Analysis and Application: Water in a Cup Demo

In this activity, you will demonstrate what happens when a cup of water covered with an index card is inverted. You will discuss with your students what this reveals about the omnidirectional nature of air pressure.

Materials

- A plastic cup filled with water
- An index card slightly larger than the mouth of the cup

Steps

- Fill the cup full with water and place the index card on top of the cup.
- **Ask:** "Predict what will happen when I turn the cup upside down." Have students write down their predictions on a piece of paper.

Note to Teacher: Do the next steps over a sink or large container to catch any water drippings; also make sure that the hand holding the card is dry.

- Put one hand on top of the card and invert the cup, holding the card in place.
- Take the hand that was holding the card slowly away. (*The water should stay in the cup*.)
- **Ask:** "What do you think is keeping the water in the inverted cup? Write down your ideas on the piece of paper." Encourage students to include a drawing to help them to explain their idea.
- **Ask:** "What caused the water to stay in the cup when it was upside down?" Elicit responses from the class.
- Have students discuss their responses from the initial activities with a partner. Then they should draw a model to explain what happens with the water in the cup. How have their ideas changed?

- **Follow-up Questions**

Do:

Use your TOE: Conceptual understanding, Inquiry, and Discourse Rubric/foldable to analyze this activity

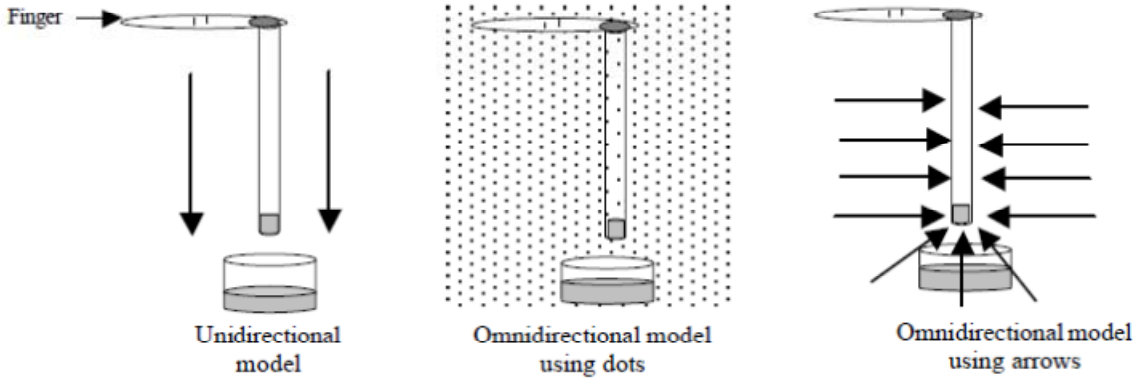
Ask:

- "What does this activity suggest about whether air pressure only pushes down or whether it pushes in other directions, too? What do you think?" Have students share their models as part of the discussion.
- "What do you find puzzling about the activity? What does and does not make sense to you?"
- "Do you think that this activity offers convincing evidence that air pressure works in all directions? Why or why not?"

Note to Teacher: The reason this activity works is because the air pressure (14.75 lbs. per square inch) acting omnidirectionally outside the cup is greater than the air pressure inside the cup. If the cup is completely full, there is no air, and therefore no air pressure in the cup, so only outside air pressure is acting to keep the water in the cup. If the cup is not completely full, then Boyle's Law is in action. As you invert the cup, some water

drips out, and the volume containing the air pocket increases. However, no more air can enter the cup, so the air in the pocket spreads out to fill the available space and the air pressure is lowered. The outside air pressure is greater than the inside air pressure, so the water stays in the cup.

What is the difference between the *Water in a Straw* activity and this activity (see diagram below)? In the straw activity, you don't need a card across the bottom of the straw because the diameter is small enough that the **surface tension** of the water forms a meniscus and prevents the water from dripping and the air from displacing the water. Unlike the *Water in a Straw* activity, turning the cup sideways often results in the seal to the paper breaking and the water spilling out. Theoretically, however, one should be able to turn it sideways



So, if we are high school teachers, this is called "Boyles's Law" and it is represented by symbols: P1V1 = P2V2 and we say that decreasing volume increases collisions and increases pressure and a model of how that looks is:

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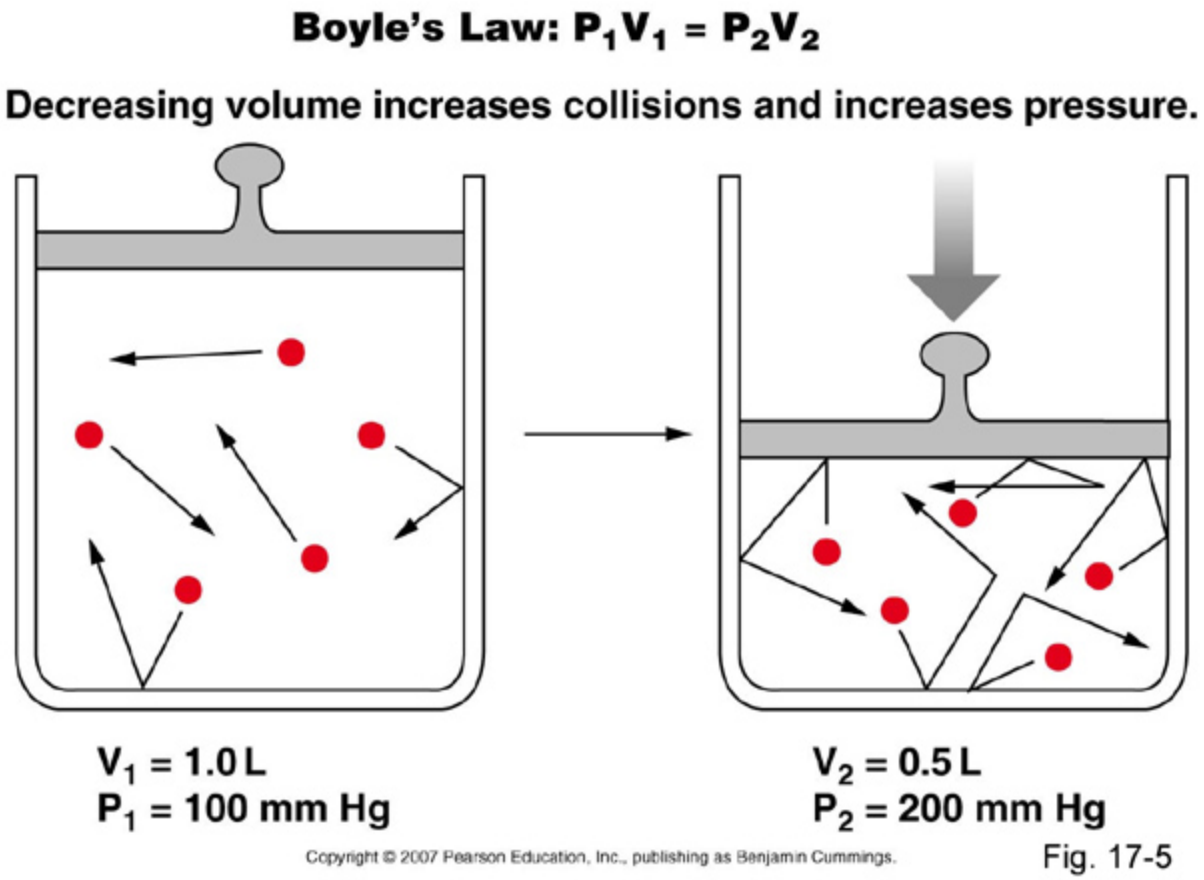

Show clip from *A Private Universe: Where does most of a tree's mass come from?*

Ask for reactions to clip. Why do these students believe that most of a tree's mass comes from water or soil?

Do we explicitly teach students that the mass of trees comes from water or soil?

Why do they believe that?

How do we usually teach photosynthesis? (Usually, the equation first or near the beginning)

Is the equation conceptual or procedural?

What is the concept behind photosynthesis?