Build a Boat for Scientific Research

Timeframe
1-2 Fifty minute class periods

Target Audience
High School (9th- 12th)

Materials
- Aluminum foil
- Tape
- Clay
- Straws
- Skewers
- Pipe cleaners
- Popsicle sticks
- Corks
- Cups
- Legos

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Description

Students will take part in a hypothetical challenge that will help them to better understand the process of engineering and designing a boat for scientific research.

Objectives

Students will:

- Apply an understanding of buoyancy
- Design a boat that floats while carrying a substantial amount of weight
- Determine what type of design will best meet the given boat parameters
- Understand tradeoffs that boats make to address various needs/ goals (speed, stability, weight, space)

Essential and Guiding Questions

What is the best design for a boat that does scientific research?

- How do you get a boat to float with heavy equipment?
- How can you make your boat stable so that you can collect the best data?

Background Information

The most crucial part of an ocean going venture is most certainly the vessel itself. A boat is an island unto itself once it leaves the safety of its dock and heads out on the open seas. Any ship, no matter what its size, must carry all of the supplies and equipment that its crew will need to live safely for the extent of the voyage.

In the case of research vessels, the vessels must also be equipped with special tools and technology that allow scientists to explore ocean environments. Research vessels are highly advanced traveling research stations. They must be able to offer scientists stable platforms from which they can deploy equipment, divers, and submersibles. In addition, these vessels carry electronics, computers, and navigational and communications systems.

For additional information and resources around ocean exploration and research vessels go to the **NOAA Okeanos Webpage**.

How is that ships carrying such heavy loads are able to float? Archimedes Principle can help explain this. The Archimedes Principle came from the Greek scientist named Archimedes who discovered the scientific law of buoyancy. Archimedes figured out that if the weight of the object being placed in the water is less that the weight of the water displaced, the object will float. An object will float if it displaces as much water as it weighs. This is known as buoyancy or the Archimedes Principle. A ship made out of metal is able to remain lighter than the amount of water it displaces, because it is not a complete solid. The very bottom of the ship is hollow and therefore adds support to the ship without adding any mass. When a ship is fully loaded, there is a maximum amount of weight it can carry before the weight of the ship increases past the amount of water it displaces.

Activity Introduction

Review with students what causes things to sink or float. Ships are built out of heavy materials, why don't they sink? Remind students that whether something sinks or floats is determined by density, which has to do with weight (mass) and size (volume) together. If the density is greater than that of water, the object will sink. If the density is less than (or the same as) that of water, the object will float. Even if boats are made of things that sink they can float IF THEY ARE SHAPED RIGHT. Students will prove this by measuring the volume of water displaced by their model ships.

Activity

1. To introduce students to the various forms and functions of boats by showing them pictures of various types of boats (see PPT slide). Ask:

   -Why do boats have different shapes?

Next Generation Science Standards

DISCIPLINARY CORE IDEAS:

ETS1.B.: Deveoping Possible Solutions

ETS1.C.: Optimizing the Design Solution

PERFORMANCE EXPECTATIONS:

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints including cost, safety, reliability, and aesthetics as well as possible cultural, and environmental impacts.

SCIENCE AND ENGINEERING PRACTICES:

Constructing Explanations and Designing Solutions

-Which of these boats would be the most stable? Support the most weight? Travel the furthest without going back to land? Be the fastest? Slowest?

2. Tell students that there are many ways to build a boat depending on what your goals are. Let them know that they are going to work in teams to build a vessel that can conduct scientific research. Introduce them to **Oregon State University's ships** and talk about the various types of research that is done on these vessels. Show students the **VIDEO** of the design plan for OSU's soon to be built Regional Class Research Vessel.

3. Break students into groups of 3-4 and give them a bag of random items (Legos, etc.) that represent equipment they must incorporate into their design (specify indoor vs. outdoor). These materials represent the equipment, labs, crew, and supplies. Let them know that during testing their boat will need to accommodate the weight of additional equipment being brought aboard by researchers (100 pennies min).

4. Give students the Boat Design Challenge Student Handout to read, discuss, and draft a design plan.

5. Once students have completed their design plan they can "purchase" materials and start building. When they complete their models they can test them in a provided tank (long Tupperware container or something similar) and compare to the builds of other students. Give students a chance to re-engineer their designs before they make final presentations.

6. At some point during the testing process have students test the Archimedes Principle by recording the water height in the test container with and without the boat. Weigh the boat and convert the change in water height to a volume of water displaced by multiplying the width and length of the container at the water line by the change in water height. Convert water volume to mass and compare to the weight of the boat.

7. Have students present their final boat models to the rest of the

group. Final presentations should address the given parameters:

-Is it within the specified size range: no more than 12 inches long

-Does it support the weight of the given research equipment (100 pennies)

-Does it have deck space for deployment and recovery of scientific equipment (Lego assortment)

-Does it have indoor space for labs, 6-8 crew, and supplies (Lego assortment)

Wrap Up

Once all groups have presented have students vote on which boat best met the design needs and why.

- What was difficult about designing and building your vessel?
- What trade-offs did your group make to meet the constraints that were given?
- Which of the given criteria did your group prioritize? (cost, space, stability, etc.?)
- What would you still change about your design to better meet the needs of an ocean-going vessel?

THANKS TO THE FOLLOWING CONTRIBUTORS:

Chris Romsos
Don Hilliard

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Resources:

http://mocomi.com/buoyancy/

http://oceanexplorer.noaa.gov/technology/vessels/vessels.html

http://ceoas.oregonstate.edu/ships/

Boat Design Challenge- Student Handout

The Problem
The International Commission for Ocean Exploration (ICOE) has a number of vessels that do world class research and are utilized by many. More than one of their current research vessels is aging and needs to be replaced. The ICOE is looking to contract with a boatyard to build a number of new and modern vessels that will operate in coastal regions worldwide and on the open ocean.

The Challenge
The ICOE has contacted your boatyard to create a vessel design plan with a cost estimate for building your vessel as well as a model of your vessel. You will then present your plan to the ICOE and tell them why they should choose your boatyard to build the vessel.

Your vessel will be evaluated on the following criteria:
1. **Cost:** is cost efficient to build while meeting the needs of the vessel
2. **Size:** is no bigger than 12 inches' long
3. **Space:** has deck and indoor space (wheelhouse) for equipment, labs, 6-8 crew, and supplies (provided materials)
4. **Stability:** supports the weight of the various research equipment without sinking or becoming unstable when tested (100 pennies min)
5. **Aesthetics**: overall look and appeal of vessel is pleasing

The Materials
To build your boat you have a budget of $100,000. You can choose from the following materials to build your boat, but must stay within budget. Remember that a big part of your challenge is to create a model that will support weight and be economical to build. Choose your materials wisely, they are expensive!

- Sheet metal (aluminum foil)- $30,000 per 1 foot sheet
- Welding materials (tape)- $20,000 per 1 foot strip
- Pre-fabricated wheelhouse (cups)- $20,000 each
- Softwood (corks)- $15,000 each
- Fiberglass (clay)- $15,000 per cube
- Reinforcements (straws or skewers)- $10,000 each
- Hardwood (popsicle sticks)- $10,000 each
- Cable (pipe cleaner)- $5,000 each

Testing Observations
Once your group has completed your model you will have a chance to test it and compare with other models. You will then have a chance to redesign and rebuild your model. Observations are an important part of understanding what worked and what didn't work. Record your observations from your own design as well as that of others in the space below:

Research Boat Design Plan

Discuss with your group what boat design you think would most successfully meet the criteria given.

Draw a detailed boat design that includes location of: wheelhouse, deck, and equipment.

Design 1

What equipment will you need to build a model of your vessel? Fill out the purchase order below.

Purchase Order			
Item	**Item Price**	**Number Ordered**	**Subtotal Price**
Sheet metal (aluminum foil)	$30,000 per 1 foot sheet		
Welding materials (tape)	$20,000 per 1 foot strip		
Pre-fabricated wheelhouse (cups)	$20,000 each		
Softwood (corks)	$15,000 each		
Fiberglass (clay)	$15,000 per cube		
Reinforcements (straws/skewers)	$10,000 each		
Hardwood (popsicle sticks)	$10,000 each		
Cable (pipe cleaner)	$5000 each		
		Total Price	

Why do boats have different shapes?