observe Samples

Ask students to gather or examine pre-collected water samples from different sources. Let them pour the samples into transparent jars and observe the water with their eyes. What does it look like? Is it clear, cloudy, colored? Does it have a smell?

Step 2: Test pH
Use pH strips or a digital pH meter to test each sample. Record the values. Compare these to the safe pH range for drinking water (6.5–8.5). Discuss what extreme pH values might mean for fish or boat materials.

Step 3: Examine Clarity and Turbidity
Use magnifying glasses to inspect the water. Ask: Are there visible particles? How many? Use a scale (e.g., 1 = very clear, 5 = very murky) to rate turbidity. Discuss why murky water might be a problem for ecosystems or navigation.

Step 4: Test Conductivity (if available)
Use a digital conductivity meter to measure how much salt or dissolved solids are in each sample. Higher readings may indicate more pollution or natural mineral content. This is especially useful for understanding water from different environments.

Step 5: Discuss Sensory Indicators
Have students smell the samples. Does it smell clean? Do any have a musty or chemical odor? What could that mean?

Step 6: Compare and Reflect
Guide students to fill in a comparison chart based on all their results. Lead a discussion: Which sample is cleanest? Which would be safest for people or animals? What kind of water would you prefer for sailing?

Ask students to create a colorful comparison chart or a "Water Detective Report" where they draw or color-code results. They could mark each sample with smiley/sad faces based on cleanliness or suitability for sailing and drinking, and write one fun fact they learned about water quality.

To conclude the activity, bring the class together and ask:
- What did you find surprising about the water samples?
- Which test was the most fun or the most difficult?
- How would you explain what you learned to a friend or family member?

Encourage students to reflect on how testing water helps protect nature, people, and sailing environments. Reinforce the idea that even small observations can make a big difference when we care for the waters around us.

Activity 3: Hands-On Water Filtering

In this creative, hands-on activity, students will build their own mini water filters using natural and reused materials. They will simulate how water is cleaned through physical filtration and understand the process behind basic water treatment systems. This activity not only deepens their understanding of water pollution and sustainability but also links directly to the importance of clean water in sailing environments and daily life.

By the end of this activity, students will be able to:

- Build a water filter using natural and reused materials.
- Understand how filtration improves water clarity.
- Describe how filters simulate real-world treatment.
- Reflect on sustainability in water use for sailing.

Materials Needed

- Reused plastic or carton caps
- Cotton pads or sponge
- Sand, gravel, activated charcoal
- Dirty water (tap water + soil/leaves)
- Labels and markers

Sustainability Note: Use natural materials. Reuse containers and charcoal. Avoid synthetic filters.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Ask students:

"Would you drink water straight from a river?"

Explain that even water that looks clean may contain harmful particles. This is why many people and communities filter water before using it. Filtering helps remove visible debris and some pollutants, making water clearer and safer for use.

Introduce the materials and explain their roles in filtration, starting from those that remove larger debris to those that refine the clarity and purity of water:

- Big stone gravels: Help remove large particles and serve as the first barrier to trap twigs, leaves, and other coarse debris.
- Small stone gravels: Catch smaller solid impurities and help slow the water's movement, allowing for better filtration through the layers below.
- Sand: Removes fine particles such as dirt or silt and contributes to overall water clarity.
- Activated charcoal: Absorbs odors, discoloration, and some chemical pollutants, improving the appearance, smell, and safety of the water.
- Cotton pads or sponge: Capture very fine particles and floating impurities that have passed through the previous layers.

2. Introduce the scientific concepts:

Explain that in this activity, students will become water scientists—just like professionals who monitor rivers and lakes for safety and health. Introduce the idea of "testing water like scientists do" and present real parameters used by Environmental Protection Agencies:

- **pH level**: acidity or basicity; safe drinking water is between 6.5–8.5.
- **Turbidity**: cloudiness caused by particles. Clearer water lets more light through.
- **Conductivity**: tells how many minerals or salts are present.
- **Color and smell**: unusual color or odor may indicate pollution.

Explain why these are important for ecosystems and sailors: murky water can damage boat parts, and acidic water harms aquatic life.

Experiment: How Natural Materials Filter Water

Before beginning, explain to students that they will be building their own water filter using layers of natural materials. Let them know they are simulating how nature—and some human-designed systems—clean water by trapping larger and smaller particles step by step. Remind them to carefully observe the water before and after filtering and to think about which layers were most effective and why.

Step 1: Prepare the Filter Structure

Each group of students will use small reusable plastic or carton cups as filtering chambers. Drill a small hole on the side, near the bottom, of each cup to allow water to pass through. Insert a short piece of transparent tubing (clear hose) into each hole and seal it securely using a glue gun to prevent leakage. If working with younger students, prepare these cups and connections before class.
Place each cup in a sequence so that water flows from one to the next through the tubes. Use a larger shared container filled with "dirty water" as the starting point and connect it via transparent tubing to the first filtering cup. At the end of the filtering sequence, use another large container to collect the clean water.
This structure simulates a miniature multi-stage water treatment system and allows students to observe the filtration process step by step.

Step 2: Layer the Materials

Starting from the bottom (narrow part of the funnel), place the cotton pads or sponge first, followed by activated charcoal, sand, small gravel, and big stone gravel at the top. Each layer should be even and about 2–3 cm thick. This order ensures that larger particles are removed first, with finer filtration below.

Step 3: Pour Dirty Water

Slowly pour the prepared dirty water (tap water mixed with soil and leaves) into the top of the filter. Let it pass through all the layers naturally.

Step 4: Collect and Compare

Observe and collect the filtered water in a clean container below. Compare the clarity, color, and smell of the water before and after filtration.

Step 5: Label and Discuss
Have students label each layer and discuss its function. What role did each material play? Which layer seemed most effective?

Step 6: Repeat and Observe
Optional: Have students pour the same water through the filter a second time. Is the water even cleaner? Why might repeated filtering help?

To conclude the activity makes a connection to sailing: sailors often need to rely on limited fresh water supplies while at sea. Some boats use compact filtration systems to clean collected rainwater or stored water for use. Understanding how filtration works is also important for preserving the health of marine ecosystems that sailors depend on, and for preventing damage to boat equipment that may occur from polluted or sediment-heavy water.

Introduce students to the idea that clean water in rivers, lakes, and seas can often be judged by the presence of certain indicator species—organisms that help signal the health of a water body. For example, a healthy population of freshwater mussels or dragonfly larvae in rivers and lakes usually indicates good water quality. In coastal waters and seas, the presence of seagrass meadows and filter feeders like oysters or sea cucumbers contributes to maintaining water clarity and ecological balance. These species are essential allies in keeping the water clean and supporting a stable aquatic environment, which benefits both marine life and sailing activities.

Optional - Activity 4: Where Are the Microplastics?

In this eye-opening activity, students will explore the invisible world of microplastics—tiny plastic pieces that end up in rivers, lakes, and oceans. Through simple filtering and close observation, they'll learn how plastics break down, how they affect nature and sailing, and what we can do to reduce pollution. This activity turns students into mini marine researchers, helping them understand big environmental problems through small everyday items.

By the end of this activity, students will be able to:

- Explain what microplastics are and how they enter the water.
- Filter water and identify small plastic particles using simple tools.
- Understand the environmental impact of plastic waste.
- Suggest personal and community actions to reduce plastic pollution.

Materials Needed

- Water samples (tap, rain, or simulated samples with plastic shavings, glitter, or fibers)
- Coffee filters or natural fabric strainers
- Transparent glass jars or clear plastic containers
- Magnifying glasses or USB microscopes (optional)

- Wooden sticks or spoons for stirring
- Observation sheets or simple charts for results
- Tray or paper towel for drying filters

Sustainability Note: Use simulated samples—do not add plastic to nature. Reuse jars and natural filters. Encourage safe collection practices and avoid single-use plastic during the activity.

Theoretical Introduction

1. Begin by engaging the class with a discussion

Start with a questions:

- "Have you ever seen plastic floating in the water?"
- "What do you think happens to plastic after it breaks into tiny pieces?"
- "Why is plastic a problem for fish, birds… or even boats?"

Explain that microplastics are plastic pieces smaller than 5 mm. They come from broken toys, old clothes, packaging, and even toothpaste. Once in the water, they are very hard to clean up.

2. Introduce the scientific concepts:

Let students know that even clear water might hide pollution. They'll be acting as scientists today—filtering and examining water to find out what's really in it.

- Microplastics: Tiny bits of plastic that can be found in oceans, rivers, and even drinking water.
- Sources: Clothes (fibers), cosmetics (microbeads), broken plastic items, packaging, and litter.
- Impact on nature: Microplastics can harm fish and animals that mistake them for food.
- Impact on sailing: Floating plastics can damage boat equipment, block filters, and pollute the water sailors enjoy.

Hands-On Learning: Pollution explorers

Before you begin, tell students that today they'll become "Pollution Detectives." Their mission: to filter water, find hidden microplastics, and help protect nature.

Step 1: Prepare Water Samples

Give each group a water sample. This can be from a local source (with permission), or you can simulate pollution by mixing clean water with small plastic fragments (like cut-up straws, thread, or glitter). Make sure to label the samples.

Step 2: Filter the Water

Place a coffee filter or piece of cloth over a clean jar. Carefully pour the sample water through the filter. Let it sit until all the water has passed through.

Step 3: Dry and Examine

Remove the filter and place it on a tray or paper towel. After drying slightly, observe it using magnifying glasses or microscopes. Look for:

- Shiny bits
- Tiny threads
- Colored specks

Step 4: Record Observations

Use a simple chart to record what was found:

- Number of plastic pieces
- Type (fiber, flake, glitter, etc.)
- Color
- Possible source

Step 5: Group Discussion

Ask the students:

- "Were you surprised by what you found?"
- "Where do you think the plastic came from?"
- "What do you think happens if fish eat these pieces?"

Step 6: Take Action

Invite students to create a class pledge or "Plastic-Free Promise." Ideas include:

- Saying no to plastic straws and glitter
- Using reusable bottles and lunch boxes
- Helping with clean-up efforts
- Talking to family and friends about plastic pollution

Wrap up the activity by reminding students that even the smallest choices can help keep water clean. Whether it's picking up litter or choosing a reusable item, they have the power to protect the rivers and oceans they sail on.

Ask:

- "How would clean water help animals—and sailors?"
- "What will you do differently after today?"

Optional - Activity 5: Investigating Water Sources

In this exploratory activity, students will investigate local water sources such as rivers, lakes, or reservoirs using maps, photos, or in-person visits. They will identify how these water bodies are used, evaluate their condition, and connect them to daily life and sailing. The activity encourages environmental awareness and shows students how their actions can protect the water they sail on and drink from.

By the end of this activity, students will be able to:

- Identify and locate local water sources.
- Describe how these water sources are used in daily life and sailing.
- Reflect on environmental threats and human impact.
- Suggest ways to protect and preserve water sources.

Materials Needed

- Recycled paper or digital maps
- Notebook or worksheet for sketches and notes
- Colored pencils or markers
- Photos or videos of local water sources (optional)
- Clipboards for field trip use (optional)

Sustainability Note: Use digital resources where possible. If printed maps are used, print double-sided or reuse materials. For field trips, encourage walking, cycling, or carpooling to minimize carbon footprint.

Theoretical Introduction

1. Begin by engaging the class with a discussion
Ask students:

- “Where does our local water come from?”
- “Can you name a river or lake near your home or school?”
- “How do people use these water sources? What about sailors?”

Use a physical or digital map to point out nearby water bodies. Discuss how they support local life: drinking water, farming, fishing, swimming, and sailing. Then introduce environmental concerns such as littering, oil spills, and habitat loss.

2. Introduce the scientific concepts:

Let students know that every water body is part of a larger system and that observing even small details can reveal important information about the health of the environment. Just like scientists, they will explore how water connects places, people, and species, and how to recognize when water needs our protection.

- Watersheds: These are land areas where water collects and drains into a common outlet (river, lake, or sea). Every drop of rain eventually becomes part of a larger system.
- Human impact: Pollution from garbage, factories, and farming can enter these water systems and harm the life within.
- Indicator species: Some species help us understand water health. Frogs, dragonflies, and freshwater mussels in lakes and rivers often mean the water is clean. The absence of life can mean pollution.
- Connection to sailing: Sailboats depend on clean, navigable waters. Trash and oil spills make sailing dangerous and damage boats and nature.

Experiment – Exploration Mission

Before starting, explain to students that they will take on the role of "Environmental Explorers." Their mission is to investigate and report on the health and use of local water sources. They will observe, sketch, and think critically about what they see—or what can be seen through images and maps. Encourage them to ask: "Is this a place I would sail or swim in? Why or why not?"

Step 1: Identify Local Water Sources

Using a digital or printed map, guide students to locate and mark rivers, lakes, or reservoirs near their home, school, or sailing areas. Highlight how water flows through the region—what it connects to, and how it eventually reaches the sea.

Step 2: Observe (In Person or Through Media)

If possible, organize a short field visit to a nearby river or lake. If that's not feasible, show students photos or videos of the chosen site. Ask them to pay attention to:

- The water's appearance (clear, murky, greenish, foamy)
- The surrounding environment (trees, buildings, roads)
- Evidence of human use (boats, fishing, bridges, waste)
- Sounds (birds, running water, traffic)

Step 3: Record and Sketch

Ask students to draw a simple picture or map of the water body. They should include:

- Labels for nearby features (park, factory, boat dock, houses)
- Notes on water quality and surroundings
- A "rating" scale (1 to 5) for visual cleanliness and signs of life

Step 4: Analyze and Discuss

Bring students together to share their sketches and impressions. Use these questions to guide discussion:

- "What kinds of things did you notice in or near the water?"
- "Do you think this water is healthy? Why or why not?"

- “Would you feel safe sailing here? Swimming? Drinking the water?”

Step 5: Propose Actions

Encourage students to brainstorm small actions people can take to help protect local waters. Examples:

- Throwing away trash properly.
- Using reusable water bottles instead of plastic.
- Participating in or starting a community clean-up.
- Teaching others about pollution and its effects.

To conclude the activity, gather the students and invite them to share what they learned. Let them imagine being water detectives who followed the journey of a drop of water from a cloud, to a stream, to a river, and finally into the sea.

Ask questions like:

- “What was the most interesting thing you saw or learned today?”
- “Did anything surprise you about your local river or lake?”
- “If you were in charge of keeping the water clean, what would you do?”

End with this message:

Water is all around us—it gives life to animals, plants, and people. Even sailors need clean water for their boats and the seas they love. By noticing what’s happening in the rivers and lakes near us, we can help protect our world, one drop at a time.

Implementation of the Activities Based on Available Time

This module can be delivered over **2 to 4 sessions of 45–60 minutes**, depending on whether activities take place indoors, outdoors, or include field-based exploration. While each activity builds understanding of water's properties, quality, and impact on sailing, they can also be conducted individually based on your teaching context and goals.

45 minutes
Start with **Activity 1: Exploring Water's Properties**. Use common materials to test water's behavior under different conditions—temperature, salt, dye, and ice. This engaging, hands-on activity introduces foundational concepts like density, solubility, and the physical uniqueness of water in a fun and memorable way.

90 minutes
Combine **Activity 1** with **Activity 2: Water Quality Testing** for a full "Water Detectives" session. Students examine local or prepared water samples for clarity, pH, turbidity, and conductivity. Together, these activities encourage students to think critically about the water they use, how it's tested, and how it connects to sailing and ecosystem health.

3 hours
Add **Activity 3: Hands-On Water Filtering** to the mix. After exploring water's physical properties and testing water samples, students will design and build mini water filters using natural and recycled materials. This sequence deepens their understanding of sustainability, pollution, and water treatment while reinforcing scientific thinking and problem-solving.

4+ hours
For a full environmental exploration, complete all activities over multiple sessions. Begin with **Activities 1–3**, then add **Activity 4: Where Are the Microplastics?** to introduce the invisible threats in water systems and their impact on marine life and sailing. Conclude with **Activity 5: Investigating Water Sources**, where students explore and reflect on local rivers, lakes, or seas—via maps, photos, or field trips—and connect personal actions to water stewardship. Wrap up with a creative project such as a "Water Heroes" pledge, presentation, or a visual report that celebrates students' discoveries and proposed solutions.

MODULE 6: ENVIRONMENT AND SUSTAINABLE SAILING

Subjects: Nature and Society, Nature

Learning Objectives

- Understand the basic principles of ecosystem services;
- Recognize forms of water pollution;
- Identify examples of effective water protection practices in the region;
- Learn the principles of sustainable sailing

Key Concepts

- The Importance of Preserved Seas, Rivers, and Oceans
- Factors Affecting Marine and River Ecosystems
- Positive Impacts of Sailing on River Ecosystems

Lesson Plan & Activities

Activity 1: Sailing as a unique example of an ecosystem service

Materials needed for the activity:

- Illustration of the aquatic food web
- String, scissors, paper
- Optional: reusable plastic cups and cards on ecosystem services

Theoretical Introduction

According to the Millennium Ecosystem Assessment by the United Nations, ecosystem services are divided into the following categories:

• **Supporting Services**: These are services that support and enable all other processes in nature and are crucial for the existence of life on Earth. Examples include land formation, photosynthesis, the cycling of water and matter, habitats for species, and biodiversity.

• **Provisioning Services**: These are services that we can use directly and are essential for our survival. Examples include food, water, raw materials, fibers, fuel, genetic resources, biochemicals, and natural medicines.

• **Regulating Services**: These services regulate numerous processes in nature and contribute to natural balance. Examples include regulating air quality, climate, erosion, carbon dioxide storage, water purification, pollination, and regulating disease and pest outbreaks. Plants and their roots prevent soil erosion, and forest protection reduces erosion. Nature also helps in protecting against landslides and avalanches, purifying dirty water, and regulating species populations through predator-prey relationships. Trees and parks provide more pleasant temperatures in cities and prevent them from overheating.

• **Cultural Services**: These can be defined as non-material benefits people receive from ecosystems through recreation, aesthetic enjoyment, spiritual experiences, education, and cultural heritage. Sailing is an activity that takes place in natural aquatic ecosystems like lakes, rivers, or seas. By participating in sailing, people engage with these ecosystems for recreation, relaxation, and educational purposes.

Experiment: The Water Life Web

Description: Students form a circle and play a role-playing game, representing various organisms living in the water (fish, plankton, algae, crabs, water habitat birds, etc.). One student starts by saying: "I am an algae and produce food," and then throws a ball of string to another student who represents an organism that feeds on algae, for example, "I am a shrimp and eat algae," while holding the string. The game continues as each student introduces their role and connects by holding the string to the organism they eat or that eats them, thus building a food web.

Preserved habitats are the foundation of a healthy food web, which is a prerequisite for all recreational activities, including sailing on the sea, ocean, river, or lake. When the food web is disrupted and some species disappear, this can negatively impact the overall health of the ecosystem and reduce its ability to provide cultural services. For example, a decrease in the number of pollinators (a part of the food web) can lead to the loss of flowering species, diminishing the aesthetic value of landscapes. Therefore, maintaining the food web is indirectly important for sustaining and enhancing cultural ecosystem services.

This activity illustrates ecosystem services and the interdependence of organisms in aquatic ecosystems. By identifying with living beings, children develop empathy and awareness of underwater life forms that we usually don’t see.

Outdoors: If you're in nature, observe the environment and try to create a food web composed of the organisms around you. Look for plants, algae, insects, birds, paw prints in the soil, and so on.

Classroom: Divide the students into a circle and write the names of different species that make up the aquatic food web on small pieces of paper. Start with producers and aim to spread out as much string as possible.

Once the food web is formed, begin a conversation with students using questions like:

- What does being in nature mean to you?
- How does the web of life support sailing?

- Does sailing have any negative impacts on biodiversity?

The string can be replaced by plastic cups with species names on them. During the creation of the food chain, students will stack the cups on top of each other. When they reach a break point, they will realize that it's not a simple chain but a network of material and energy cycling— the food web.

You can also support the discussion with cards about ecosystem services.

Estimated Total Time: 35–40 minutes

Activity 2: Factors Affecting Marine and River Ecosystems

ITheoretical Introduction

Water, through its continuous circulation in the biosphere, enables the exchange of matter and information on both micro and macro levels. From physiological processes within a cell to the formation of vegetation cover patterns on Earth, water is essential for the functioning of life as we know it today.

Water pollution can be categorized based on the nature of the pollutant into:

- **Physical Pollution** (noise and vibrations, industrial and municipal waste, heat, light);
- **Chemical Pollution** (oil, heavy metals, chemicals);
- **Biological Pollution** (invasive species).

This activity continues to focus on understanding the factors that threaten biodiversity in aquatic ecosystems. It emphasizes the interdependence of species and habitats, and how different forms of pollution can disrupt this balance.

Discuss with students
Divide the students into at least three groups. Start a competition between the groups, where each team's task is to list as many examples of pollution that could arise from sailing activities as possible. The use of the internet is allowed for collaborative work, and the winning group is the one that finds the most examples in 15 minutes. The winning team should present and explain the pollution sources they identified in a discussion with all participants.

If you're outdoors: During an educational walk, try to identify as many examples of pollution in the area you are in. Ask the participants to actively engage and take notes. After the walk, discuss the following questions: Can sailing contribute to any type of pollution?

Materials:

- Notebook, pencil for participants.

Physical Pollution:

- **Plastic waste and litter**: Sailors can contribute to physical pollution by leaving garbage on the shore or in the water, including plastic bottles, food packaging, and other items.
- **Loss of equipment**: Parts of sailing equipment may end up in the water and become physical pollutants. Sometimes small pieces of equipment are "easily blown away or detached."
- **Impact on benthos and habitats**: Sailing activities, especially in shallow waters, can lead to physical damage to the seabed and habitats such as coral reefs or seagrass meadows.
- **Sedimentation and reduced light penetration**: Although not specific to sailors, general physical pollutants like sediment can reduce the penetration of light into the water, which can affect aquatic plants and organisms that rely on light.

Chemical Pollution:

- **Fuel and oil spills**: Motorboats that accompany sailing regattas or are used for support may release fuel or oil into the water, which constitutes chemical pollution.
- **Antifouling coatings**: Some coatings used on the hulls of sailboats to prevent fouling can release harmful chemicals into the water.
- **Use of detergents and cleaning agents**: Sailors may use chemical detergents when cleaning their boats, which can end up in the water.
- **Wastewater**: Discharging untreated wastewater from boats contains chemical and biological pollutants.

Biological Pollution:

- **Introduction of invasive species**: Organisms may attach to the hulls of sailboats and other equipment, being transported to new areas where they can become invasive species and disrupt local ecosystems. For example, algae or small invertebrates can be transferred from one body of water to another.
- **Spread of pathogens**: Wastewater from boats may contain pathogenic microorganisms that can contaminate water and pose a risk to wildlife and human health.
- **Impact on wildlife**: The physical presence of sailors and sailboats can disturb waterfowl and other wildlife, especially in sensitive habitats. For example, disturbances caused by boating can affect the survival of chicks.

Experiment Suitable for the Classroom, Sailing Club, or Outdoor Activities

Experiment: Visualization of Water Pollution Effects

Prepare several transparent jars with clean water:

- For **physical pollution**, add various types of small debris (paper, dry and green leaves) to one jar. Observe how the clarity of the water decreases and how the debris either floats or sinks.
- For **chemical pollution**, add food coloring to another jar. Watch how the color spreads and alters the appearance of the water.
- For **biological pollution**, this is harder to visually demonstrate without laboratory equipment. You can symbolically represent it by adding some cloudy liquid (e.g., water with a bit of soil) to a third jar and explain that it may contain invisible harmful microorganisms, spores, and eggs of foreign species, or parts of invasive plants and algae.

Discuss how this could impact the life of organisms in the water. Does it disrupt light flow, visibility when hunting, or finding a mate?

Estimated Total Time: 40–45 minutes

Activity 3: The Impact of Sailing on Birds and Mammals

Theoretical Introduction

The shores of oceans, seas, rivers, and lakes provide homes for various species of birds and mammals. For some species, these habitats are temporary resting spots during migration or places for hunting and replenishment during the summer months. To preserve the uniqueness and functionality of the nature we inhabit, we must be particularly sensitive to birds and mammals. Among these animal groups, there are often species that are crucial for maintaining the balance of the ecosystem. Such species are typically found at higher trophic levels, as they feed on carnivores of the first or second order.

When on the water, we must be especially cautious and avoid:

- **Disturbance during nesting and mating**: Approaching shorelines, rocks, and islands where birds or mammals rest, mate, or nurse their young (during such times, birds may abandon their eggs, and young animals may perish).
- **Stepping on nests**: When sailors land on small islands or rocky shores, they may unintentionally step on hidden nests.
- **Making noise**: Motorized support boats create noise that scares animals. For certain birds, mothers may permanently abandon the nest if they feel unsafe due to noise.
- **Pollution with waste**: Plastics, ropes, food scraps can end up in nature. Such waste often leads to animal suffocation as they mistake it for food. Frequently, waste becomes entangled in animals, preventing movement and feeding. Entanglement in fishing tools like nets, longlines, hooks, and ropes left unattended in the water is extremely harmful to a large number of animals.
- **Collisions with animals**: Fast boating near the shore can lead to collisions with turtles, birds landing on the water, or even young whales and dolphins.

- **Cutting river vegetation to create improvised docking stations**: This leads to the loss of shelter for birds and mammals.

Divide the participants into groups and try to identify which species of mammals and birds might be endangered by sailing activities in the Balkans.

If you're in nature (with appropriate supervision and safety measures):

- **Observation**: If it's possible to visit the shore of a river or lake, students can document the presence of various types of pollution (especially plastic waste). Discuss potential areas where bats, otters, beavers, herons, white-tailed eagles, water shrews, or any other species of mammals and birds could be endangered by one of the aforementioned types of pollution.
- **Waste collection**: Conduct a beach cleanup focusing on types of waste that can directly harm aquatic birds and mammals. Analyze the collected waste and discuss its potential impact. Safely dispose of the collected waste and, if possible, sort it for recycling.
- **When in nature, listen to the sounds of aquatic birds around you and try to identify the species. It is important not to disturb wildlife!**

Classroom Adaptation: Use images and videos depicting the effects of various types of pollution on aquatic animals, including birds and mammals. Real case studies of actual pollution incidents and their consequences on wildlife can also be used.

Some of the endangered aquatic bird species in the Balkans:

- **Yellow-legged Gull** (*Larus michahellis*) – nests on the rocky islands of the Adriatic.
- **Common Tern** (*Sterna hirundo*) – sensitive to disturbances on sandy shoals.
- **Mediterranean Cormorant** (*Phalacrocorax aristotelis desmarestii*) – critically important for the Adriatic, nests on cliffs.
- **White Pelican** (*Pelecanus onocrotalus*) – Lake Skadar and Prespa, highly sensitive to human presence.
- **Dalmatian Pelican** (*Pelecanus crispus*) – Lake Skadar, particularly sensitive during nesting season.
- **Marsh Ducks** (e.g., *Aythya nyroca* – white-headed duck) – observed on most lakes in the Balkans.
- **White-tailed Eagle** (*Haliaeetus albicilla*) – nests near large lakes, marshes, and river meanders. Very sensitive to disturbances!
- **Black Stork** (*Ciconia nigra*) – shyer than the white stork, nests in quiet, wooded areas near rivers.
- **Little Tern** (*Sterna albifrons*) – nests on gravelly shoals and sandy shores.
- **Great White Heron** (*Ardea alba*) – often seen in shallow waters, feeds on amphibians.
- **Spoonbill** (*Platalea leucorodia*) – has a distinctive spoon-shaped bill, and lives in marshy waters.

For more information on aquatic birds, check out this resource: [Coneixelriu Birds].

Some endangered mammal species living on the shores of the Balkans:

- **Otter** (*Lutra lutra*) – lives along clean river flows, feeds on fish.
- **Pine Marten** (*Martes martes*) – active near forested areas along rivers.
- **Beaver** (*Castor fiber*) – reintroduced to many parts of the Danube, builds dams and alters river flows.
- **Bats** – many species use the Danube's forested areas for feeding, as most feed on mosquitoes or larger insects. In Serbia, 31 bat species have been recorded, all strictly protected.
- **Bottlenose Dolphin** (*Tursiops truncatus*) – Adriatic Sea.
- **Mediterranean Monk Seal** (*Monachus monachus*) – extremely rare, with small populations still present in the Adriatic (especially in caves and hard-to-reach coves).

Estimated Total Time: 40–45 minutes

Activity 4: Be a Sustainable Sailor

Theoretical Introduction

This activity focuses on specific actions that individual sailors can take to reduce their negative impact on the environment and contribute to sustainability.

Reducing single-use plastic:

- Use reusable water bottles.
- Avoid plastic packaging for food and snacks
- Refusing plastic straws

Responsible waste management:

- Bring your own recycling and composting bags
- Properly dispose of waste on shore and in marinas
- Collect floating waste, set up bins or bags on boats to collect waste is from the water

Sustainable behavior on the water:

- Use environmentally friendly cleaning products for boats.
- Carefully manage oil, fuel, and engine use (if applicable).
- Respect marine life.
- Reduce water waste during washing by using special water nozzles.

Sustainable transport:

- Use sustainable modes of transport to reach sailing locations (bicycle, public transportation, train, etc.)

Supporting sustainable initiatives:

- Participate in policy-making processes for environmental protection
- Sign petitions and support environmental protection campaigns
- Take part in beach and water clean-up activities
- Support organizations promoting sustainable sailing

Education and raising awareness:

- Talk to friends and family about the state of the environment and its threats
- Share information about sustainable sailing with other sailors.

If you're in the classroom: Discuss ecological habits. Try to calculate someone's ecological or carbon footprint and discuss ways to reduce it. Try to find success stories from the world of sailing (beach or water mirror clean-up activities, waste management improvements in sailing clubs, zero-waste regattas…).

If you're in nature: Emphasize to students that they should prepare and bring their eco-friendly alternatives (metal or glass water bottles, food containers, vegetable bags, shopping bags, etc.). Allow time for students to discuss why some eco-friendly alternatives are better choices.

Estimated Total Time: 30–35 minutes

Optional - Activity 5: Sailing and Ecotourism

Theoretical Introduction

This activity highlights how sailing can be a form of ecotourism that contributes to the preservation of natural resources and supports local communities.

Sailing allows people to appreciate the natural beauty of aquatic ecosystems in a non-intrusive way. Compared to other forms of tourism, sailing, especially without the use of engines, has a very small negative impact on the environment. Through slower movement, it fosters a deeper connection with nature, which, through direct contact, also provides education about it. Ecotourism-focused sailing can benefit local communities through activities such as renting sailboats, employing local guides, and supplying food and equipment. Sailors can contribute to gathering data on the condition of marine or freshwater environments (e.g., observations of pollution, the presence of certain species) during their voyages, which can be useful for scientific research.

To make future sailors ambassadors of ecotourism, we'll give them the opportunity to try organizing promotional events!

If you're in the classroom: Set up an improvised booth showcasing sailing as a form of ecotourism. First, list the necessary materials with the students, and then discuss the benefits of sailing as an example of ecotourism.

If you're in nature: Plan an eco-regatta. Through discussion, first list what is necessary for the regatta to be environmentally friendly (answers can be found in the description of previous activities).

If you're in a sailing club: Organize an evening presentation and discussion with sailors about their experiences in different competitions. Ask students to take on the role of hosts and, at the end, select the most eco-friendly regatta.

Estimated Total Time: 40–45 minutes

Implementation of the Activities Based on Available Time

This module can be implemented over 2–4 sessions of 45–60 minutes, depending on your setting, student age group, and whether you're indoors, outdoors, or at a sailing club. While the activities are interconnected, each can stand alone if needed. Priority 1 activities lay the foundation for sustainable thinking, while others deepen understanding through observation, discussion, and creative exploration.

45 minutes
Begin with **Activity 4: Be a Sustainable Sailor**. This high-impact session introduces students to everyday actions that reduce environmental impact while sailing. Students explore sustainable choices related to plastic use, waste disposal, and eco-friendly boating habits. Ideal for classroom discussions and personal reflection.

90 minutes
Combine **Activity 4** with **Activity 3: The Impact of Sailing on Birds and Mammals**. After learning sustainable habits, students investigate how sailing activities disturb wildlife. This session can include a nature walk or classroom discussion using videos and images, encouraging empathy and awareness of biodiversity.

3 hours
For a deeper learning experience, begin with **Activities 3 and 4** to establish the connection between sailing behavior and wildlife impact. Then add **Activity 1: Sailing as a Unique Ecosystem Service**, where students build a living food web and learn how aquatic ecosystems support recreation and biodiversity. End with a short discussion or group reflection tying together empathy, systems thinking, and personal responsibility.

4+ hours
Complete the full module across multiple sessions. Begin with **Activities 3 and 4** (core sustainability and wildlife protection), continue with **Activity 1** (ecosystem services) and **Activity 2: Factors Affecting Marine**

and River Ecosystems, where students explore types of pollution and simulate their effects. Conclude with **Activity 5: Sailing and Ecotourism**, a creative and collaborative project where students design eco-regattas or present sailing as a model for sustainable tourism. This final session empowers students to become ambassadors for environmental protection in their sailing communities.

MODULE 7: UNDERSTANDING AND CREATING TECHNOLOGY

Subjects: Technical Education, Computer Science
Sailing Concepts: Sailing technology

This module shows students how technology works. What needs to be done so that computer games work 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 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.

Learning Objectives

Upon completion of this module, students will:

- Be empowered to create technology (not just use it)
- Understand fundamental principles of coding/computer programming
- Be able to code with simple commands and language (with objects)
- Be able to make simple 3D designs

Key concepts:

- Understanding coding (what is computer programming)
- Coding with simple commands (arrows in code.org)
- Coding with language (blocks in code.org)
- Programming in 3D environment (in Kodu Game Lab)
- Simple 3D design (in tinkercad.com)

Lesson Plan & Activities

Activity 1: Understanding Coding

In this activity, students will explore how technology works and what role coding (computer programming) plays in it. First, students will discuss technology and then do role playing to simulate coding without using computers or any other gadgets.

By the end of this activity, students will be:

- motivated to create technology (not just use it)
- able to understand the relationship between a coder/programmer and a program(med object)
- able to understand what is a computer program

Materials needed: paper, pencil and an object that can be considered a “treasure” for the students (in a treasure-hunt game)

Duration: 45 minutes (can be shortened or extended by making Hands-on games less or more complex and by the way they are played - all students play at once or one pair/group serves as demonstration for the rest which then repeat)

Theoretical Introduction

1. Begin by engaging the class with a discussion

Initiate discussion by asking questions like (formulation depends on students’ age):

1. What gadgets do you use? (smartphone, computer, game consoles, smart house etc.)
2. What are the differences between these gadgets respectively in how they work, what do they do, what do we use them for?
3. Who produces them? The hardware (what we can grab) and the software (what changes in the gadgets)?
4. In these gadgets/software what can be personalized/changed and what not?
5. What do we need to know to be able to do to make changes in the gadgets? Have you heard of coding (computer programming)?
6. Has somebody tried coding yet? What can be coded? Can you code LEGO blocks?

etc.

2. Introduce the scientific concepts:

Introduce the following concepts through simple explanations, visuals, or props:

- Coding: transforming your ideas into commands (“programming language”) that a computer, a robot or another software (e.g. games) can understand respectively follow to perform what you tell it to do
- Programming: using one of the programming languages to make software (and objects) perform what you tell it to do
- Coder/Programmer: A person (or artificial intelligence) who/that does coding/programming
- Programm: A set of commands written by a programmer (usually to fulfill a certain task) like a recipe is a set of commands on how to prepare food

Hands-on Learning: Coding without Computers

Game 1: Code a Boat

Work in pairs or in a group (no materials needed)

1. One partner is the "captain" and one or more partners are "boats".
2. The captain decides on a simple task for their partners "boats" to do; the simpler the task, the better, like "walk across the room."
3. Next, the captain gives their partner "boat" step-by-step instructions, also known as an algorithm, to complete the task, like "walk 3 steps in front then turn left and walk 2 steps then turn left and walk 3 steps". "Boats" need to remember that they can only do *exactly* what their coder tells them to do.
4. If one of the steps is incorrect or not specific enough, this will result in a bug in their algorithm and it will need to be redone.
5. Switch places when finished.

Coding Connection: Computers need an explicit sequence of instructions to do anything! As a result, there will be bugs and the program won't work correctly if instruction (code) is not clear enough.

Game 2: Treasure Hunt Regatta

Work in pairs or in a group (use paper, pencil and a "treasure")

1. One person hides a piece of "treasure" (this could be anything!) in an indoor or outdoor space - this is the "finish line of the regatta".
2. Then he sets obstacles that need to be overcome to find the treasure, i.e. the course that needs to be mastered to finish the race.
3. Next, the treasure hider writes out instructions explaining how to find the hidden object. The instructions need to be *very* clear so the finder knows exactly what to do - otherwise, they won't get to the treasure! Example:
   a. Go to the object X
   b. Find there A and take it with
   c. Turn into direction of Y and make 5 steps
   d. Find there B, take it with (and replace it with A)
   e. etc.
   f. Find the treasure / finish the race
4. Once the instructions are written, the finder / captains / sailors (teams) follow them exactly.
5. If instructions aren't clear enough, the hider may need to find the bug and fix it so the finder can successfully reach the treasure.

6. Switch roles when finished.

Coding Connection: The treasure finder needs very clear instructions for how to find the treasure, just like computers need very clear and concrete algorithms to execute their tasks.

More ideas on "coding without computers" to be adopted to sailing (and/or ecology) scenarios:

https://www.kodable.com/learn/unplugged-coding-activities

https://www.csunplugged.org/en/

Activity 2: Coding with simple commands

In this hands-on activity, students will learn to code by directing characters (they know from cartoons) in fields and mazes. It is done on the platform code.org with self-guided "puzzle games" developed for the Hour of Code.

By the end of this activity, students will be able to:

- Code the way of a character through a field or a maze.
- Understand that programing is telling a character/software what to do but in a different way that games are played

Materials Needed: Computer (with a computer mouse), tablet or smartphone with a browser and connected to Internet

Duration: 45 minutes (can be shortened or extended by limiting the Hands-on part)

Theoretical Introduction

Engage Students' Experience Begin with a few thought-provoking questions:

- *How do we move characters in computer games?*
- *How do they know where we want to move them? Do they see or hear what we commanded them?*
- *In a game, can we tell the character what to do in next 5 minutes or do we need to do every move for it?*
- *In a game, If we fail to complete a task and we need to do it again, can we just "tell" the character to do the same all over again or we need to repeat every move?*
- *etc.*

Explain to students (the concepts):

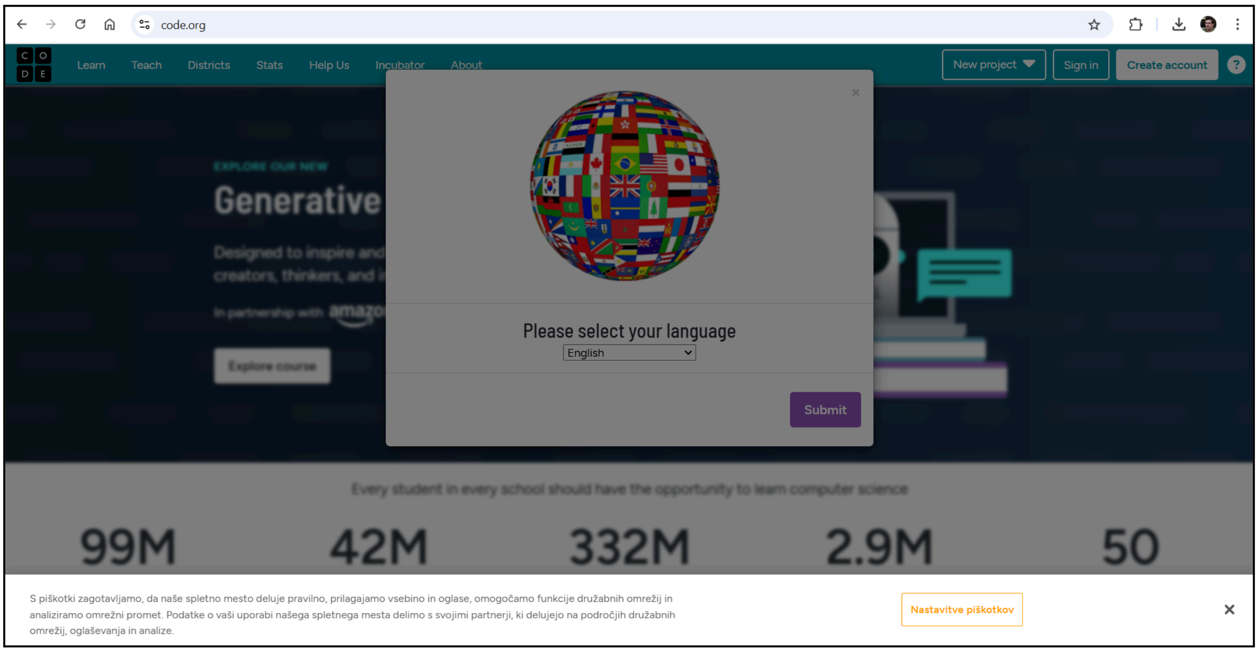
- that playing games (having direct, immediate influence on a character move by move) is different from programming (writing - a long - set of commands that a character follows, can be repeated over and over again…)
- <u>that by playing games we are (just) users of technology and by programming (games or by "hacking") we are creators of technology</u>

<u>Hands-On Learning:</u>

1. Type code.org into the search engine/row.

If you are not using code.org for the first time on your computer/browser, continue at 4. If it is the first time, proceed as follows:

2. Set cookies (click orange box) or close the "Cookie window" (click X) at the bottom of the page (see Screenshot 1)
3. Set your language (in the centre of the screen, see Screenshot 1) and click Submit.



enshot 1

4. Scroll down and click [Elementary school](#) on the purple block on the second left block of the screen (with the image of a bee).
5. Scroll down the screen to the two blocks side to side with purple buttons. Click the left one saying [Start Pre-Reader Course](#) (with the images of a dog and a unicorn).
6. Click in third line [4. Programming with Rey and BB-8](#) (with *an environmental/sustainability issue*) the circle with number 2.

7. Close (click X) the window that pops up and click anywhere to remove the shadow layer from the screen.
8. Follow the instructions - drag blue-greenish objects with arrows and drop/attach them to the blocks on the right/white part of the screen - with the goal to move the robot BB-8 over the *spots with trash (to collect it)* and hit the *trash bin in the end (to dispose all the trash that has been collected*). When you are done hit the orange button Run on the left:
   a. if you solved the task/puzzle (BB-8 collected all the trash and disposed it into the bin) hit the grey button Continue that will pop up.
   b. if you haven't solved the task/puzzle yet, click the blue button Reset on the left to try again until you succeed (and hit the grey button Continue, see a.).
9. When you have solved all (10) tasks, hit the back/left arrow on the left top of the page (to get to the previous page) and choose number 2 in another line, e.g. 3. Programming with Angry Birds and proceed with number 8. above.

More games to code/play with arrows:

- Lightbot (on computer/in browser the Flash player needs to be installed), also an app/game for mobile devices.
- Beach Cleanup (in Kodable - with *an environmental/sustainability issue)* involves also designing the path that needs to be followed/coded with arrows.

Activity 3: Coding with language (blocks)

In this hands-on activity, students will learn to code by giving language based commands to characters (they know from cartoons). It is done on the platform code.org with self-guided “puzzle games” developed for the Hour of Code.

By the end of this activity, students will be able to:

- Use (predefined) descriptive commands to programme (more than just spatial moves)
- Understand that commands need to be placed in the right order so the program does what we want it to do

Materials Needed: Computer (with a computer mouse), tablet or smartphone with a browser and connected to Internet

Duration: 45 minutes (can be shortened or extended by limiting the Hands-on part)

Theoretical Introduction:

Engage Students' Experience Begin with a few thought-provoking questions:

- *How do we move characters in computer games?*
- *How do they know where we want to move them? Do they see or hear what we commanded them?*
- *In a game, can we tell the character what to do in next 5 minutes or do we need to do every move for it?*
- *In a game, If we fail to complete a task and we need to do it again, can we just "tell" the character to do the same all over again or we need to repeat every move?*
- *etc.*

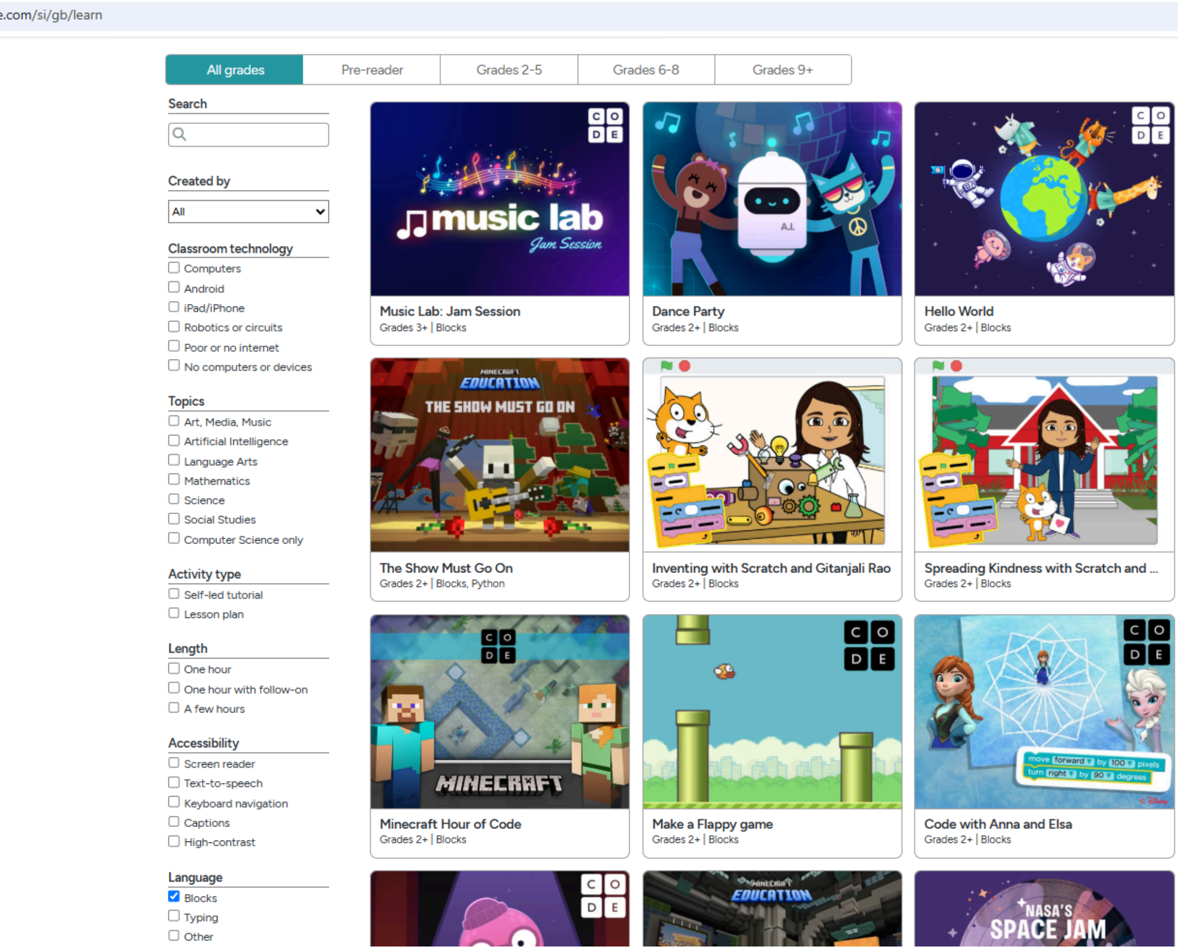
Explain to students (the concepts):

- that playing games (having direct, immediate influence on a character move by move) is different from programming (writing - a long - set of commands that a character follows and can repeat over and over again without our interference)
- that by playing games we are (just) users of technology and by programming (games or by "hacking" existing programs) we are creators of technology

Hands-On Learning: Coding on various platforms

1. Go to https://hourofcode.com
2. Choose Activities in the menu bar (and change language on the far right if you wish). In English a big variety of games to play/code with blocks will display (in other languages the selection is - much - smaller).
3. Set the parameters in the top line (Grades) and on the left (at the bottom you will find the option to choose - programming - Language: Blocks / Typing / Other, the latest includes also arrows but not only), see Screenshot 2.
4. Click on the icon of the game you want to play/code. Click the orange button Start in the window that will pop up.
5. A new page (in a new or the same tab) will open. Follow the instructions there (displayed games are produced by various providers so there are no universal instructions how to play/code with objects)

eenshot 2



Hands-On Learning 2: Coding on code.org

For the first 3 steps see above Activity 2: Coding with simple commands > Hands-On Learning. Then:

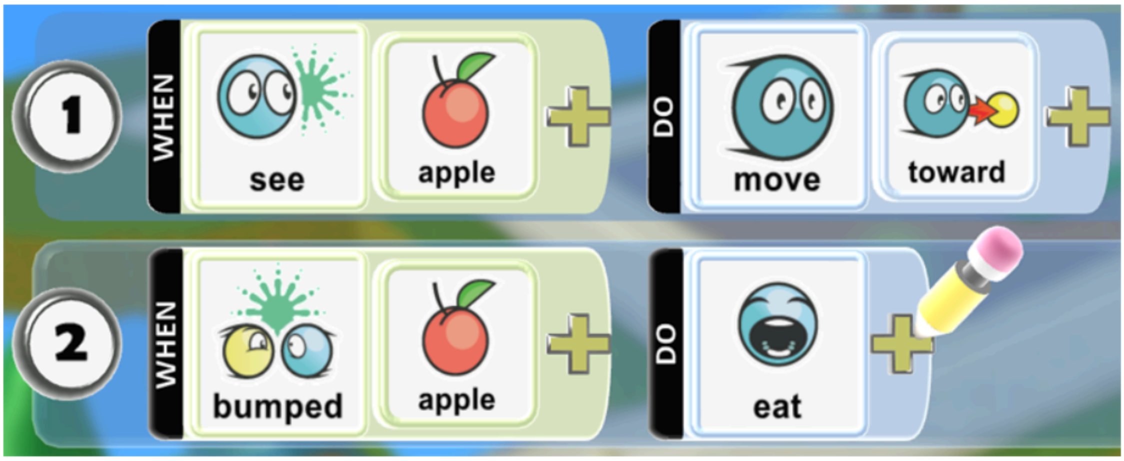
4. Scroll down and click Try the Hour of Code on the blue-greenish block on the far left of the screen (with the image of two MInecraft characters).
5. Choose Explore Minecraft (with *an environmental/sustainability issue*) by hitting the purple button in the most right box in the middle of the screen
6. Choose Minecraft Adventurer by clicking Get started on the purple button in the third box from the left.
7. Close (click X) the video that pops up.
8. Select the character that you want to play with by clicking Select under it.
9. Follow the instructions - drag blocks on the left and drop them on the right part of the screen to fulfill. When you are done hit orange button Run on the left:
    a. if you solved the task hit the orange button Continue that will pop up.

b. if you haven't solved the task/puzzle yet, click the blue button Reset on the left to try again until you succeed (and hit the grey button Continue, see a.)

Another game to code/play with blocks in code.org (with *an environmental/sustainability issue*) [Rey and BB-8]

Activity 4: Programming in 3D environment (in Kodu Game Lab)

In this hands-on activity, students will learn to design and program in 3D environment. The platform Kodu Game Lab (operating only on Windows OS) will be used. "Kodu Game Lab is a 3D game development environment that is designed to teach kids basic programming principles. Kodu allows creators to build the world's terrain, populate it with characters and props, and then program their behaviors and games rules in a bespoke visual programming language…. The heart of Kodu is the tile-based programming language. The language is high level in the sense that a lot can be accomplished in a very few lines of "kode" compared to traditional programming…." Quote from Kodu Game Lab



By the end of this activity, in Kodu Game Lab students will be able to:

- Design "a world"
- Program a character (to react to its environment)

Materials Needed: Computer with Windows operating system (and a computer mouse)

Duration: 90 minutes (can be shortened or extended by limiting the Hands-on part)

Theoretical Introduction:

Engage Students' Experience Begin with a few thought-provoking questions:

- *What means 3D? Where can you find this expression?*
- *Do you know any games in 3D? Which games are not in 3D? What is the difference between these games?*
- *When programming, can we make up commands or we need to use the ones that are given?*
- *Can we program a character/an object so that it reacts to other objects (or only the programmer can tell what will happen next)?*
- *Have you ever thought of programming a game?*
- *What would happen in your game?*
- *Would you like to design your own world for your game?*
- *etc.*

Explain to students (the concepts):

- an object can be programmed so that it responds to other objects (resp. their programs) - the programmer can define the reactions but he cannot predict all moves that the object will do after reacting to other objects (this is why artificial intelligence can “grow dangerous”)
- when creating a computer game we need to think of as many reactions (scenarios) as possible including what the player might do (and be prepared for that - by programming or designing the world) and set limits to what the player can do

Hands-On Learning: Programming in a 3D World

Go to https://www.kodugamelab.com/downloads/ and click the link KoduSetup.EXE. Install the file that was downloaded.

Kodu Game Lab is very complex but not hard to learn. There are many video-tutorials made by users and posted on Youtube.

Here is one for a general introduction (in brackets is video duration in minutes and seconds):

- Kodu Game Lab: Tutorial (11:49)

Here is a series of videos on Kodu Game Lab features :

- Kodu Game Lab - Beginner - 01 Creating a New World (5:24)
- Kodu Raising Terrain & Water (6:04)
- Kodu Game Lab - Beginner - 02 Saving/Importing/Exporting Worlds (2:01)
- Kodu Game Lab - Beginner - 03 Player Movement (1:44)
- Kodu Game Lab - Beginner - 04 Spawning (2:55)
- Kodu Game Lab - Beginner - 05 Score Points (2:38)
- Teleporting in Kodu (7:20)

Here some videos, how to program games in Kodu Game Lab:

- Coding for kids | Create a game with KODU game lab | Age 5+ (4:10)
- How to collect an object in Kodu games lab (4:19)
- How to create a target game in Kodu Game Lab (4:15)
- How to create a racing game in Kodu Games Lab (4:15)
- How to create a world for your games in Kodu Games Lab (4:33)

Activity 5: 3D design (in tinkercad.com)

In this hands-on activity, students will learn to design 3D objects. The platform tinkercad.com will be used. "Tinkercad is a free web app for 3D design, electronics, and coding. We're the ideal introduction to Autodesk, a global leader in design and make technology." Quote by Autodesk, the producer of TinkerCAD and many other popular 3D designing tools that are all used with similar commands/logics. So by learning 3D design in ThinkerCAD one gains access to more complex 3D designing tools.

"TinkerCAD is a free, online Computer Aided Design (CAD) tool from Autodesk. Unlike other CAD programs, TinkerCAD has a very small learning curve and is easy to use. It is best suited for creating simple 3D objects or performing simple modifications to pre existing 3D objects, such as those downloaded from Thingiverse." Quote by Boise State University

Materials Needed: Computer (with a computer mouse) with a browser and connected to Internet. On smartphones and tablets the mobile app TinkerCAD can be used (however instructions here below are for the browser-version of the programme)

Duration: 45 minutes (can be shortened or extended by limiting the Hands-on part)

Theoretical Introduction:

Engage Students' Experience Begin with a few thought-provoking questions:

- *Have you heard of 3D design? What is called design that is not 3D?*
- *What is design? Is "computer design" different from "computer aided design"/CAD?*
- *Why is 3D design so cool/popular?*
- *What does a 3D printer do? etc.*

Explain to students (the concepts):

- 3D means 3 dimensions, next to width and height (2D) also depth (adding time is 4D, adding triggers for more senses, like odours is 5D etc.)

- Design is giving form, shape, colours etc. to an object (different to drawing, painting etc. which is creating an image)
- Computer aided design is designing with help of computer software (that in many aspects simplifies designing by hand. e.g. “technical drawing”)

Hands-On Learning: Design Your 3D World in TinkerCAD

Type tinkercad.com in your browser.

We suggest that you register (sign up) on the site in the upper right corner (because only then you will be able to save designs to your account and work on them later; registration also permits you to use tutorials made by Autodesk).

Here are tutorials by Autodesk/TinkerCAD (for registered/signed up users) in which you can learn by doing.

Here are tutorials in text (and images) by the Boise state university

There are many video-tutorials on Youtube.

Here are two for a general introduction (in brackets is video duration in minutes and seconds):
- TinkerCAD - Tutorial for Beginners in 10 MINS! [FULL GUIDE 2024] (10:44)
- TINKERCAD for Beginners - Simple Basic Tutorial tinker cad (7:17)

Here are videos on how to design a sailing boat (by various users for various designs):
- TinkerCAD - Sailboat (8:49)
- How to make a SAILBOAT ⛵ | Step by step - Tinkercad 3D Design tutorial (10:23, no speech/voice-over)
- [1DAY_1CAD] SAILING SHIP (Tinkercad : Know-how / Style / Education) (10:33, no speech/voice-over)

Here are 3D designs created by users. When logged/signed in, you can download the designs and transform them on your own:
- sailing boat
- Sailing Yacht
- Small Sailboat
- awesome triple hull sail boat

Implementation of the Activities Based on Available Time

This module can be implemented over 2–4 sessions of 45–90 minutes depending on the available devices, internet access, and student familiarity with digital tools. The activities are progressive: students begin with unplugged, no-tech games and gradually move toward interactive coding and 3D design using digital platforms. Each activity can also stand alone to suit specific learning goals.

45 minutes
Begin with **Activity 1: Understanding Coding**. Students are introduced to the concept of programming through hands-on, unplugged games like "Code a Boat" and "Treasure Hunt Regatta." This offline introduction to algorithms and debugging helps students internalize the logic of coding without screens, making it ideal for mixed-age or tech-limited environments.

90 minutes
Combine **Activity 1** with **Activity 2: Coding with Simple Commands** on *code.org*. After understanding the basics of how instructions function, students transition to coding with arrows in environmental-themed puzzle games. This hands-on practice introduces them to coding interfaces, sequencing, and troubleshooting.

3 hours
Build a fuller progression by implementing **Activities 1–3**. Begin with unplugged coding, move to directional arrow-based coding in *code.org*, and then advance to **Activity 3: Coding with Language (Blocks)**, where students program with predefined blocks in increasingly complex game-like environments. This session fosters a shift from user to creator, helping students develop logical thinking and problem-solving through code.

4+ hours
Complete the full module by implementing **Activities 1–5** across multiple sessions. After establishing coding fundamentals (Activities 1–3), transition to **Activity 4: Programming in 3D Environment (Kodu Game Lab)** where students explore game logic and character behavior in a visual 3D space. Conclude with **Activity 5: 3D Design in TinkerCAD**, empowering students to become digital makers as they build their own sailboat models or tech-inspired creations. This longer format provides a comprehensive journey from offline coding to 3D design and interaction, ideal for clubs, camps, or project-based learning environments.

MODULE 8: MARINE ROBOTICS AND APPLICATIONS TO SAILING

Subjects: Nature and Society, Nature, Science and Technology, Mathematics, Chemistry, Physics, Technical Education
Sailing Concepts: Technology for sailing, Pollution and sailing

Learning Objectives

Upon completion of this module, students will:

- understand what are marine robots and how they can be used in a myriad of applications
- know what type of marine robots exist and how they can be applied specifically to sailing and environmental protection
- know how to pilot a Remotely Operated Vehicle (ROV)

Key Concepts

- Marine robots and their applications
- The role of marine robots in environmental monitoring and protection
- Application of marine robots in sailing contexts
- ROV operation and piloting
- ROV maintenance

Lesson Plan & Activities

Activity 1: Learning about Marine robotics and piloting an ROV

In this activity, students will learn the basics of marine robotics, their applications in general and to the fields of environmental protection and sailing. They will also experiment with piloting an ROV remotely. This activity can be done together with UNIZG-FER or another university experienced in marine robotics and possessing ROVs that can be accessed remotely.

By the end of this activity, students will be able to:

- understand what are marine robots and how they can be used in a myriad of applications
- know what type of marine robots exist and how they can be applied specifically to sailing and environmental protection
- know how to pilot a Remotely Operated Vehicle (ROV)

Materials Needed

- Computer
- Phone
- Projector
- Large screen
- Good internet connection for remote access

Sustainability Note: Present examples of marine robotics in sustainability applications such as sustainable blue economy. Use renewable energy power when possible and avoid diesel generators when on field trials.

Theoretical Introduction

1. Start by motivating the need for marine robotics.
Ask students questions like:

- "Why do you think we need marine robots?"
- "What do you think marine robots are used for?"

2. Introduce the basics of marine robots:

- What type of robots are there?
- How do marine robots work?
- What applications exist for marine robots?

3. Give examples of applications of marine robots:

- Provide several examples of applications.
- Go into specific examples for environmental protection
- Present specific examples for sailing

4. Introduce the basics of operation and maintenance of ROVs:

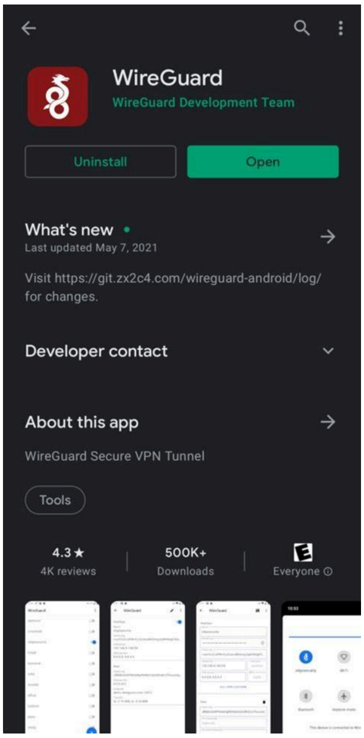
- Explain how typically ROVs are piloted
- Provide an overview of the main issues of operation
- Introduce the basics of deployment, recovery and maintenance of ROVs

Experiment: Piloting the ROV

Before beginning the experiments, invite students to pay attention to what they see in the underwater environment. Tell them they will be observing different objects (depending if the experiment is at sea or in a pool) and performing different tasks in different conditions (e.g. go through a polygon, inspect an area, pilot ROV with different camera setups). Explain that they should take notes or draw diagrams showing what happens in each task, and compare their notes. This will help them understand how hard it can be to pilot an ROV and what variables/conditions influence the operation the most. In the following, the steps for installing the software to control the ROV from a remote location. This software should be installed in the teacher's phone that then each student can use to pilot the ROV. A different software described in the Student's Guide can be installed by each student to observe the actions of the ROV pilot.

Step 1: Installing WireGuard on Android or iOS

1. Open the Google Play Store or App Store and search for 'WireGuard'.
2. Tap 'Install' or 'Get' to download and install the app.



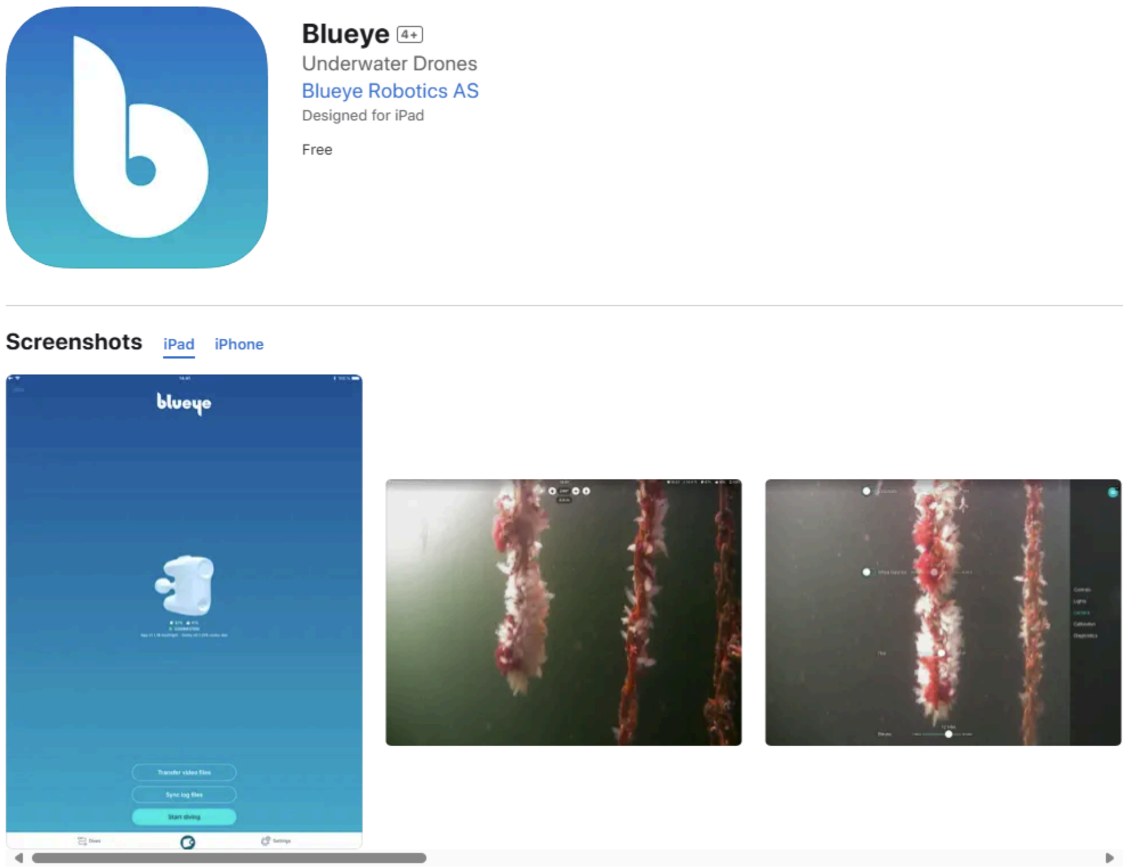
2. Configuring WireGuard tunnel

1. Launch the WireGuard app after installation.
2. Tap the '+' or 'Add tunnel button' button to add a new tunnel.
3. Select 'Create from QR code'
4. Scan the QR code below and name the tunnel as you desired (e.g., BlueyeWG)

5. Tap the switch to activate the tunnel and connect to the VPN.

3. Installing the Blueye App

6. On Android: Open Google Play Store, search for 'Blueye' and tap 'Install'.
7. On iOS: Open App Store, search for 'Blueye' and tap 'Get'.
8. Wait for installation to be completed before launching the app.



4. Connecting Blueye Underwater Drone at the pool

1. Power on the Surface Unit using the power button.
2. Use the USB-Ethernet converter and plug it into the Surface Unit.
3. Plug the ethernet cable from the USB-Ethernet converter into any access port around the pool.
4. Activate the Blueye ROV by placing the magnet near the LED lights of the ROV.

5. Connecting to Blueye from the phone

1. Activate WireGuard connection.
2. Open the Blueye app
3. The phone should show the Blueye connection as in the picture below.
4. Start the dive and use the app interface to navigate, view live video, and control lights.
5. Explore various features like depth hold, tilt lock, and video recording.

6. Additional Resources

- WireGuard official site: https://www.wireguard.com
- WireGuard Android: https://play.google.com/store/apps/details?id=com.wireguard.android
- WireGuard iOS: https://apps.apple.com/app/wireguard/id1441195209
- Blueye Support: https://support.blueye.no
- Blueye Android: https://play.google.com/store/apps/details?id=no.blueye.blueyeapp
- Blueye iOS: https://apps.apple.com/app/blueye/id1369714041

Implementation of the Activities Based on Available Time

This module can be completed in one or two sessions of 60–90 minutes, depending on available equipment, technical setup, and whether remote ROV piloting is included. It offers a rich introduction to cutting-edge marine technology and engages students in hands-on exploration of robotics used in sailing and environmental protection.

60 minutes
Begin with **Activity 1: Learning about Marine Robotics**. Introduce the concept of marine robots and explore their applications in ocean research, pollution monitoring, and sailing safety. Use videos, discussions, and visuals to build student understanding. If live ROV access is not available, use recorded footage or virtual simulations for demonstration.

90 minutes
For a more immersive experience, expand **Activity 1** to include a **remote piloting session**. After the theoretical introduction, guide students through installing and using the Blueye app and WireGuard connection. Let students take turns piloting the ROV in a pool or controlled aquatic environment. Encourage them to observe visibility, control sensitivity, and task precision (e.g., maneuvering, inspecting, or navigating obstacles). Wrap up with a short group reflection on the challenges of underwater robotics and how it supports sustainability.

2+ hours (in extended university-supported sessions or robotics clubs)
In school partnerships with marine research institutions or during STEM club days, this module can be enriched further. Begin with the classroom session on marine robotics, proceed to the live ROV piloting experience, and conclude with a student-led reflection project (e.g., presentations, sketched ROV designs, or ideas for robotic applications in sailing and conservation). This structure nurtures deeper understanding, creative problem-solving, and real-world technology exposure.

Evaluation of Activities and Student Progress

Student assessment during and after the implementation of the *Sailing Into STEAM* module should focus on **formative evaluation**, which encourages reflection, discussion, and skill development. Instead of traditional tests, the following methods are recommended:

- **Observation and Notes**: Teachers and coaches record participation, initiative, teamwork, problem-solving, and application of learned concepts in hands-on activities.

- **Reflective Activities**: Through keeping a logbook, students express their thoughts, learn from mistakes, and track their own progress.

- **Discussions and Presentations**: Students present their solutions and ideas to a group or the whole class, developing communication skills.

- **Practical Demonstrations**: Students demonstrate how a model, experiment, or device they created works.

- **Self and Peer Assessment**: Students evaluate their own work and that of their peers using simple criteria (e.g., "what I learned," "what I can improve," "how I contributed to the team").

Teachers and coaches can use simple checklists, rubrics, and comments to provide constructive feedback. The focus is not on grading, but on **learning through experience** and developing children's confidence and curiosity.

Safety Guidelines

Given that the course includes water-based activities, experimental work, and team collaboration, **children's safety is a top priority**. The following guidelines are recommended:

General Safety:

- At the beginning of each module, provide age-appropriate safety instructions.
- Monitor students' health, especially during outdoor or water-based activities.
- Ensure an adequate number of adults (teachers/coaches/assistants) in proportion to the number of students.

Water Safety:

- All children must wear life jackets appropriate to their size.
- Water activities must be supervised by trained staff and conducted only under safe weather conditions.
- Provide communication tools and first aid equipment on shore.
- Instruct children on safety rules for behavior on the boat and during boarding/disembarking.

Laboratory and Experimental Work:

- Use safe and non-toxic materials.
- Provide safety goggles, gloves, and other protective equipment if needed.
- Adults must always supervise the use of tools and electrical devices (if applicable).

Teamwork and Mutual Care:

- Encourage mutual respect and support among students.
- In case of conflict, provide a space for peaceful discussion and resolution.
- Promote empathy, patience, and active listening.

These guidelines can be further adapted according to the specific needs of the group, institution, or local regulations.

Final Note

We hope this guide serves as both a practical tool and a source of inspiration for educators and coaches implementing the *Sailing Into STEAM* course. By combining the power of nature, science, and teamwork, this program opens doors for children to explore technology, environmental awareness, and personal growth in meaningful ways.

Thank you for your commitment to joyful, hands-on learning. May every session bring curiosity, creativity, and the wind in your sails.

— *The Sailing Into STEAM Team* ⚓