A Scientist's Toolbox

INTRODUCTION

From an early age, students learn that science affects our lives in countless ways. Colonists in America encountered science in their daily living as well, but they did not always have theoretical knowledge of the principles upon which this science is based. Tradespeople in particular learned how to ply their crafts without benefit of scientific explanations about why their techniques worked or failed to work. Brickmakers, for example, heated Virginia clay to change its chemical composition and shape it into sturdy bricks, but they did not know the chemistry behind the process. Instead, they learned from practice, trial and error, and generations of experience how long and at what temperature to fire the bricks. Today, however, we have the scientific knowledge they lacked. In this lesson, students examine several scientific principles and explore their importance in the lives of eighteenth-century tradespeople and their customers.

OBJECTIVES

As a result of this lesson, students will be able to:

1. Identify the scientific principles behind eighteenth-century technology.
2. Describe how these scientific principles work.
3. Explain how the scientific principles are used in everyday situations.

STANDARDS OF LEARNING

This lesson meets the National Standards for Science Education in the areas of inquiry, physical science, technology, and the history/nature of science.

This lesson meets the National Standards for History in the area of historical analysis and interpretation.

MATERIALS

Scientific Principles Graphic Organizer
Activity Center #1 Instructions
Activity Center #1 Task Cards
Teacher Answer Key for Activity Center #1 Task Cards
Activity Centers #2–8 Instructions

Provided by teacher:

[**Note:** Before gathering the following items, check with the science teachers in your building. Many of these materials come in kits that they may already have.]

small paper plates
chalk
one new nail and one rusty nail
white vinegar
pulley
five pencils, unsharpened
shoebox filled with shells, rocks, or other heavy material
two eyedroppers
500-ml beaker
modeling clay
container of soap bubbles with wand
cornstarch
water
two small bowls

string
textbook
dry cereal, such as O-shaped cereal
two small cups
wooden freezer pop sticks
toy car
small ramp (for toy car)
materials for students to devise a small wedge (for toy car)
moist towelettes (for hands)
small weights
cotton balls
one marble
"bouncing" putty, such as Silly Putty®
wooden block
tape measure or ruler
paper towels

SETTING THE STAGE: PREPARING ACTIVITY CENTERS

Activity Center #1: Chemical and Physical Changes (four tasks)

1. Break the chalk into enough pieces so that each group has one. Leave extra pieces of chalk and paper plates in the center of the work area so students can set up for the next group.
2. Place a piece of chalk on a paper plate.
3. Pour 300 ml of white vinegar into a beaker; place an eyedropper in the beaker.
4. Place a copy of Task Card A next to the chalk and vinegar.
5. Place a chunk of modeling clay on the table; place a copy of Task Card B in front of it.
6. Place a new nail and a rusty nail side by side on the table. Place a copy of Task Card C in front of them.
7. Place the container of soap bubbles on the table; place a copy of Task Card D in front of it.
8. Place Activity Center #1 instructions in the center of the area.

Activity Center #2: States of Matter

1. In a small bowl, mix one cup of cornstarch with approximately ½ cup water. Stir until the mixture becomes smooth.
2. Place moist towelettes for students to clean their hands after the experiment.
3. Place instructions in the activity area.

Activity Center #3: Properties of Matter

1. Set a cotton ball, bouncing putty, wooden block, and marble in the center of the activity area. Leave extra cotton balls in the center of the activity area so that students can set up for the next group.
2. Place a small cup of water and an eyedropper near the other materials.
3. Place paper towels in the center of the activity area.
4. Place instructions in the activity area.

Activity Center #4: Force

1. Set out a large quantity of wooden freezer pop sticks.
2. Set out a box of small weights.
3. Place instructions in the activity area.

Activity Center #5: Lever

1. Pour a small amount of O-shaped cereal into a bowl and place in the center of the activity area. Make sure the activity area you are using has enough space for students to flip pieces of cereal a few feet.
2. Set out a wooden freezer pop stick and a pencil.
3. Set out a small cup and a ruler or tape measure.
4. Place instructions in the activity area.

Activity Center #6: Pulley

1. Place the shoebox filled with heavy materials in the activity area.
2. Tie a string securely around all four sides of the box (so that it won't open accidentally). Leave a long end of string for students to wrap around a pulley.
3. Set the pulley next to the box.
4. Place instructions in the activity area.

Activity Center #7: Wedge and Inclined Plane

1. Set out the ramp and the toy car.
2. Set out materials for students to devise a small wedge.
3. Place instructions in the activity area.

Activity Center #8: Wheel and Axle

1. Set four pencils in the activity area.
2. Tie a long piece of string around the textbook and set it in the activity area.
3. Place instructions in the activity area.

STRATEGY

1. Tell students that they will learn how tradespeople during America's colonial period used science in everyday life. They will do simple experiments with common examples of basic scientific principles.
2. Distribute copies of the Scientific Principles Graphic Organizer to all students.
3. Divide the class into eight groups of two to three students.
4. Tell students that each group must *first* read the instructions in the center of their assigned activity area(s). Explain that they should follow the directions, then complete their group activities, and, finally, answer all the questions on the graphic organizer.
5. Students should spend five minutes or less at each activity center. (Or, if time is limited, assign only centers 1–4 or 4–8, so that each half of the class does half of the activity centers. Allow time for sharing results.)
6. After students have completed all assigned activities, reconvene the class. Conduct a brief discussion about the students' observations and the answers they recorded on their graphic organizers. You may want to collect and display the correct answers.

LESSON EXTENSIONS

1. Ask students to look around their homes. Where do they see examples of the scientific principles identified in this lesson? Have them make a list of specific objects or situations that demonstrate one or more of these principles. If possible, they should bring at least one object to school as an example. Next, ask students to choose a day during which they keep a list of where and when they see one or more of these scientific principles demonstrated at school. They should be sure to record which principles they observe and how they work.

2. Have students use the Internet, the school's media center, or the public library to look for information about Rube Goldberg. They should read about his "contraptions"—comical machines that he designed to make simple everyday tasks extremely complicated. On their own or working with others, have students design a Rube Goldberg-type machine that incorporates one or more of the scientific principles reviewed in this lesson. For ideas and inspiration, or for information on the Machine Contest open to high school and college students, see www.rubegoldberg.com.

Scientific Principles Graphic Organizer

Directions: For Activity Centers 1–8, use this chart to record observations and answer questions.

Activity Center	Write the Definition	Results/Observations	Answer Questions
1	Physical changes: Chemical changes:	Physical or Chemical Change? Vinegar + chalk = Clay = Rusty nail = Bubbles =	What is the difference between a physical and a chemical change?
2	States of matter:	Write down your observations of the cornstarch and water mixture.	What did you do to the cornstarch and water mixture to make it a solid? What did you do to make it a liquid?

Activity Center	Write the Definition	Results/Observations	Answer Questions
3	Properties of matter:	List as many properties of matter as you can think of for each of these objects: Cotton ball Marble Putty Wooden block	What happened when you added water to each item? Did each repel or absorb the water? Cotton ball Marble Putty Wooden block
4	Vertical force: Lateral force:	Draw a picture of the structure(s) you built.	How much weight did your structure hold? What could or did you do differently to make it stronger?

Activity Center	Write the Definition	Results/Observations	Answer Questions
5	Lever:	Complete this activity three times, moving the fulcrum (the point where the stick meets the pencil) each time. Measure the distance that your cereal piece traveled and record each of the results. 1. 2. 3.	Explain what happened as you moved the fulcrum from one side of the freezer pop stick to the other.
6	Pulley:	On a scale of 1 to 10 (10 being easiest), how hard was it to lift the box using: One finger? Pulley?	Did the pulley make lifting the box easier? How else can pulleys be used?

Activity Center	Write the Definition	Results/Observations	Answer Questions
7	Wedge: Inclined plane:	Draw a diagram of how your wedge stopped the toy car from rolling down the ramp.	What did you use to devise your wedge? How else are wedges used in everyday life?
8	Wheel and axle:	On a scale of 1 to 10 (10 being easiest), how hard was it to pull the books using: Just the string? Wheel and axle?	Which method of pulling the textbook was easier: the string alone or the wheel and axle? Why?

Activity Center #1 Instructions: Chemical And Physical Changes

Understanding the differences between chemical and physical changes is important. Both types of changes are based on observing chemical reactions and states of matter. However, physical changes refer to energy and states of matter; a physical change does not produce a new substance. A chemical change, on the other hand, alters the structure of the substance's molecules and produces a new substance.

Physical change: Occurs when the substance remains the same before and after the change and the change can be undone. Physical changes are caused by energy, motion, temperature, and pressure. A piece of paper cut into pieces is still paper, but it now has a different shape. Melting a piece of ice or heating water until it turns to steam does not change water into another substance; it only changes water's form. The particles of the substance have been rearranged.

Chemical change: Occurs when the original substance (before the change) is not present after the change; a new substance has been formed and the change cannot be undone. Think about a log in a fireplace. If it is never lit, it will not change. If you set the log on fire, however, the fire burns the wood to ash. The wood is no longer the same substance. A chemical change has occurred, and the particles of the log have been broken down and rearranged. A new substance—ash—is in its place.

Follow the directions on the Task Cards, and write your responses on the graphic organizer.

Activity Center #1 Task Cards

Task Card A: Chalk and Vinegar

1. Using the eyedropper, apply 3–5 drops of vinegar to the chalk.
2. Observe the reaction. Is it physical or chemical? Why?
3. Discard the chalk and paper plate and replace them with fresh ones for the next group.

Task Card B: Modeling Clay

1. Take a piece of the modeling clay.
2. Mold the clay into a new shape.
3. Is the result a physical or chemical change? Why?

Task Card C: Rusty Nail

1. Look at both the new and the rusty nail.
2. Closely observe the differences.
3. Has the rusted nail undergone a chemical or a physical change? How do you know?

Task Card D: Bubbles

Task Card D: Bubbles

1. Take the container of soap bubbles and blow a few bubbles onto the table using the wand.
2. Observe what happens.
3. Is this a physical or chemical change? Why?

Teacher Answer Key for Activity Center #1 Task Cards

Task Card A: Chalk and Vinegar

Answer: Chemical change. The chalk contains calcium, and vinegar is acetic acid; together, these substances form carbon dioxide, a different substance.

Task Card B: Modeling Clay
Answer: Physical change. However you change the shape, the material is still clay.

Task Card C: Rusty Nail
Answer: Chemical change. The iron atoms in the nail have reacted to oxygen atoms in the air to form a product called iron oxide, or rust.

Task Card D: Bubbles
Answer: Physical change. Even though the bubble doesn't have its original shape or consistency after it comes in contact with the table, it is still soap.

Activity Center #2 Instructions: States of Matter

Everything in the world is made of matter. Matter is found mostly in three forms: solid, liquid, and gas. A solid has a fixed shape and volume. (Your desk, for example, is a solid.) A liquid has a fixed volume, but it changes shape based on the container it is in. (Picture a cup of water poured into an empty fish tank. The water takes on a different shape in the fish tank than it had in the cup, but it is still the same amount of water.) A gas has no fixed shape or volume. (The air around you is a mixture of gases that you can't see.)

Activity: Changing States

1. Look at the cornstarch and water mixture.
2. Hold some of the mixture firmly in your hand. What form of matter is it? Open your hand and spread your fingers. What happens to the mixture? What form of matter is it now?
3. Wipe your hands, then record your observations and answer the questions on your graphic organizer.

Activity Center #3 Instructions: Properties of Matter

Everything in the world is made of matter. When scientists talk about matter, they usually describe its properties, just as you might describe your friends by the way they look and their personalities. The physical properties of an object can include:

- mass (the property of a body that causes it to have weight)
- volume
- density (the mass of a substance compared to its volume)
- shape
- length
- color
- melting point (temperature at which it starts to melt)
- boiling point (temperature at which it starts to boil)
- luster (how shiny it is)
- hardness

Activity: Properties of Matter

1. Look at the cotton ball, putty, wooden block, and marble. Make a list of the physical properties of each object on your graphic organizer.
2. Use the eyedropper to apply a small amount of water to each object. Record what happens.
3. When you are finished, discard the cotton ball and replace it with a new one for the next group.

Activity Center #4 Instructions: Force

A force is a push or pull on an object. When engineers build houses, bridges, tunnels, and other structures, they design them to stand up to these forces. Gravity is the main force that pulls objects; this is an example of vertical force. Wind is a natural force that pushes against the sides of structures; this is an example of lateral force.

Activity: Resisting Vertical Force

1. Use the freezer pop sticks to build a structure that you think can withstand vertical force.
2. Place weights on top of the structure one at a time. See how many it can support before it collapses.
3. Draw your tower in the graphic organizer and answer the questions.
4. If you have time before moving to the next activity, try to design a stronger structure and repeat the process. Does the second structure withstand more weight? How?

Activity Center #5 Instructions: Lever

A lever is a simple machine that makes work easier. It consists of a bar or board that pivots (turns) against a fixed point called a fulcrum. If you have ever used the claw end of a hammer to remove a nail, you have used a lever.

Activity: Build a Catapult

1. Place a pencil on the table.
2. Lay a freezer pop stick across the pencil with one end touching the table.
3. Place a piece of cereal on the end of the stick that is touching the table.
4. Have another student hold the pencil in place. Flip the cereal into the air by tapping the end of the stick that is not touching the table. Make sure you flip the cereal into an empty area!
5. Measure the distance the piece of cereal traveled, and record it on your graphic organizer.
6. Place a cup at the same distance as the cereal piece landed.
7. Try to flick the cereal piece into the cup.
8. Move the pencil (fulcrum) to a different point on the stick. Try flipping the cereal a third time. Does it fly farther or not as far? Why?
9. Record the results on your graphic organizer.

Activity Center #6 Instructions: Pulley

A pulley allows us to move a heavy object with less effort than if we were to move it directly. A pulley is made up of a rope or belt that is fitted into grooved wheels. Brackets on the sides of the wheels allow them to turn freely. The brackets may be attached to a fixed point such as a ceiling or wall or, in some cases, to the object being lifted. When a person pulls down on the rope at one end of the pulley, the rope moves through the grooves of the wheels and lifts the object at the other end. The more pulleys are used at one time, the less effort is needed to lift the object and the more rope must be pulled to move the object the same distance.

Activity: Lift the Box

1. Pick up the shoebox. It has been filled with heavy objects.
2. Make a loop at the end of the string tied to the box and put your finger through the loop. Now try to lift the box using only that finger.
3. Remove the string from your finger and attach it to the rope on the pulley.
4. Make a loop in the pulley rope and put your finger through the loop. Now use the pulley to lift the box using only that finger.
5. Answer the questions on the graphic organizer to compare how it felt to use the pulley to lift the box with how it felt to use just your finger to lift it.

Activity Center #7 Instructions: Inclined Plane and Wedge

An inclined plane is a flat surface that is slanted, like a ramp. It is among the simplest of machines because it stays still while you move, but it allows you to use less effort than you would if you did not have an inclined plane. What if you want to load a box into a truck? You would have a much easier time doing it if you were to slide that box up a ramp than if you tried to lift it into the truck. Even a simple screw is an example of an inclined plane: its threads are one long inclined plane that is wrapped around a cylinder.

A wedge is similar to an inclined plane. It is used to push objects apart or to hold them in one place. Think of a wedge as the pointed end of an inclined plane, or as two inclined planes joined back to back. For example, the blade of an axe is a smooth, slanted wedge. As you swing it into a piece of wood, the ax blade forces the wood to separate into two parts.

Activity: Stop the Car

Can you keep the toy car from rolling down the ramp? By inserting a wedge in front of the wheels, you can keep the wheels from rolling.

1. Using the materials available to you, devise a wedge.
2. Place the car at the top of the ramp.
3. Test your wedge by placing it in front of the car.
4. Record your observations on your graphic organizer.

Activity Center #8 Instructions: Wheel and Axle

A wheel and axle mechanism is made up of two circular objects of different sizes. The axle is a rod or shaft that passes through the center of a wheel. All wheels need an axle to operate. You must apply effort to the wheel to turn the axle and effort to the axle to turn the wheel. They move together.

Examples of a wheel and axle are doorknobs, the wheels of roller skates, and the handles of a faucet.

Activity: Move the Book

1. Holding the string tied around the textbook, try to pull the book across the table.
2. Now place the four pencils underneath the textbook.
3. Try to pull the book across the table again. What happens?
4. Answer the questions on your graphic organizer to describe the results.

We would enjoy copies of some of your students' work from any of the lesson plans in this teacher's guide. If you care to share examples, please send them to:

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