What Floats Your Boat?

By Kathy Carter and Joan Chadde, Michigan Tech University Center for Science & Environmental Outreach

Grade: 4-6

Topic: buoyancy, density, Great Lakes shipping**,** ship's draft
Duration: 35 minutes

Lesson Overview

Students use the principles of buoyancy to create a boat out of clay that will float in a tub of water and hold the maximum amount of cargo (marbles) without sinking.

Sources Consulted

1. Duke University's Center for Inquiry Based Learning (CIBL). *www.biology.duke.edu/cibl*
2. How Stuff Works. Why *can boats made of steel float on water when a bar of steel sinks?* www.science.howstuffworks.com
3. Robertson, Bill. 2007. Science *101: How can an ocean liner make of steel float on the water?* Science & Children. Vol. 44, No.9, Summer 2007.

Learning Objectives

After this presentation, students will be able to:

1. Explain why a material that is denser than water can float.
2. Define buoyant force as the upward force of the water which needs to be greater than the gravitational force pulling it down. If the object is either less dense than the liquid or is shaped appropriately (as in a boat), the upward force of the water can keep the object afloat.
3. Explain why a ship made of steel and loaded with cargo can float.

Science Curriculum Benchmarks Addressed

- Generate scientific questions about the world based on observation.
- Develop solutions to problems through scientific investigation.
- Manipulate simple devices that aid observation and data collection.
- Develop strategies and skills for information gathering and problem solving.
- Classify common objects and substances according to observable attributes/properties.
- Explain forces.

Materials Needed:

Per Classroom:

Taconite pellet
Large photo of a ship ("freighter" or "laker")
Styrofoam ball (baseball size)
Demo #1
1 slotted craft sticks
2 washers

9-12 oz. clear plastic cup of water

Demo #2:

2 small balloons, inflated

Clear plastic tub (9" x 9" x 15" – tub contains supplies) fill 3/4s with water, set on tub lid

Paper towels for clean up

Per Small Group:

Shoebox sized clear plastic tubs half-filled with water (per 2 groups)

1/2 stick modeling clay (non-hardening) or 6"x6" square aluminum foil

12" x 12" sheet of wax paper and tape to cover work space

75-100 small marbles

Paper towels for clean up

Room Arrangement: put desks into groups of four to create flat work space.

PROCEDURE

Introduction & Welcome (2 min)

Welcome everyone to Family Transportation Activity Night.

Each student will give their name, major, university, describe a few of the careers/jobs that people with your major might do.

Attention-getter (2 mins)

Hold one taconite pellet and 1/2 stick of modeling clay over a tub of water and ask the students if they think the objects will float or sink. After the students make their predications, drop each into the water *(aha! Both sink!).*

Ask the students "why do they sink?" Introduce the term **density** and explain that it means how closely packed the particles (molecules) are in a solid, liquid or gas. In this case, both of the objects are denser than water so they sink. Show the student a Styrofoam ball and ask if it will sink or float? Explain that it will float because it is less dense than water.

Display a large photo of a ship ("freighter") and ask: "How can a boat 1000 feet in length made of steel and capable of carrying 70,000 tons possibly float?" Take responses. Explain that whether or not something floats does not just depend on density, but also on 'buoyancy.'

Tell them that you are going to give them a ½ stick of clay (that sank initially) and their goal is to make an object that will float.

Activity 1: Tell students to make an object out of clay that will float. (10 min)

Have each student tape a large piece of wax paper (about 12" across) at their work station. Have several tubs of water placed throughout the classroom. Give each student 1/2 stick of clay (equivalent to what sank initially) and a paper towel, ask them to design a boat that will float.

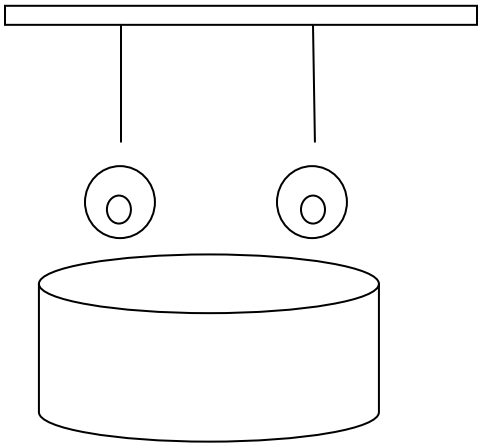
Tell them that they can test their designs as often as they wish, but advise them to dry the clay each time between testing to prevent the clay from becoming too waterlogged.

After most students are successful, ask the students if they changed the density of the clay? *(No)* Then, why does the clay float now, when it didn't before? Explain again that whether or not an object floats depends on something other than just the density of the object. *What?*

Demonstration 1: A Fluid's Force (5 min)

Show the students that water (any fluid) exerts an upward force on any object put into it. Demonstrate this by balancing (See Figure 1) a wooden popsicle/craft stick and two washers on your finger. Lower one of the washers into a clear cup of water. The washer moves up, correct? This is a called the 'buoyant force.' The buoyant force is 'the upward force that a fluid (water) exerts on an object placed in the fluid.'

(Figure 1)



Explain that there are two forces that act on an object in water, the **buoyant force** (pushing up) and the **gravitational force** (pushing down). It is the size of these forces that determines if an object will float. Let's learn a bit more about buoyant force.

Demonstration 2: How "Buoyant Force" Works. (5 min)

Show the students two identical balloons, blow one up a little bit and the other one up a lot. **Convince the students that these two balloons weigh the same, and therefore the gravitational force is the**

same as well. Submerge both balloons in a tub of water and let them go. Which one shoots up the highest? Which one experienced the greater amount of buoyant force? **The larger balloon, correct?** This shows how the buoyant force works---the amount of buoyant force depends on how much fluid the object displaces or moves out of the way.

Ask the students why the modeling clay that was not able to float initially was able to float when they shaped it differently? *(It moved more water out of the way)*

Large ships work the same way. If you take a chunk of steel and throw it in the lake or ocean, it will sink straight to the bottom, but if you shape it so that it has lots more surface area and displaces a lot of water (moves water out of the way), the buoyant force (pushing up power of the water) will be large enough to equal the weight of the boat (i.e. the weight of the water displaced must be greater than the combined weight of the ship & cargo).

Activity 2: Design a boat that will hold the most cargo without sinking. (10 min)
Ask the students to use what they have learned to build a boat that will carry the most cargo.
Each time their boat sinks, encourage the students to make improvements to their design. Which boat can carry the most cargo (marbles)? Why?

Assessment of Student Learning (5 min)

1. Which boat designs worked best? What made these designs successful?
2. Which boat designs didn't work well? Why did these designs not work well?
3. What is the buoyant force? How do you increase it?
4. How did your boat design change?
5. How can a boat that is made from steel float?

Final Thought
Next time you see a large ship, think about how the *buoyant force* of the water (pushing up power) is holding up the ship and keeping it from sinking.

Cleanup (2 min.)
Empty tubs of water, wipe up spills, collect clay balls and marbles (dry out for reuse). Allow students to wash their hands.