Science FriXion STEM Lesson Plans

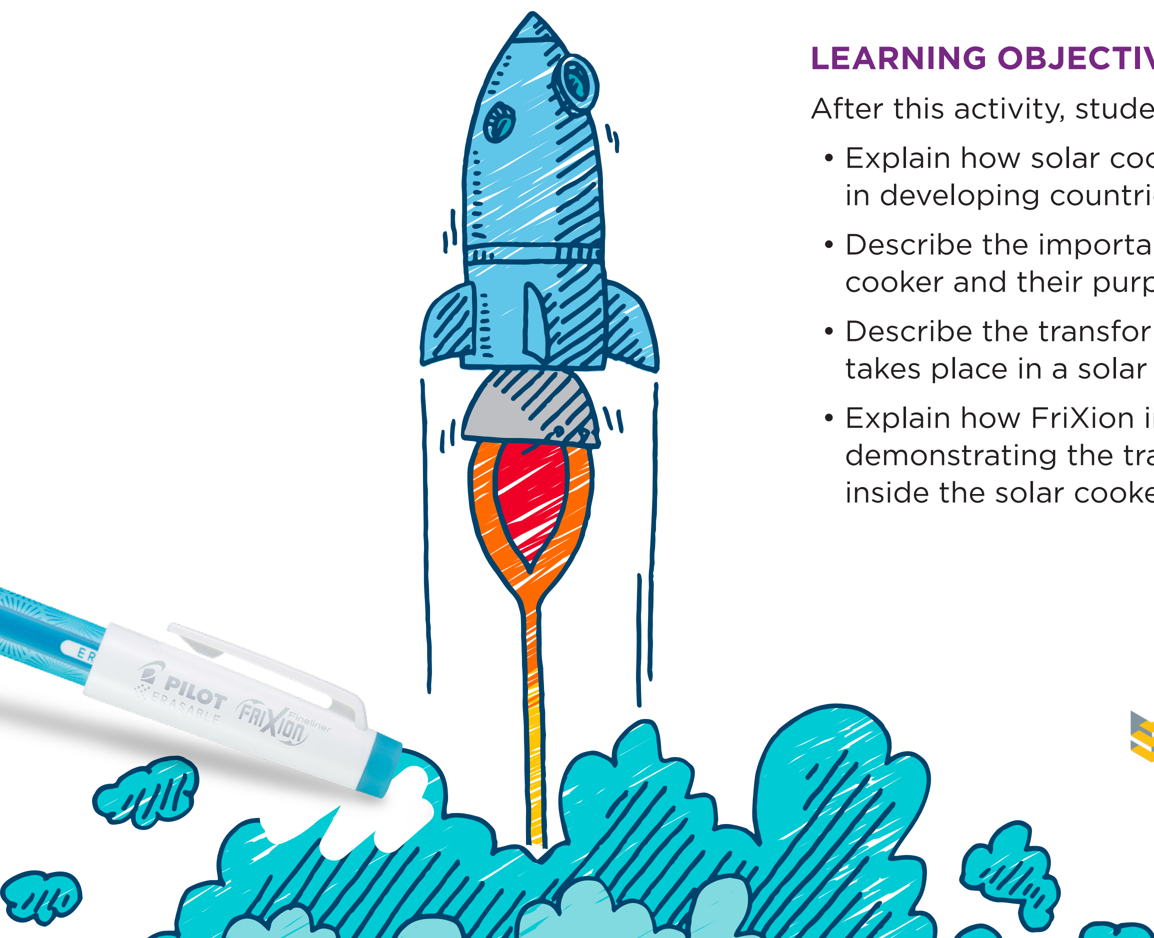
FriXionSTEM.com

Bringing science to life with the incredible, ERASABLE FriXion pens, markers and highlighters.

Grades 3–5

THERMAL ENERGY: COOKING WITH THE SUN

Students learn about using renewable energy from the sun for heating and cooking as they design and build a solar cooker using thermo-sensitive FriXion erasable pens to aid in the engineering process. They explore the concepts of insulation, reflection, absorption, conduction and convection.



LEARNING OBJECTIVES

After this activity, students should be able to:

- Explain how solar cooking can benefit people in developing countries
- Describe the important properties of a solar cooker and their purposes
- Describe the transformation of energy that takes place in a solar cooker
- Explain how FriXion ink is helpful in demonstrating the transformation of energy inside the solar cooker

Developed by

STEM.org FriXion by Pilot

MATERIALS LIST

- FriXion pens
- Non-erasable pens, such as G2
- Scissors
- Paper
- Glass jar
- A non-mercury thermometer
- Water, 200 ml per cooker
- Timer
- 1 cardboard box, ~12 in (30 cm) on the longest side
- Tape
- Aluminum foil, roll or sheets, to line the inside of the box
- Food items-Hot dogs, nachos/cheese, marshmallows, etc

INTRODUCTION/MOTIVATION

Who likes to cook? Who likes to eat? How do you think you could heat water or cook food without a stove, oven or microwave? How did people cook before such appliances? Have you ever heard of cooking with the sun? Although people have used the sun to dry foods for centuries, solar cooking (cooking with the sun) is a more recent technology.

In areas without electricity or gas for energy, people often do not have ovens or stoves for cooking, so engineers design inexpensive solar cookers to help them. Cooking food with the sun is basically the same as regular oven or stove cooking (not microwave cooking). However, there are three principles of solar cooking that engineers must consider:

- Directing the maximum possible amount of sunlight to the food by reflection
- Converting sunlight into thermal energy
- Holding on to solar heat by using insulation

Also, all solar cookers must be able to absorb as much sunlight as possible. Black pots, pans and dishes are all used in solar cookers to maximize the absorption of light. Some solar cookers have black interior surfaces to maximize conversion of sunlight into thermal energy.

Review the ways heat moves:

- Conduction = by direct contact of two materials
- Convection = by the interaction of fluid molecules (such as air or water)
- Radiation = by the movement of heat waves

Which method of heat transfer delivers heat from the Sun to the Earth?
(Answer: Radiation) Radiation is how the heat is going to get into our solar oven. So, how are we going to keep the heat in the oven? How does your house keep heat in during the winter, or keep heat out in the summer? (Answer: Insulation) Insulation is any material that slows down heat transfer. For our solar ovens, we are going to use cardboard as insulation. While cardboard is not the best insulator, it will work well-enough for our solar oven. (What might be a better insulator?)

One goal when designing your solar oven is to make sure you have optimal heat in your oven. You can test this by using the thermo-sensitive ink in FriXion erasable pens. Since heat is needed to break the covalent bonds in the ink, FriXion is excellent for illustrating the effects of heat transfer on a system and the methods by which this occurs.

By design, FriXion erasable pens, markers and highlighters incorporate science, technology, and engineering. The unique, heat-sensitive ink uses covalent bonds to help the ink to:

- **Write smoothly** in many different colors
- **Be 'erased' completely** and become invisible when it's rubbed with the eraser or gets hotter than 140°F (65°C)
- **Reappear** when the ink gets colder than 14°F (–20°C)

The heat-sensitive chemistry in FriXion three types of chemical compounds that react to one another. When you rub the ink with the hard rubber eraser, heat created by friction causes the temperature-sensing compound to activate the acid compound, making the ink clear.

The 3 compounds are:

A. The Color Pigment

B. A Color-Activating/Developer

C. A Temperature Regulator

When A & B bond you can see the ink color. When that bond is broken with heat, B & C bond and the ink becomes invisible. If the ink is cooled down, then the bond between A & B is reformed and the ink color will reappear.

Can you think of any ways to get more heat into our oven? Can we reflect heat? We can reflect heat just like we can reflect light. This means that if we use something reflective, such as aluminum foil, we can bounce more heat into our oven.

Placing a brick or other high heat capacity object in a solar cooker increases its ability to use solar energy. Although the solar cooker takes longer to heat up, the thermal mass (an object that stores the heat from the sun) stores energy that can be used to cook food after the sun sets. Using thicker pots increases solar cooker efficiency for the same reason.

Today, we are going to become engineers and compare different designs of solar cookers. Our goal is to build a solar cooker to successfully cook food using specific materials. Do you think you will be able to heat water (and make some food)? Once we learn about the design of solar cookers, we can help people who do not have ovens or stoves. Let's get cooking!

PROCEDURE

In this activity, students will build a solar cooker designed to heat water efficiently. They will also look for spots within their design that are not efficient by observing the cookers effect on FriXion ink. Students also really enjoy using the solar cookers to heat or cook quick-cooking foods.

Before the Activity

- Gather materials

Building the Solar Cookers

1. Cut off the top flaps of the box. (Or, remove the cover, if a shoe box.)
2. Cut the cardboard box edges.
3. To make the shiny inside surface of the box panel solar cooker, cut pieces of aluminum foil so they completely cover one side of the flattened cardboard box. Glue (or tape) the foil to the cardboard surface.
4. Fold the flattened cardboard into a box shape again with the foil surface on the inside of the box, being careful not to rip the foil. The side and front walls are adjustable to help direct sunlight into the cooking area.
5. Draw grid lines on paper using the erasable FriXion pens, and tape or glue them into the cooker box. This will allow students to see where the sun hits their solar cookers most efficiently.

Testing the Solar Cookers

1. Take the cookers, thermometers, water and a timer outside. Position each cooker to receive maximum sunlight. Have the students pay careful attention to how they position their cooker so it receives the most sunlight and does not cast shadows inside the cooker. The side and front walls of the box cooker may be adjusted to better reflect sunlight onto the cooking area. Sometimes it helps to tilt or angle the cooker.
2. Pour 200 ml of water into a jar for each cooker. As a control, place one container of 200 ml of water in the shade, with its own thermometer.
3. Have students place their jars in their cookers.
4. Start the timer and have students measure the temperature of the water in their cookers every 2 minutes for 20 minutes, recording the temperature in their science notebooks. Note that FriXion ink will disappear at 140°F (60°C). Assign one student to measure and record the temperature of the control (shade) water jar at the same time intervals.
5. As time progresses have students circle spots on their oven grids where they notice the FriXion ink disappearing using non-erasable G2 pens. Why is the FriXion ink disappearing? How can this information be used to make the oven more efficient?
6. Conclude with a class discussion, comparing results and graphs. How did each team's cooker temperature graph compare to the control (shade) temperature graph? Which solar cookers worked the best? How do you know? Did you adjust your cooker in any way to make it work better? What solar cooker characteristics made them work the best? Was there a certain location in each cooker that seemed to get the hottest?
7. Based on the FriXion erase patterns, which oven cooked most effectively? How might they be able to roast marshmallows? Nachos? Etc.?

DISCUSSION QUESTIONS

- What are some reasons to use a solar cooker? (Possible answers: To save fuel, money and energy; to reduce pollution and emission of greenhouse gases; to reduce deforestation.)
- What is the transformation of energy that happens in a solar cooker? (Answer: Sunlight, in the form of solar radiation, is reflected, absorbed and converted into thermal energy.)
- What are the important properties in a good solar cooker? What are their purposes? (Answer: Good reflection of light onto the cooking area, insulation to retain heat, dark cookware or a dark surface to absorb sunlight. Solar cookers have reflecting surfaces that direct the sunlight to one spot in the cooker. It helps if the shiny surfaces are adjustable.)
- The best solar cookers also have clear covers and insulation to minimize the loss of the collected thermal energy. Some cookers have thermal mass to absorb and retain the collected thermal energy
- Engineers always want to improve the design of their inventions. If you were an engineer, how might you improve your solar cooker to work better? (Answers: Add a clear glass or plastic cover to trap heat; add insulation to keep from losing heat, add bricks or stones for thermal mass, put it on a revolving tray to easily be turned to track with the sun, etc.)
- Why might engineers be concerned about providing methods for people to use solar energy to cook? (Answer: Because some people do not have technologies such as ovens or stoves.)
- What attributes of FriXion ink help it provide good feedback for modifying the cooker designs?
- If you would want to run the experiment again reusing these materials, how could you reuse your FriXion grid? How might you be able to reuse the grid without redrawing?