

Author: Brad Ferris
Institute for Chemical Education and Nanoscale Science and Engineering Center
University of Wisconsin-Madison

Purpose: To learn about buoyancy forces through the designing of aluminum foil boats

Learning Objectives:

1. Understand that buoyancy is the ability of an object to float in a liquid.
2. Understand that water has a force that counteracts gravity
3. Explore how surface area impacts how much a boat can hold
4. Understand that salt increases the density of water and thus increases an object's buoyancy.

Next Generation Science Standards (est. 2013):

- PS1.A: Structure and Properties of Matter (partial)
- PS2.A: Forces and Motion (partial)
- PS2.B: Types of Interactions
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

Grade Level: 2-8

Time: 45 minutes

Materials:

- 1 roll of Aluminum Foil
- Pennies (At least 25 per student) or other types of coins
- Dishpans or large Tupperware that is at least 5x5" and 3" deep (one per student)
- Paper towels
- 1 ruler per student
- Pitcher
- Brine to test the boats*
- 2 plastic spoons per student
- Scissors
- 1 small bowl

Preparation ahead of time:

Cut aluminum foil into 4"x4" squares with at least two squares per student.

Introduction:

The ability to float on a liquid (buoyancy) is a critical idea for our civilization. Expansion of the human race around the world wouldn't have happened if people hadn't figured out how to transport large items across vast oceans. Boats, which are heavy pieces of metal, wood and/or plastic, which would normally sink, are

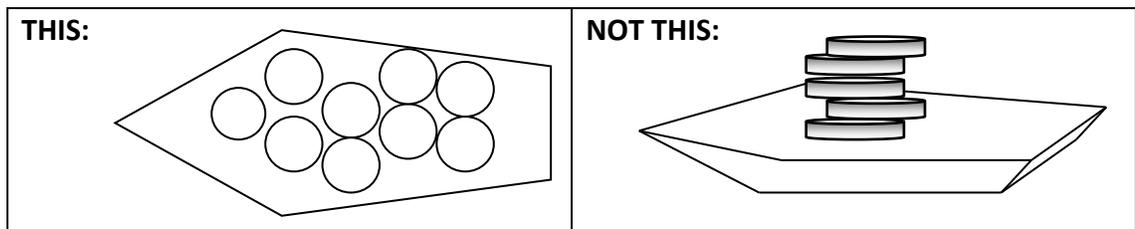
able to float because of their design. The shape of the boat helps it overcome the pull of gravity, which wants to sink it to the bottom of the lake or ocean. This activity starts by exploring why things float and moves on to engineering the best way to build a boat that can carry a heavy load.

Procedures:

1. Buoyancy
 - a. Place one inch of water in each of the dishpans or Tupperware containers.
 - b. Give each student a foil square and ask them to predict what would happen if they dropped it into the dishpan: would it float or sink? Make sure they write their prediction on the worksheet.
 - c. Ask the students what causes things to fall down. Explain that gravity pulls objects towards the ground when they are on the planet Earth. Ask the students if they know what happens to astronauts when they are in space. Because they are further from the Earth, they don't have the pull of gravity so everything floats.
 - d. Have the students drop the foil into the bin with water and ask if their prediction was correct
 - e. Ask the students why the foil didn't fall to the bottom of the pan (floated)
 - f. Repeat steps b-d scrunching the foil (you will need to step on the foil to make it really packed and sink)
 - g. Ask the students if they have any theories about the packed foil going all the way to the bottom while the flat foil didn't.
 - h. Give the students the example of floating in a lake or pool. If they ball up, they will sink but if they lay on their back and stick their arms out, they will float.
 - i. Explain that the ability to float is called "buoyancy" and it happens because there is a force pushing against them.

2. Designing the Boat

NOTE: Encourage students to spread out the pennies in order to distribute the weight evenly across the surface. AT THE END (in step i), they can test what happens if you stack the pennies. Feel free to show students this image:



- a. Give each child a square of foil and a pack of pennies.

- b. Challenge the students to design a boat that can hold pennies using their foil square. The rules for making the boat are:
 - i. They can bend and fold it but must not cut or rip the foil.
 - ii. Once the boat is placed in the water, they may not use their hands or anything else to touch the boat and hold the pennies on it.
- c. Note: Some students might not put sides on their boat, causing the pennies to slide off. If this happens, ask the students what they could do to keep the water off the top of the boat once the pennies weight pushes it down. Encourage them to think about what keeps the water INSIDE the dishpan, which could also help keep water OUTSIDE the boat (it has walls).
- d. Each time students build a boat, they should fill out the worksheet with the size of the boat, a prediction of the number of pennies the boat will hold, and the actual results.
- e. Repeat the test with a boat with ~half the surface area as their last boat; by having the students fold the foil in half. Make sure they fill out the work sheet.
- f. Ask them whether their first or second boat held more pennies and have them write the answer on their worksheet.
- g. Give the students a new piece of foil and have them repeat step e with a boat that has a different surface area (either larger than the first boat or smaller than the second boat).
- h. Continue repeating step e as long as you have time and foil. Challenge the students to find the size of boat that will hold the most pennies.
- i. Have the students investigate what happens if they spread the pennies on the boat surface or if they place all the pennies in one place.
- j. Have students compare the sizes of the boats and how many pennies each could hold and ask them to find a pattern in the relationship between surface area and pennies. In theory, the larger the surface area, the more pennies the boat can hold; however, this is not guaranteed to happen. Ask the students if they can think of things that might have happened to impact the ability of the boats to hold pennies. Topics you may want to bring up with them include whether the pennies are in a pile or are spread out on the boat and how gently the pennies were placed on the boat.
- k. Pour the water out of the container when done.

3. Boats in Salt Water

- a. Add approximately 1 inch of salt water to each container.
- b. Ask the students if they think having salt water in the pan rather than plain water will change number of pennies the boats can hold.

- c. Have the students pick the boat that held the most pennies and have them predict if it will hold more or less pennies than before. Ask them why they chose their answer.
- d. Have the students redo the penny test for all boats and plot the results on their worksheet.
- e. Ask the students if changing the liquid made a difference.

Discussion:

There are 2 main concepts being taught during this lesson. The first is the concept of buoyancy. Objects will float when the upward push of the liquid they are floating on is stronger than the downward pull of gravity. The larger the surface area of an object that touches the liquid, the greater the weight it can hold. Think of the analogy of walking on a frozen lake with thin ice. The worst thing you can do is to stand on one leg because that means your entire weight is pushing down on one spot in the ice. Instead, you should lay down flat with your arms and legs spread out so the pressure of your weight (which is pulled downward by gravity) is spread out.

The second concept that comes into play is buoyancy changes as the liquid changes.

Evaluation:

What is it called when something floats?

Did bigger or smaller boats hold more weight?

What happens if you spread out the pennies? If you put them in one place?

Why did the same boat hold more weight when the salt was added to the water?

Where would it be easier for you to float, in a lake or in the salty ocean?



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