Sink that Boat!

Middle School | Standard(s): MS-PS2-2, MS-ETS-1-2, CCSS-ELA SL.2, SL.4, SL.6 | Topic: Overcoming buoyancy force | Developed by: ASNE

Overview: Students will try to sink objects representing boats and determine problems that can affect ships. By sinking boats students should begin to see some of the problems that boat designs could have. You can also ask probing questions about why things are happening to get at key scientific concepts like mass, the center of mass, buoyancy force, density.

Sample Lesson Flow

- Introductory engagement (3 min), investigating sinking methods in groups (15 min), discussing the sinking methods discovered (10 min), explore ship height and weight distribution in FLEET (15 min), exit slips (2 min)
- Introductory engagement (3 min), investigating sinking methods in groups (15 min), discussing the sinking methods discovered (15 min), investigating sinking methods in groups (15 min), discussing the sinking methods discovered (10 min), explore ship height and weight distribution in FLEET (15 min), discuss findings (5 min), create/diagram/test tinfoil boats (10 min), ensure notes are complete for next class (2 min)

Prior Student Knowledge Required:
- Continue implementing your engineering design process.

Student Learning Objective:
- Experiment with buoyancy, stability, and centers of mass.

Materials:
- Anything that can be in the water will be fine. Cans, containers, jugs, bottles, Frisbees, boxes, sandwich bags, have all worked well in previous investigations. If possible, have at least 3 per group so they can explore different shapes and densities.
- Students need to record sinking methods so that they can refer to them during the next lesson.
- Containers or sinks with at least 4-6 inches of water.
- One piece of tinfoil per person or group for closing activity.
- String or cord to pull boats.
- Computers with FLEET for students to investigate ship height and weight distribution.
- Tinfoil and test sink for students to build one boat that will definitely float and one that will definitely sink.
- Create two sketches and two descriptions of tinfoil boats.
- Students can draw their tinfoil boat designs with descriptions of what makes them float/sink.

LESSON PLAN – (This uses the 5-E Model)

Engage
1. Today’s work is all about sinking boats. By sinking boats students should begin to see some of the problems that boat designs could have. You can also ask probing questions about why things are happening to get at key scientific concepts like mass, the center of mass, buoyancy force, and density.

Explore
2. Actively reinforce your engineering process by briefly discussing each step of the process before you begin.
3. Ask students to take organized notes so that their notes next class (the next lesson is engineering a solution to one or more of the challenges that can sink boats).
4. Put the class into groups to investigate the challenge:
   ❄️ Today we are going to sink a boat in as many different ways as possible. By finding all...
the ways that boats can fail, we are able to identify engineering challenges. We will use your notes next class, so be sure to organize your notes well.

5. Let students imagine possibilities, sketch their idea, plan the study, and begin trying out the different ways to sink their boat. You can have these discussions as a class or students can discuss in their small groups.
   a. What data should we write down?
      i. Students will need to clearly describe each Sinking Method. But, what else would be useful? (“How hard it was to sink this way”, “How much of the boat sinks”, etc.) Students are starting to take ownership of what data they collect and how they use data starting with this lesson.
   b. Any other types of data we could collect?
      i. Students may take short cell-phone videos to document the research if you are fine with cell phone use. Students could use scales to weigh their boats, thermometers to measure whether water temperature is a challenge for boats, etc.
   c. NOTE: If your students hesitate for more than 1-2 minutes, you can show one of the Sinking Methods listed below to help them brainstorm.

6. Encourage students to use initial trials to spur new ideas about how to sink the ship.

7. Give students a five-minute warning and tell them that they will present their data to the class.

Explain

8. There are a couple of ways to organize this discussion:
   a. Ask groups to share 2 or 3 ways they found to sink the boat. OR,
   b. Use Scattegories™ rules and ask each group to share 1 new way to sink the boat. Go around the room until there are no unique solutions left. OR,
   c. If students recorded videos of each sinking method, you could use this video library to group into videos of the same problem.
   d. Record the answers so everyone can refer to them.

9. After you have a good list of ways to sink the boat, work together to sort the issues into two groups:
   a. Could be Completely Solved: Students could make a design that would never have this problem (e.g., a cardboard boat may get wet and let water seep in, but a different boat material would make this problem go away).
   b. Could be Partially Solved: Students could make it harder to sink a boat this way, but it is always possible (e.g., a wide boat could be sunk by pushing on the side, but if the boat had more weight in the middle, especially if that weight was under water, then it would be harder to tip a boat over and sink it.
   c. You may have an Unsure category too. That is fine to come back to later.

10. If possible, take a couple pictures and/or videos of successful sinkings. Share links to those pictures or videos on the FLEET Forum (http://www.navalengineers.org/Membership/Forum) under “FLEET Exchange.”

Some Sinking Methods
- Wave fills up boat from the side
- Something pushes boat down
- The boat tips over
- Boat has a hole below the water line
- Boat moves forward into a big wave
- Many, many more!!
11. Tie the conversation together by giving some scientific terms to the issues that the students see:
   a. **Mass**: the amount of matter in an object (similar to weight in the eyes of students)
   b. **Center of Mass**: The point in an object where there is the same amount of mass in every direction.
      i. *Sinking Methods* reflected: pushing on the side of the boat, pushing on the top of the boat.
   c. **Buoyancy Force**: The force from the water that makes the boat float
      i. *Sinking Methods* reflected: pushing straight down on the boat will overcome the buoyancy force, pulling down from underneath
   d. **Hull and material**: What the bottom of the boat is made from
      i. *Sinking Methods* reflected: Poking holes in the material, tearing the material or crumpling the material
   e. **Weather concerns**: Issues related to changes in weather.
      i. *Sinking Methods* reflected: Students may create “big waves” or simulate” heavy rain” which fill up the

12. **(Optional)** Give each group a piece of string and some tape. Ask them to investigate whether a boat in motion behaves the same as the boat sitting still.
   **(Optional) What are the you can sink your ship while it is moving?**
   Are the same ways to sink the boat still relevant?
   a. In addition to the variables the students are collecting ask students to record one variable for you: the height of the tape above the water.
   b. Students will find that the force from the string can sink the boat or make it flip over (capsize). This force is particularly destructive if it is above the center of mass.

13. **(Optional)** Use FLEET to experiment how ship height and weight distribution can affect ships. You can adjust the ship height by adding a radar tower. You can adjust the weight distribution easily by adjusting the water in the ballast tanks. Then, hit “Play” to use the Stability Test to see if the ship is stable or too unsafe for sailors to use.
   **(Optional) How does ship height and weight distribution affect the stability of your ship? What does stability tell us about whether the ship will sink or float?**
a. **Radar Towers**: Add a radar tower to this ship by going to the “Advanced” menu, click “Comms”, then select the “Dish Radar” or the “Doppler Radar”. Place the radar on the ship. Then, click directly on the radar tower to Edit the component. Experiment with “Height” by clicking on the bar to increase/decrease its length.

   i. Students can use a variety of heights, then test their ship using the Stability Test by hitting the play button ( ). (Ships will have to meet the basic requirements; consider using the default ship if this causes your students issue.)

b. **Ballast Tanks**: The default ship already has a ballast tank. You can access it by clicking the Ship icon in the upper left. In the Structure menu, you can see “Ballast Tanks”. Click on the “Water Tank” button. These are the tanks currently on your ship. Click the water button in the Edit component window.

   i. Students can adjust the water level in each tank strategically to “sink” the ship in the Stability Test.

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**Evaluate**

14. (Optional) Give students a piece of tinfoil to make two boats.

   (Optional) Use one sheet of tinfoil to create one “boat” you know will float. Write a sentence describing your thinking. Then, use your tinfoil to create another boat you know that will sink immediately. Write another sentence describing your thinking.

15. (Optional) Ask students to write a sentence that describes why they made each “boat” that way.

16. (Optional) Have students create a poster or write in a notebook with these sentences then have them sketch their boat from a couple different views.

17. (Optional) Then, let them test the boat.

18. (Optional) You or the student should hold on to the sentence for future reference. You could put the sentence and a picture of each boat with both sentences on a PowerPoint slide. Or, students could simply sketch their boat and keep the sketch and their sentence in their engineering notebook.

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**Additional Resources**

A. Here is a short video by the *Washington Post* about common ways boats sink:

   [https://www.youtube.com/watch?v=J0XBMuYDy1M](https://www.youtube.com/watch?v=J0XBMuYDy1M)

B. If you would like to use the closing activity as a full-class activity. We have a lesson plan for that too! You can find it at: [http://www.navalengineers.org/STEM-FLEET/For-Educators/FLEET-Centered-Curriculum-for-HS-Students](http://www.navalengineers.org/STEM-FLEET/For-Educators/FLEET-Centered-Curriculum-for-HS-Students)

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