SN EDUCATOR GUIDE
October 1, 2016

The SN 10: Scientists to Watch

The World in a Bucket Activity

Purpose: This activity accompanies the article "Tech-savvy seafarer tracks carbon," Page 22, which explores the work of Melissa Omand, an oceanographer at the University of Rhode Island. In this activity, students will model what happens to fluids under different conditions by observing drops of food coloring in a bucket of still and rotating water.

Notes to the teacher: This activity can be implemented as a discovery experience or as a validation experiment. There are many videos that show the phenomena explored here, such as this one from UCLA's SpinLab (focus on time stamp 23:50 to the end). If you'd like to make this a demonstration rather than student exploration, scale up the size of the materials and position a mirror (think cooking show) so students can look into your rotating bucket as you discuss what is occurring.

Background: On a large scale, factors like temperature variations, the rotation of Earth and pressure differences move air and water to create wind and ocean currents. These huge-scale phenomena can be modeled in the lab. Models have limitations, but they can help students visualize some of the basic principles of fluid motion to better understand the phenomena at the larger scale.

We've all seen water sitting still in a bucket. Maybe we've stirred it or splashed it about. When you stir the water inside the bucket, a vortex forms. By putting a bit of food coloring into the system, students can observe the direction that water moves (water gets pulled down the center of a vortex and out toward the sides of the bucket). That's one phenomenon that students may be familiar with. But have they tried spinning the bucket instead of the water? This creates a different type of motion. What if both rotation and vortex formation are introduced at once? This activity allows students to observe these conditions separately and in combination to understand the principles involved.

Materials (for each team):

- A rotating tray that can be placed on a desk, often called a lazy Susan, or a turntable. (If using a turntable, you have the benefit of setting a constant speed. But, if the center metal rod cannot be removed or lowered, you'll need to put a cover with a hole in the center over the top to create a flat surface.) Try to create a white surface on the tray or turntable so the movement of the colored liquids inside the bucket will be easier to see.
- A round bucket or container (about 4-quarts is a good size) with smooth, vertical sides that fits on the rotating surface. A clear bucket (available on Amazon.com from Rubbermaid, for example) is best.
- A dump bucket or sink to discard liquids after each exercise

- Food coloring
- Pipettes or straws for each color of food coloring
- Cylinder-shaped, high-sided cup (metal preferred)
- Ice
- Washers (for use as weights)

Directions:

1. Ask students what they already know about how air and water move on Earth. (Students may know that water and air will layer based on density — with warmer water sitting on top of colder water, for example. When waters of different densities come in contact, they will push around each other — sinking below or rising above — and create circulation patterns. If these concepts are unfamiliar to your students, you may want to start with some simple demonstrations of density differences before moving on.)
2. Play one of the many videos available that show how air and water move around the globe (this NASA animation of the flow of hot and cold air, for example, or this MERRA computer model of wind and water currents). Ask students what factors could be causing the air and water to move in the ways seen (temperature and salinity differences, land contours, the rotation of the planet, for example). Chart their responses.
3. Tell students that they will now set up their own experiments to visualize how fluids move under different conditions (see Blackline Master 3).
4. Have students place the bucket in the center of the rotating surface and fill to two-thirds with water.
5. Before starting the rotation, demonstrate how to create agitation (quickly dunk one hand into the bucket in a swirling motion). Explain that the agitation represents disruption to the system.
6. Next show students how to set up the rotation of the bucket. This might take a little practice. Have students practice creating a constant rotation of the tray (students will have to push the tray on their own to get it to spin at about 20 rotations per minute) or the turntable (you want to set it to slow).
7. Set students to work, reminding them to dump out the water and refill their buckets after each exercise.
8. Once students have completed Part 1 of the experiment, discuss what students observed and how the experiment relates to the videos shown. (When there is no rotation and the water is agitated, the food coloring mixes into the surrounding water in three dimensions. The result is very similar to what happens when a hurricane forms. Yet, when the bucket is rotating and the water is agitated, the water forms two-dimensional columns that do not mix. This result resembles water eddies and larger ocean currents.)
9. Give each team a cylinder-shaped cup filled with ice water (the colder the better). Have them place the cylinder upright in the center of their bucket. They can place weights in the bottom of the cup for stability. Ask students to predict how this new variable, a temperature variation, could affect their

experiment. Have them repeat their experiment to observe whether they get the same or different results.

10. Once they have completed Part 2 of the experiment, ask students to draw parallels between what they see in the bucket and air and ocean circulation. (Hot air rises over cold air, creating air circulation. Cold water sinks under warm water, driving movements in the ocean.)

Optional Extensions:

- Have students explore what happens when the rotation speed is changed (faster and slower).
- Have students think about what would happen if the temperatures of the water changed in Part 2 of the experiment. Connect this to a discussion about the possible effects of climate change.

This activity was inspired by the Weather in a Tank projects put together at MIT. For more resources on ocean currents, visit this link from the National Ocean Service. For more on wind and air circulation, visit this link from the University Corporation for Atmospheric Research.

SN IN HIGH SCHOOLS
October 1, 2016

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World in a Bucket Activity

Scientists isolate variables so they can understand what causes a phenomenon to occur. In the first part of this experiment, you will observe what happens to food coloring when placed in a bucket of water under each of four conditions. You will then add the variable of temperature and observe whether this changes how fluids move.

PART 1: ROTATION AND AGITATION

Directions:

1. Set up your bucket. Fill it two-thirds with water and place it on your tray or turntable.
2. Practice spinning your tray or turntable so you can achieve a constant rate of rotation.
3. Create the environments as listed in the table below.
4. Drop one pipette full of food coloring into the bucket.
5. Watch what happens to the food coloring. Does it move? If so, how? Record your observations in the table below.
6. Think about how fluids move in the real world (on small or large scales). If the exercise reminds you of a situation you've seen elsewhere (from personal experience or in videos), add that to your observations.
7. Clean out your bucket and refill with clean water for the next exercise and repeat.

Use the space provided to record your observations

Exercise 1: No rotation and no agitation	**Exercise 3: Rotation but no agitation**
Exercise 2: No rotation with agitation	**Exercise 4: Rotation with agitation**

PART 2: CHANGING TEMPERATURE

Directions:

1. Set up your bucket as you did in Part 1.
2. Place a tall-sided cup full of ice water in the center of your bucket. You may need to place some washers in the bottom of the cup to help it stay in place. Try not to agitate the water around the cup in your setup.
3. Think about the effect the ice-filled cup will have on the water in the rest of the bucket. What do you think you'll see when you put the food coloring into the system?
4. Create the environments as listed in the table below.
5. Drop one pipette full of food coloring into the bucket.
6. Watch what happens to the food coloring. Does it move? If so, how? Record your observations. Include any parallels with phenomena or situations you've seen in the real world.
7. Clean out your bucket and refill with clean water for the next exercise and repeat.

Use the space provided to record your observations

Exercise 1: No rotation and no agitation	**Exercise 3: Rotation but no agitation**
Exercise 2: No rotation with agitation	**Exercise 4: Rotation with agitation**