Sail Away

Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on watercraft engineering and sailing. Students explore what marine engineers and naval architects do, and work in teams to design a sailboat out of everyday objects that can catch a breeze from a fan, stay afloat with a set load, and sail one meter. Students work in teams of "engineers" to design a boat with a sail structure, test their boat, evaluate the work of other "engineering" teams, and present reflections to the class.

Lesson Synopsis

The Sail Away lesson not only explores how engineers design watercraft, but also challenges student to work as teams of engineers to develop a watercraft that holds a set weight, captures wind from a fan for power, and can move one meter without sinking. Teams design their boats, build them, test them, evaluate the crafts of other teams, and present their project reflections to the class.

Aligned year levels

Years 2, 4, 7 and 10

Objectives

- Learn about marine engineering and sailing principles.
- Learn about engineering product planning and design.
- Learn about meeting the needs of society.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- watercraft engineering
- problem solving
- teamwork

Lesson Activities

Students explore what marine engineers and naval architects do, and work in teams to design a sailboat out of everyday objects that can catch a breeze from a fan, stay afloat with a set load, and sail one meter. Students work in teams of "engineers" to design a boat with a sail structure, test their boat, evaluate the work of other "engineering" teams, and present reflections to the class.

Resources / Materials

- Teacher Resource Document (attached)
- Student Worksheets (attached)
- Student Resource Sheet (attached)

Alignment to Curriculum Frameworks

See Alignment to Curriculum Frameworks for both Science and Mathematics section of this lesson plan.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Virtual Skipper (www.virtualskipper-game.com)
- SailTrimSim (www.wb-sails.fi/news/SailTrimSim/TrimSimFrames.htm)
- The Physics of Sailing (www.physclips.unsw.edu.au/jw/sailing.html)
- International Sailing Federation (www.sailing.org)
- WB-Sails Quest for the Perfect Sail (www.wb-sails.fi/news/98_11_PerfectShape/Main.htm)
- ITEA Standards for Technological Literacy: Content for the Study of Technology (www.iteaconnect.org/TAA)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)

Recommended Reading

- Introduction to Marine Engineering, Second Edition (ISBN: 0750625309)
- The Complete Sailor: Learning the Art of Sailing (ISBN: 0070571317)
- Toy boats, 1870-1955: A pictorial history (ISBN: 0684159678)

Optional Writing Activity

- Write an essay or a paragraph about how marine engineers have to incorporate the range of water temperatures across the globe when designing a cruise ship that will travel all around the world.

Sail Away

For Teachers:
Teacher Resources

◆ Lesson Goal

The Sail Away lesson not only explores how engineers design watercraft, but also challenges student to work as teams of engineers to develop a watercraft that holds a set weight, captures wind from a fan for power, and can move one meter without sinking. Teams design their boats, build them, test them, evaluate the crafts of other teams, and present their project reflections to the class.

◆ Lesson Objectives

- Learn about marine engineering and sailing principles.
- Learn about engineering product planning and design.
- Learn about teamwork and working in groups.

◆ Materials

- Student Resource Sheet
- Student Worksheets
- Optional Internet Access
- Construction Materials
  - **One set of materials for each group of students: empty wax coated milk or juice carton, scissors, standard weight (several coins of same denomination or film canister filled with sand), paper, cardboard, glue, tape, string, sail materials (aluminum foil, plastic wrap, silk, fabrics, balloons), toothpicks, popsicle sticks, rubber bands, wire, tape. Be sure each team has identical materials.**

◆ Procedure

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. If internet access if available, have students review physics of sailing and sailing simulators on the following websites:
   - SailTrimSim (www.wb-sails.fi/news/SailTrimSim/TrimSimFrames.htm)
   - The Physics of Sailing (www.physclips.unsw.edu.au/jw/sailing.html)
3. Divide students into groups of 2-3 students, providing a set of materials per group.
4. Explain that students must work in teams of "engineers" who have been given the challenge of designing a sailboat that will catch wind from a fan, hold a set weight, and travel 4 feet without sinking.
5. Students will first meet, plan, and draw their boat design on paper.
6. Next, students construct their boats.
7. Students take turns testing their boats on a waterway created by the teacher. The teacher runs the fan to ensure testing consistency. Student must see if their sail design captures wind, and is able to travel one meter on the water without sinking.
8. Students complete evaluation and reflection sheets, and then present their reflections to the class.

◆ Tips

1. Waterway might be a shallow long container, a plastic planter, or child's pool.
2. Teams may need to replace or redesign their sail after testing; allow students extra time and materials to redo their boat and try again.

◆ Time Needed

Two to four 45 minute sessions.

Sail Away

Student Resource:
Marine Engineering, Sailing, and Physics

◆ What is Sailing?

Sailing is the skillful art of controlling the motion of a sailing ship or sailboat, across a body of water. The force of the wind on the sails propels sailing vessels. Today, for most people, sailing is recreation, an activity pursued for the joy of being on the water and pursuing the mastery of skills needed to maneuver a sailboat in varying sea and wind conditions. Throughout history sailing has been instrumental in the development of civilization. The earliest representation of a ship under sail appears on an Egyptian vase from about 3500 BC.

◆ Sail Aerodynamics

Sails propel the boat in one of two ways. When the boat is going in the direction of the wind (i.e. downwind), the sails may be set merely to trap the air as it flows by. Sails acting in this way are aerodynamically stalled. In stronger winds, turbulence created behind stalled sails can lead to aerodynamic instability, which in turn can manifest as increased downwind rolling of the boat. Spinnakers and square-rigged sails are often trimmed so that their upper edges become leading edges and they operate as airfoils again, but with airflow directed more or less vertically downwards. This mode of trim also provides the boat with some actual lift and may reduce both wetted area and the risk of 'digging in' to waves. The other way sails propel the boat occurs when the boat is traveling across or into the wind. In these situations, the sails propel the boat by redirecting the wind coming in from the side towards the rear. In accordance with the law of conservation of momentum, air is redirected backwards, making the boat go forward. This driving force is called lift although it acts largely horizontally. The lift generated by a sail can be resolved into two main components; forward force and sideways force. These forces act against opposing forces generated by the hull and the keel. On a sailing boat, a keel or centerboard helps to prevent the boat from moving sideways. The shape of the keel has a much smaller cross section in the fore and aft axis and a much larger cross section on the athwart axis (across the beam of the boat). The resistance to motion along the smallest cross section is low while resistance to motion across the large cross section is high, so the boat moves forward rather than sideways.

◆ Marine Engineers and Naval Architects

Marine engineers and naval architects are involved in the design, construction, and maintenance of ships, boats, and related equipment. They design and supervise the construction of everything from aircraft carriers to submarines, and from sailboats to tankers. Naval architects work on the basic design of ships, including hull form and stability. Marine engineers work on the propulsion, steering, and other systems of ships. Marine engineers and naval architects apply knowledge from a range of fields to the entire design and production process of all water vehicles.

Sail Away

Student Worksheet:
Build Your Own Watercraft

◆ Engineering Teamwork and Planning

You are a team of marine engineers given the challenge of designing a sailboat using everyday materials that can hold a set weight and move 4 feet along a classroom waterway harnessing wind energy from a fan.

◆ Planning and Design Phase

Each team has been provided with a set of materials. Review these as a group and draw your plan for a boat design in the box below. Think about how the weight your boat must carry should be distributed in the boat for stability during motion. Also think about what your sail material will be and how it will be attached to the boat securely.

◆ Construction Phase

As a team, build your boat, and then complete the questions below:

1. How similar was your design to the actual boat you built.

2. If you found you needed to make changes during the construction phase, describe why you made revisions.

3. Did you find you needed to add extra materials to your boat during the construction phase? If so, what parts did you need to add?

◆ Testing Phase

Your teacher has created a waterway for testing your watercraft. Test your boat! If you find your sail or boat design doesn't work the first time, you'll have an opportunity to redesign your boat and try again. Don't worry if it fails the first time. Part of engineering is testing and designing products until the optimal design is achieved.

Sail Away

Student Worksheet: Evaluation

◆ Evaluation Phase

Answer the following questions to summarize your experience with the Sail Away activity. Work in teams to come up with group opinions.

1. Were you able to create a boat that could hold weight, catch the wind, and travel one meter?

2. If yes, did you need to rework your boat during the testing process? What did you need to change about your boat to make it meet the challenge?

3. Do you think your design could scale upward and work as a full size sailboat? Why or why not?

4. What aspects of other team's boats did you find interesting? Where there aspects of other designs you wish you had incorporated into your own team's boat?

5. How different were all the final boats? What did that tell you about problem solving?

6. If you had a chance to do this project again, what would your team have done differently?

7. Do you think you would have been able to create a successful boat if you had not been working in a group? What did the group interaction add to the design and problem solving process?

◆ **Presentation**

As a group, make a presentation to the class about what you learned during this activity.

Year 2

Science Understanding

- A push or a pull affects how an object moves or changes shape (ACSSU033)

Science as a Human Endeavour

- Science involves asking questions about, and describing changes in, objects and events (ACSHE034)

Science Inquiry Skills

- Respond to and pose questions, and make predictions about familiar objects and events (ACSIS037)
- Participate in different types of guided investigations to explore and answer questions, such as manipulating materials, testing ideas, and accessing information sources (ACSIS038)
- Use informal measurements in the collection and recording of observations, with the assistance of digital technologies as appropriate (ACSIS039)
- Use a range of methods to sort information, including drawings and provided tables (ACSIS040)
- Through discussion, compare observations with predictions (ACSIS214)
- Compare observations with those of others (ACSIS041)
- Represent and communicate observations and ideas in a variety of ways such as oral and written language, drawing and role play (ACSIS042)

Year 4

Science Understanding

- Forces can be exerted by one object on another through direct contact or from a distance (ACSSU076)

Science as a Human Endeavour

- Science involves making predictions and describing patterns and relationships (ACSHE061)

Science Inquiry Skills

- With guidance, identify questions in familiar contexts that can be investigated scientifically and predict what might happen based on prior knowledge (ACSIS064)
- Suggest ways to plan and conduct investigations to find answers to questions (ACSIS065)
- Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate (ACSIS066)
- Compare results with predictions, suggesting possible reasons for findings (ACSIS216)
- Reflect on the investigation; including whether a test was fair or not (ACSIS069)
- Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports (ACSIS071)

Year 7

Science Understanding

- Change to an object's motion is caused by unbalanced forces acting on the object (ACSSU117)

Science as a Human Endeavour

- People use understanding and skills from across the disciplines of science in their occupations (ACSHE224)

Science Inquiry Skills

- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)
- Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)
- In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (ACSIS126)
- Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate (ACSIS129)
- Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions (ACSIS130)
- Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (ACSIS131)
- Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate (ACSIS133)

Year 10

Science Understanding

- The motion of objects can be described and predicted using the laws of physics (ACSSU229)

Science as a Human Endeavour

- Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE192)
- Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities (ACSHE195)

Science Inquiry Skills

- Formulate questions or hypotheses that can be investigated scientifically (ACSIS198)
- Plan, select and use appropriate investigation methods, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS199)

For Teachers: Alignment to Curriculum Frameworks for Science and Mathematics (continued)

- Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data (ACSIS200)
- Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS203)
- Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)
- Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS205)
- Critically analyse the validity of information in secondary sources and evaluate the approaches used to solve problems (ACSIS206)
- Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208)