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NON-NEWTONIAN FLUIDS: CORNSTARCH AND WATER *(AKA OOBLECK)*

A WVU Extension Service STEMCARE Lesson

Audience:

Grades K-8

Time:

45 to 65 minutes

20 minutes to read "Bartholomew and the Oobleck" (optional); 10 minutes for introduction to activity and review of solids and fluids; 15 minutes for students to observe the properties of cornstarch-water mixture; 10 minutes for teacher to share the science behind oobleck; 10 minutes for students to record reflections; 5 minutes for clean up.

Goal:

To understand non-Newtonian fluids.

Materials:

For up to seven student groups:

Oobleck: One 16-ounce box of cornstarch; large mixing bowl and spoon; approximately 7/8 cup water (plus more if needed; green food coloring (optional)

12-ounce plastic cups (one per group); shallow aluminum pans or plastic containers (one per group); blank paper to record observations; newspaper or a plastic tablecloth to cover the table and floor; paper towels and baby wipes; examples of solid and fluid materials; book "Bartholomew and the Oobleck" by Dr. Seuss (optional)

Safety Precautions:

This mixture is nontoxic, but the food coloring may stain clothes or other porous materials. Do not pour the mixture down the drain; it can clog pipes.

Vocabulary:

Solid, fluid, viscous, non-Newtonian fluid, sheer force

Introductory Activities

1. Prepare the Oobleck Prior to the Class
   a. Mix the box of cornstarch with 7/8 cup water (ratio = 1/2 cup of cornstarch to 1/8 cup of water).
   b. Add four to five drops of green food coloring if desired. Mix well (it is easiest to mix with your hands). The mixture should be the consistency of honey. Add additional water or cornstarch as needed. The mixture should feel hard or stiff when the surface is punched, poked or slapped.
   c. Divide the mixture among the plastic cups.
   d. Distribute to each student group: one plastic cup containing oobleck, one open shallow container and one piece of blank paper.
2. Read "Bartholomew and the Oobleck" by Dr. Seuss (optional).
3. Display and discuss properties of solid and fluid materials.
   Note: Fluids can be gas or liquid.
   a. Fluid – no definite shape, conforms to pressure, and may be thick and viscous, like syrup, or runny and nonviscous, like liquid water.
   b. Solid – has a definite shape and can maintain its shape with the application of a sheer force.

Core Learning Activity: Non-Newtonian Fluids

Students record observations of the oobleck at each of the following steps:

1. Pour the mixture into the aluminum pan or plastic container. Notice its unusual consistency when you pour it into the pan. Stir it around with your finger—first slowly and then as fast as you can.
2. Skim your finger across the top of the glop. What do you notice?
3. Sink your entire hand into the glop and try to grab the fluid and pull it up. Note: This works best if using at least 2 cups of the mixture per container.
4. Try to roll the fluid between your palms to make a ball. If you stop rolling, the solution becomes runny again.

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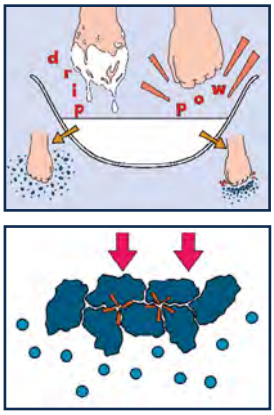
5. Hold your hand flat over the top of the pan and slap the liquid glop as hard as you can. Most students will run for cover as you get ready to slap the liquid, fearing that it will splash everywhere. Fear not; at the right consistency, all the glop stays in the pan.
6. Ask students why the liquid behaves in this manner. What causes it to feel like something solid when you squeeze it, yet flow like syrup as it drips off your finger? Students should notice that force or pressure seem to make it thicker, and without pressure or force, it is thin and runny. Explain the science behind oobleck to the class. Allow students time to observe the mixture again.

Evaluation

Students may submit a written or audio response to the following prompt: Why is oobleck like a liquid sometimes and like a solid at other times?

Background: The Science Behind Oobleck



A shear-thickening non-Newtonian fluid. (Credit: Hannah Carey, Department of Chemical and Biomedical Engineering, WVU)

Oobleck is a suspension of cornstarch particles dispersed in liquid water. This non-Newtonian fluid defies Isaac Newton's law of viscosity, which states that fluid can be changed only by changing the fluid's temperature. For example, you can make honey thinner if you heat it but not by adding pressure or force. Oobleck is different than honey because it's viscosity changes under pressure not heat. Oobleck is an example of a shear thickening non-Newtonian fluid, because its viscosity increases when pressure or a force is applied.

Why?

Cornstarch particles have a rough surface. When a fast shear force is applied (like punching it), the long starch molecules are forced closer together causing the particles to lock together. The impact of this force traps the water between the starch chains to form a semi-rigid structure. When the pressure is released or a slow shear force is applied, the particles roll over each other allowing the cornstarch to flow again.

Everyday Implications of Non-Newtonian Fluids

- If a house is built on certain types of clays and an earthquake puts stress on this material, the solid ground can turn into a runny liquid.
- Ketchup is a shear thinning non-Newtonian fluid, so its viscosity decreases with increasing shear stress. That's why it often dumps out all over your food when you hit the bottle.

Fun Oobleck Videos

Oobleck on a Speaker: https://www.youtube.com/watch?v=3zoTKXXNQIU

Oobleck in Slow Motion: https://www.youtube.com/watch?v=Sl0BHueSjvA

Resources

Steve Spangler Science, www.stevespangulerscience.com.

Wikipedia, http://en.wikipedia.org/wiki/Non-Newtonian_fluid.

http://culturalfollylexicon.blogspot.com/2011/07/oobleck.html.

West Virginia Next Generation Standards

General Science

- S.2.GS.1 – Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- S.5.GS.3 – Make observations and measurements to identify materials based on their properties.

WVU STEMCARE Non-Newtonian Fluids Demonstration Video: https://youtu.be/DhfGx7_oASk

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4H20-151