SCIENCE FRIXION STEM LESSON PLANS

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

High School

SOLAR ENERGY: ZERO-ENERGY HOUSE

Students investigate solar building design with a focus solely on heating. They learn how insulation, window placement, thermal mass, surface colors, and site orientation play important roles in solar heating. They use this information to design and build their own model homes. Students will test and optimize their designs with the help of thermo-sensitive FriXion pens.

LEARNING OBJECTIVES

After this activity, students should be able to:

- Model a few techniques used in passive solar heating
- Explain the importance of passive solar heating
- Identify the role an engineer plays in passive solar design
- Explain how and why FriXion ink can be used as an indicator of heating efficiency and/or inefficiency

Developed by

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MATERIALS

Each group needs:

- FriXion Pens
- Shoe box
- 1 sq. ft (.09 sq. m) thin clear plastic
- 4 sq. ft (.37 sq. m) aluminum foil
- 2 sq. ft (.19 sq. m) thin rubber (any kind)
- 2 sq. ft (.19 sq. m) black fabric (any kind)
- White or graph paper for designing and graphing
- (Optional) Excel software for recording and graphing group data

For the entire class to share:

- Hot glue guns and/or tacky glue
- Scissors
- Utility knife
- Thumbtacks
- Scotch tape
- Masking tape
- Protractor
- Straight edge (metal ruler)

For one testing station (you may want more than one station):

- Hair dryer
- Thermometer
- Watch or timer to determine 30-second intervals

INTRODUCTION/MOTIVATION

Imagine if we could heat houses without the use of ANY electrical or gas heaters! Think about the positive effects it would have on people all around the world.

Although passive solar design might seem new to you, the basic principles have been around for centuries. Today, engineers are expanding upon principles so we can be efficient in our energy usage and save some money on our heating bills.

An important part of a good passive solar design is excellent insulation. This is true for any HVAC (heating, ventilating and air conditioning) system, but it is especially important in passive design because passive solar heating does not produce as much heat as conventional methods. Therefore it is important that the heat produced is not wasted.

Windows are another important component of passive solar designs. For example, windows let considerably more heat escape to the outside than the walls of your home.

You don't want to have too many windows for a good passive solar design. On the other hand, while a windowless building would have the best insulation, would you want to live in it? Rather than eliminate windows altogether, you can install high-quality, double-pane

windows and place them in strategic locations. Double pane windows are much better insulators than single pane ones. Windows, placed in the right locations, can bring in the most sunlight without losing too much heat.

Once the sunlight comes into a room, two other aspects of passive solar design become important: thermal mass and surface color. You probably already know that darker colors absorb more sunlight than lighter colors, so, for passive solar heating, we would want darker colors on the outside and inside of a building. A good thermal mass is a material that can absorb lots of heat and release it slowly when the surrounding temperature starts to go down. A few materials with a high thermal mass are concrete, bricks and water. When used properly, these materials absorb the heat from the sunlight coming through windows and then release that heat throughout the night.

Another point to consider is the space being heated. Larger volumes of space need more heat to make the same gain in temperature as a smaller volume. So, a smart passive solar design would limit the space that needs heating.

The final component to remember in passive solar design is the overall orientation of your design elements. You must know from which direction the sun shines so you can place your walls and windows intended to capture the sunlight facing in that direction. Also, if you know the regular direction of cold wind, it is smart to position and design the house to block or divert that wind, to minimize it cooling your house.

One of the most unique and fun aspects about passive solar heating is that it can be done in an almost unlimited number of ways. Engineers who design passive solar heating systems can be as creative as they want!

PROCEDURE

Background

The goal for students is to design and build a one-bedroom model house within the provided design constraints, utilizing passive solar heating design to warm up the house as much as possible and then sustain that temperature as long as possible.

Once built, teams test their model house designs to compare ideas and results and see what design modifications worked best and which did not work so well.

Students will use FriXion pens to draw a grid in their homes. Since FriXion ink is erased by heat this will be a good indicator of what parts of their homes are insulated well and what parts are needing modifications.

By design, FriXion erasable pens, markers and highlighters incorporate science, technology, and engineering. The unique, thermo-sensitive ink formula utilizes covalent bonding and PH to allow the ink to:

- **Write smoothly** and vividly in a variety of colors
- **Be 'erased' completely** by becoming invisible with erasing friction or when heated to temperatures higher than 140°F (65°C)
- **Be made to reappear** when cooled to extremely low temperatures of less than 14°F (–20°C)

The thermochromic chemistry in FriXion uses three types of chemical compounds that rely on acid-base interactions, temperature sensitivity, and covalent bonding. When you rub the ink with the hard rubber eraser, heat from the resulting friction causes the temperature-sensing compound to activate the acid compound, thus neutralizing the dye.

The 3 compounds are:

A. The Color Pigment (which is stable at room temperature but changes color upon reaction with acids).

B. A Color-Activating/Developer that acts as an acid to produce the color change that bonds.

C. A Transparency/Color Change Regulator that controls the temperature at which the color transition takes place.

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

Provide students with a variety of materials that can be used a number of ways. Below are examples of how some materials might be used:

- Foam core board: for walls and roofing, to mimic insulation and thermal mass
- Thin clear plastic: to let light in as windows, to heat up the homes
- Aluminum foil: to imitate metal surfaces; while not a thermal mass, it does reflect heat and light
- Thin rubber: to imitate a thermal mass
- Black fabric: while not a thermal mass, it absorbs a lot of heat from light
- Glue: besides holding the house together, it serves as a final insulator to seal up any cracks and small air leaks in the model homes

Before the Activity

- Gather materials and set up a testing station(s)

With the Students

1. Introduce passive solar design for purposes of heating and its primary design considerations and methods, as described in the Introduction/Motivation section.

2. Briefly describe to the students what they will be designing during the activity.

3. Divide students as necessary for your class.

4. Have the teams brainstorm ideas and discuss possible passive solar heating techniques using the materials provided. Encourage them to design unique houses. For example, they do not necessarily have to have the traditional four walls.

5. Once teams have come up with several ideas, have them choose one and sketch it on paper. Double-check their designs to make sure they meet the requirements before handing them their materials.

6. Make sure students add their FriXion grids inside their homes.
7. Give the teams time to build. Keep them on task by setting deadlines.
8. Once the groups are done building their model homes, set up a testing area and give each team time to test record their data.
9. Allow students to find areas where they need to improve their homes. Where is their solar power lacking?

DISCUSSION QUESTIONS

- What did they do well in their designs? How would they improve?
- How did FriXion pens help arrive at this conclusion?