Whatever Floats your Boat: Buoyancy and Submarines

Grades: 3-8

Time Frame: 30-40 minutes (10-15 minutes introduction, 10-15 mins activity, 10 minutes conclusion)

Materials Needed:
- Tub of water
- Orange
- Small Tupperware
- Some kind of weight (coins work!)

Objectives: Through this activity, students will learn about buoyancy, including concepts such as Archimedes Principle, displacement, weight, and buoyant forces. The students will interact with these new ideas by making their own “submarine” achieve neutral buoyancy. Through trial and error, as well as a subsequent discussion about buoyancy in the USS Albacore, students will learn how to work through an engineering problem while considering criteria for success and constraints on materials, time, or cost, in accordance with the Maine, Massachusetts, and New Hampshire curriculum frameworks.

Connection to Curriculum Frameworks:
Maine
- 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost
- 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 4-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost
- 4-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost
    - 5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Massachusetts

- 3.3-5-ETS1-1.Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet.
- 7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices.

New Hampshire

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3.3-5-ETS1-2.Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem

Classroom Setup: Students must be able to work around a tub (or tubs) of water, so the classroom should be set up in a way that allows this kind of workspace. Paper towels should be on hand in case of spills. To social distance, set up multiple tubs throughout the classroom so that students can stand six feet apart when working.

Albacore Setup: Table set up under a tent with tub of water, Tupperware, weights, paper towels, spray for wiping down Tupperware, and Purell.

Introduction and Diagnostic Assessment:

- With a tub of water set up next to you, hold up an orange and ask the students if they think it will sink or float when put in the water
- After getting a few answers and asking for their reasoning, put the orange in the water…it floats!
- Now ask the students what they think will happen if the orange is peeled
- After taking a few answers, peel the orange and place it in the water again...it sinks!
- Ask if any of the students know why some things float and others sink
- Explain Archimedes Principle:
    - When you put an object in water, that object “displaces” some of the water, or forces it to move out of its way.
    - There is a force, called the “buoyant force” that presses up on the object with the same force that the displaced water presses down. (This force is also the weight of the displaced water)
    - In other words: When an object is in water, gravity pushes it down according to the weight of the object, while the buoyant force pushes it up according to the weight of the displaced water
- For an object to float, the buoyant force must be greater than the object’s weight
- When the orange has a peel, it displaces enough water for the weight of the water displaced to be greater than its weight.
- When the orange is peeled, it no longer displaces enough water for this to be the case. Since its weight is greater than the weight of the displaced water, it sinks.
- Because the peel was filled with air pockets, it was able to displace the additional water without adding too much to its own weight, like wearing a life jacket!

Procedure and Formative Assessment:

- Set up a large tub of water.
- Give each student (or group of students) small Tupperware and weights of assorted sizes (can use coins or any other objects you can think of)
- The students should, through trial and error, put the right amount of weight in the Tupperware so that it floats in the middle of the water (neutral buoyancy).
- Walk around to make sure that everyone understands the assignment. Ask them what is working and what isn't.

Follow-up and Summative Assessment:

- Bring the students back together and ask them how the experiment went
- Ask them how they think submarines manage to float in the middle of the water
    - What factors would have to be taken into account?
    - How would materials, time constraints, and cost figure into the equation?
- How do they think the crew controls submarines rising and sinking?
- Explain what ballast tanks are:
    - Submarines have tanks filled with air
    - When it is time for the submarine to submerge, the tanks are filled with water
- The Albacore had a special new kind of ballast tanks that were operated via a switch and indicator board rather than an air manifold
- If electricity went out on the Albacore, the electro-pneumatic valves would blow the ballast automatically, so the boat would quickly surface

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Life jacket under heading: https://commons.wikimedia.org/wiki/File:Pictograms-nps-water-life_jacket-2.svg