FUTURE U.

Waterproof Transport

Objectives

Students will collaborate to design, build, and test a waterproof carrier that safely transports an egg underwater.

Overview

Students will be presented with the challenge of delivering materials to Boeing's underwater Echo Voyager through the development of a watertight protective carrier. Using as few materials as possible, the carrier should: 1) have a way for the materials to enter; 2) be waterproof; 3) provide protection so the materials don't break; and 4) ensure that the carrier will sink down to the vessel. After constructing their carrier, class-wide testing will be performed and students will assess each of the group designs. The activity will culminate with a discussion around the opportunities that their innovations present for protecting objects underwater and what may need to be considered if the carriers were to transport humans in the future.

Grade Range

5–8

Timing

45–60 minutes

Objective

Students will collaborate to design, build, and test a waterproof carrier that safely transports an egg underwater.

Materials Needed

- Echo Voyager images, to project or print
- Underwater Challenge handout, one per student
- Eggs, one dozen (regular or hardboiled)
- Water Contact Indicator Tape or washable markers
- Balloons, at least 10
- Plastic sandwich bags, at least 10
- Foil, at least one roll
- Duct tape, at least two rolls
- Scissors, at least 10

- Marbles, stones, or some other kind of weight, enough for the class to share
- Cushioning materials: bubble wrap, cottons balls, paper towels, etc., enough for the class to share
- Tall trash bin filled with water (greater than 2 feet tall but shallow enough so that your arm can reach the bottom!), one
- Towel, one for the instructor

Preparation

- Check with the classroom teacher about projection capabilities. In some cases, it may be easiest for you to send the website link to the teacher in advance. In other cases, you may be able to easily connect your laptop.
- Copy the *Underwater Challenge* handout.
- Prepare the materials in advance. It may be helpful to ask the classroom teacher about the best way to fill the trash bin with water before the session begins.

Next Generation Science Standards

MS: Engineering Design

- 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.
- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Procedure

1. **Warm-Up Activity:** Project or display the Echo Voyager images. Explain that this is a Boeing undersea vehicle called the Echo Voyager. It is an autonomous ship, which means it can drive and control itself without anyone onboard! It is designed to spend up to six months on any underwater mission.

   Ask the class to brainstorm: What challenges may unmanned or manned ships face if they stay underwater for months at a time?

2. Explain that Boeing would like to focus on the challenge of efficiently delivering materials to the underwater vessel so it doesn't have to come to the surface frequently…and you are recruiting the students' help with this!

3. Prepare the class for the challenge:

   - Divide students into teams of three or four.
   - Distribute an Underwater Challenge handout to each student.
   - Review the handout's Challenge Overview section.
   - Explain that, for this challenge, an egg will represent the contents that the carrier transports.
   - Distribute one egg to each group. Then guide students in either wrapping water contact

indicator tape around their egg or coloring their egg with a washable marker. Explain that both options will allow them to tell if their egg gets wet, because the tape will change color and the marker will smear.

- Review the other materials that groups will have available as they build their prototype. Remind the students that minimizing resources used to build their prototype will reduce materials costs and increase efficiency in production.
- Lastly, bring students' attention to the trash bin that the class will be using for their testing. Explain that during their trials, their carrier will be placed on the water's surface. The bottom of the trash bin represents the top of the Echo Voyager, so the carrier should sink to the very bottom of the bin.

4. Deduct about 15 minutes from the end of the session and tell students they will have this much time to complete Steps 1–3. At that point, the class will reconvene, test their designs, and complete the final steps. Then instruct students to begin following the instructions!
5. Rotate around the classroom as students work, and provide timing updates when there are 10 and then five minutes of work time remaining.
6. When there are 15 minutes left in the class period, assemble the class back together to begin the trials. Bring the students' attention to Step 4 on their handout. Explain that as each group shares and tests their design, the rest of the class should jot notes on its effective and ineffective design elements. They will later use these notes to optimize their design ideas.
7. Then call up groups to the water testing bin one at a time and guide them through the following process:
    - Encourage groups to briefly share their design decisions.
    - Instruct them to place their carrier (with the egg inside) on the water's surface.
    - After allowing a little time for the carrier to sink, determine whether it has met the criteria of sinking to the bottom.
    - Help the students remove the carrier from the water and fully dry it with the towel.
    - Ask the group to open their carrier to determine if it protected the egg from getting wet and from cracking, and have them share their results.
8. **Wrap Up:** Once the trials are complete, conclude the session with a full-class discussion around the students' learnings. Discussion questions may include:
    a. If we were to learn from all of our design successes, what elements could we combine to create an optimized carrier?
    b. Do you think it would be possible to recreate this optimized carrier on a larger scale so it could transport materials to the Echo Voyager? Why or why not?
    c. If Boeing wanted to use a carrier like this to transport humans to undersea vehicles in the future, what else should be considered?

Before you leave, thank students for their participation and encourage them to continue learning more about advances in exploration—in the ocean and beyond!

Underwater Challenge

Your Challenge: Help Boeing deliver materials to an underwater vessel through the development of a watertight protective carrier that:

- sinks down through the water to the vessel.
- uses as few materials as possible.
- includes a way for the materials to enter and exit.
- is waterproof.
- provides protection so the contents don't break.

Step 1: Review the materials available and brainstorm carrier ideas with your team. Sketch potential prototypes below and on the reverse side of this paper. Be sure to take all of the requirements into account!

Step 2: Choose a design that you think will be most effective while using minimal resources and work with your group to construct it. Make changes as needed throughout the building process.

Step 3: Prepare to briefly share your carrier with your peers and explain how your design meets each of the requirements.

Step 4: As you learn about your peers' design decisions *and* watch their trials, jot notes below:

Effective Design Elements	Ineffective Design Elements