CREEPY PUTTY

Grades 3–5, 6–8

30–45 minutes

DESIGN CHALLENGE

Experiment with the properties of materials as you manipulate a Silly Putty-like material to have different degrees of viscoelasticity. Create a material that is elastic but peels away easily from surfaces.

MATERIALS

Supplies and Equipment:

- ☐ Water
- ☐ 2 mixing bowls or pitchers
- ☐ 2 cereal-sized bowls per team

Consumables:

- ☐ Silly Putty
- ☐ 1 gallon Elmer's school glue
- ☐ 1 box Borax
- ☐ 1 box sandwich-size zipper bags
- ☐ Plastic spoons (3 per team)
- ☐ 50–100 plastic cups
- ☐ Optional: Food coloring

Multicolor putty showing its liquid properties. Credit: © ITL Program, College of Engineering and Applied Science, University of Colorado, Boulder.

GETTING READY

Save time by mixing the two solutions below in advance of the activity. You could do this with the participants if you have plenty of time.

Saturated Borax solution:

- ■ Fill a pitcher or mixing bowl with hot water.
- ■ Add a small amount of Borax and stir until dissolved.
- ■ Repeat until no more Borax will dissolve.
- ■ Cool to room temperature. (Some Borax may be present in the bottom of the container—this is okay.)

2:1 glue/water solution:

- ■ Pour 2 parts Elmer's school glue into a mixing bowl. (If possible, get your Elmer's glue in gallon quantities. This makes mixing your glue solution easier and creates less plastic waste.)
- ■ Add 1 part water.
- ■ Stir gently until mixed.

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GETTING READY (CONTINUED)

Set up the activity by putting out bowls of Borax solution, glue solution, and water. Place plastic spoons at each bowl.

INTRODUCTION

Show participants the Silly Putty. Is it a solid or a liquid? It can flow like a liquid and takes the shape of its container, but it also bounces and can be broken like a solid. Ask participants to think of very soft solids, like some foams, and very thick (viscous) liquids, like syrup.

Silly Putty is a **viscoelastic material**. Viscoelastic materials have properties of solids and fluids, depending on how they are handled. Silly Putty takes the shape of its container like a fluid, but it can bounce and be ripped apart like a solid.

INSTRUCTIONS

Ask participants to explain the difference between a solid and a liquid.

- The molecules in a solid are packed tightly and bonded in a matrix, making the material rigid. Solids hold their shape.
- The molecules in a liquid can move around, allowing it to flow. Liquids take the shape of their container.

Introduce the design challenge. Describe the desired properties of the end product: elastic and easily peeled off of surfaces (like Silly Putty). Explain the 3 ingredients available: glue solution, Borax solution, and water. Participants may use the ingredients in any combination, but they are limited to 4 spoonfuls of ingredients per batch.

Provide instructions to the participants:

1. Add the desired amount of glue solution to a cup. Add up to 2 drops of food coloring if desired.
2. Add the desired amount of water to the cup. Mix thoroughly.
3. Add the desired amount of Borax solution to the cup. Mix thoroughly with a spoon until your mixture appears thick enough to meet your requirements. (Depending on the ratio of ingredients, some liquid may remain in the cup. This liquid can be discarded.)

Examine the products. How do they compare to the desired outcome? Try different combinations until the conditions of the design challenge are met.

Participants may store their putty in a plastic zipper bag to prevent it drying out.

Evaluate the success of each design:

- ☐ Was your final material elastic?
- ☐ Could you peel your final material off of a surface such as a table or your hands?

ACTIVITY VARIATIONS

Have participants write out the amount of ingredients of the combinations they make on multiple trials, along with written descriptions of the product. Illustrate the results with a graph.

TROUBLESHOOTING

- Avoid cross-contaminating your mixing solutions by keeping the spoons for each solution separate.
- Test several recipes before you begin the activity. If no solid product forms, ensure that you are working with a saturated Borax solution and that you did not water down the glue too much.
- Some brands of white glue may not work.

RELEVANT TERMINOLOGY

Elasticity: The ability of a material to return to its original shape after being stretched or pulled. Rubber bands have elastic characteristics.

Fluid: Something that takes the shape of its container. Air, water, and oil are all fluids. (For older kids and adults: A state of matter in which the molecules can move past one another; fluids assume the shape of their container.)

For older kids and adults:

Polymer: A compound, like starch, that is made of large molecules with relatively simple repeating units.

Solution: A mixture of two or more substances in which the particles are dispersed evenly throughout. Kool-Aid that is completely dissolved in a pitcher of water is a solution.

Viscoelastic material: A material that behaves like an elastic solid and a viscous liquid, meaning that it can change its shape when pressure is applied but can also flow slowly.

GUIDANCE FOR YOUNGER CHILDREN

QUESTIONS TO ASK AFTER THE ACTIVITY

- What was your first product made of? Did you change the recipe? Did that make it better or worse?
- How do you think this process relates to the design process that engineers follow?
- How did you test your putty material?
- How did you go about improving your putty mixture?
- What was the best putty recipe you discovered?
- Did you notice which ingredients make the putty more goopy or more firm?

ENGINEERING CONNECTIONS

Materials engineering is one of many types of engineering. It combines different sciences, such as chemistry, with mathematics to design useful materials. Materials engineers use their experience and education to create products like metals, ceramics, and plastics. They figure out how to make things stretchy, stiff, hard, or soft—whatever is needed for a particular product.

Silly Putty was invented by engineers working for General Electric and Dow Corning during World War II as they were searching for a cheaper substitute for synthetic rubber. It turned out that the putty they invented wouldn't work as a good substitute for rubber, but it did work as a fun toy!

SCIENCE CONNECTIONS

Everything in the world is made of molecules, which are so tiny that scientists only saw them for the first time in 2013, using an atomic force microscope. Sometimes molecules string together in a repeating pattern in a very long chain, like a string of lights on a Christmas tree. A polymer is a special kind of substance that is made up of molecules strung together in this way. The thing that makes polymers so much fun is how they behave when you change the molecules that they are made of or change how those molecules are put together. Some polymers are rubbery like a bouncy ball, others are sticky like Silly Putty, and some are even hard like plastic.

Polymers can be natural or manufactured. Wool and silk are two examples of polymers found in nature. Humans have used these natural polymers for thousands of years. Plastics, rubber tires, and Silly Putty are polymers manufactured by people.

GUIDANCE FOR OLDER YOUTH AND ADULTS

QUESTIONS TO ASK AFTER THE ACTIVITY

- What was the best putty recipe you discovered? Can you make any general statements about the relationship between the ingredients?
- How did you test your putty mixture?
- What modifications did you make while designing your putty mixture?
- What properties did you observe to assess your putty mixture? How did you determine the best ratio of Borax to glue and to water?
- How does this design challenge relate to the work performed by chemical or material engineers?

ENGINEERING CONNECTIONS

Materials engineers create new plastics, metals, ceramics, conductors, and coatings. Most materials engineers work with only one of the following types of materials: metals, ceramics, polymers, semiconductors, or combinations of materials known as composites. These professionals first select the materials used to design a specific product and then carefully monitor the entire process during which those materials are combined into the final product. Everything around us is made of materials, many of which would not exist without materials engineers.

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SCIENCE CONNECTIONS

Polymers are special materials that consist of very large, chainlike molecules bonded (connected) together by another chemical. By contrast, water is a small molecule. It's made of only 3 atoms: 2 hydrogen and 1 oxygen. Polymers can have 10,000–100,000 atoms per molecule! These large molecules get tangled up with one another, like cooked spaghetti noodles. Some polymers occur naturally, but others are manufactured by engineers and chemists. These human-made polymers, called synthetic polymers, include polyethylene, nylon, and Teflon, and can be used in a wide variety of applications. Wool, silk, and DNA are examples of natural polymers.

Elmer's glue is a polymer. But Silly Putty is different: it is based on a silicone polymer, whereas Elmer's base molecule is vinyl. Unlike most polymers, silicone polymers do not have carbon in their backbone structure. Instead, silicone polymers have a backbone structure built of silicon and oxygen. Silly Putty's ability to flow comes from an ingredient called polydimethylsiloxane (PDMS), which is a viscoelastic substance. This means that it acts like both a viscous liquid (something that flows) and an elastic solid.

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TEACHENGINEERING curriculum for k-12 teachers

www.teachengineering.org/sprinkles/view/cub_creepysillyputty

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