3M Young Scientist Lab

Classroom Activity | Grades 6-8

It's Getting Hot In Here

GUIDING QUESTION

How do the characteristics of materials impact the temperature inside a space?

LEARNING OBJECTIVES

Students will be able to:

- collect, organize, display, and analyze temperature data.
- investigate the effect of a covering on the solar heating of a model house.

OVERVIEW

The heating and cooling of our dwellings are necessary for comfort and survival. Before the advent of independent sources of energy for such purposes (wood, natural gas, electricity), humans depended on solar energy. In this lesson, students will investigate the absorption and reflection of solar energy on the top surface of a simple model house by collecting and analyzing actual temperature data. As an extension of the concepts, they will have the opportunity to research related information found on the internet. Students and parents then work together at home to further investigate and research the interaction of solar energy and surfaces on heating and cooling of dwellings.

NEXT GENERATION SCIENCE STANDARDS

- PS3.A: Definitions of Energy
  - Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4)
  - The term "heat" as used in everyday language refers both to thermal motion (the motion of atoms or molecules within a substance) and radiation (particularly infrared and light). In science, heat is used only for this second meaning; it refers to energy transferred when two objects or systems are at different temperatures. (secondary to MS-PS1-4)

- PS3.B: Conservation of Energy and Energy Transfer
  - The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)
- ETS1.B: Developing Possible Solutions
  - There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) (secondary to MS-PS3-3)(secondary to MS-LS2-5)
  - Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
  - Models of all kinds are important for testing solutions. (MS-ETS1-4)
- ETS1.C: Optimizing the Design Solution
  - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (MS-ETS1-3)(secondary to MS-PS1-6)
  - The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MSETS1-4)(secondary to MS-PS1-6)

LESSON TIME FRAME

This lesson requires four 45 minute sessions to complete. It is recommended to have one session to engage students and introduce the activity, a second for students to build their model houses, a third to collect temperature data outdoors, and a fourth to discuss and analyze their data.

BACKGROUND INFORMATION

Energy comes from the sun primarily as electromagnetic radiation. Sometimes the word "radiation" connotes something dangerous and threatening. If the radiation is of high enough energy, it can be dangerous; x-rays and gamma rays are examples. However, at lower energies radiation is not harmful to humans; light, heat, and radio waves are examples. Most of the electromagnetic radiation that reaches the Earth from the sun is in the visible or infrared (heat) range. In this lesson, light and heat from the sun will be referred to as solar energy. When light or heat shines on a surface, it can be absorbed, reflected, or transmitted. Dwelling roofs are directly impacted by solar energy. Their properties affect the extent to which the roof mainly absorbs or reflects that energy. In a few situations, people want their roofs to transmit light such as with a skylight. Knowing the absorptive and reflective properties of roofing materials is important for the design of dwellings. This lesson will provide the opportunity for students to investigate what effect, if any, various surface coverings (roofs) have on the heating of a model house due to solar energy.

MATERIALS

Teacher Materials/Prep

- Blackboard, chart paper, or computer with projector
- Print copies
  - It's Getting Hot in Here Student Capture Sheets
  - It's Getting Hot in Here Class Data Student Capture Sheets
  - Home Connections Resource to send home with students
- Print copies and cut out
  - Six Word Story Summary Student Capture Sheet

Student Materials

- Paper or science notebook and pencil
- It's Getting Hot in Here Student Capture Sheet
- It's Getting Hot in Here Class Data Student Capture Sheet
- Six Word Story Student Capture Sheet
- Home Connections Resource

Student Materials

- Shoebox or equivalent
- Variety of surface covering choices for the top (roof) of shoebox*
- Tape or glue
- Scissors
- Thermometer
- Timer, stopwatch, or watch
- Fabric squares, carpet samples, aluminum foil, sandpaper, construction paper, etc.

CLASSROOM ACTIVITY

Day 1

Engage

1. List the following words on the board or chart paper: X-ray, ultraviolet light, visible light, infrared, microwaves, and radio waves. Ask what, if anything, these terms have in common. Discuss briefly and take note of appropriate student conceptions and misconceptions. Continue by asking students which of these terms they associate with solar energy. You might want to let students know that infrared has to do with heat.
2. Ask students if they have had the experience of not being able to comfortably stand on sand or on pavement that's been in the sun for a while. Probe for the understanding of

the mechanism of heat absorption by the sand. Ask for other examples of materials or surfaces that absorb heat. Now switch to a similar brief discussion about light and see if students can equate heat and light. Since students have had experience with light reflections, can they imagine the concept of reflecting heat?

3. The roofs of most houses are covered with some type of shingle. On a piece of paper or in students' science notebooks, have young scientists imagine and draw what they think happens when sunlight shines on a shingle of a typical roof. Discuss and share ideas as a class.

Day 2

Explore

1. Display the following prompt: What effect, if any, does the type of top-surface covering have on the solar heating of a model house? Explain to students that you would like them to work in small groups to design and carry out an investigation that would enable them to answer this question. Show students the materials and equipment you have available for their use. As you display the thermometers, explain that the students will be expected to measure the solar heating by measuring the temperature inside the shoebox in five-minute intervals for 30 minutes.

   Ideally, you could allow each group sufficient time and materials to fully explore a range of variables and values that would address this question. To make this lesson more practical however, it would be beneficial to divide the range of possibilities among the groups, so that the class becomes the testing unit instead of each group. In other words, one group would investigate one type of covering and another group would investigate a second type of covering. Or one group might look at a thick covering while another group would look at a thin covering. So, after individual groups have had an opportunity to create a design, gather the class together and blend the various designs into a whole-class design, with individual groups having the responsibility for a particular experimental condition. Explain that once each group has made their model house, as a class they will take the models outside and place them in the sun to begin collecting temperature data.

2. Group students and allow them time to work on their particular design responsibility, providing assistance as needed. If more time is needed, allow students to continue building on Day 3.

Day 3

3. Once all groups have prepared their models, take the class outdoors to a suitable place in the sun and allow them to begin collecting data. (Anticipating that students might grow restless between temperature measurements, go prepared with some activities that could constructively fill the 5-minute intervals.)

Day 4

Explain

1. Once back in the classroom, gather students together to compile and review the data that was collected outdoors. Organize and display the raw data so all students can copy this data in their own notebooks. Then arrange for individual groups to meet together so they can analyze the class data and begin to draw their own conclusions.
2. Convene students together as a class to discuss and share individual group's conclusions. How did they answer the question? What were some of the issues with this particular blended design for the investigation? How could it be improved?
3. Once you have the class data summarized and conclusions drawn, discuss the results of the investigation from a scientific perspective. How is solar energy interacting with the top surface of the model houses? This interaction happens in the form of absorption and reflection of solar energy. Why do some materials absorb solar energy better than others? Why do some materials reflect solar energy better than others?

Extend

1. Ask students how their findings and conclusions relate to the design and construction of actual houses. Discuss the implications for energy costs for construction, heating, and cooling. Do the conclusions students reached take into account the latitude of the house?
2. One factor that affects the absorption of solar energy is the angle of incidence of solar radiation. If you have the time and resources (e.g. a heat lamp), some students could investigate this particular variable and report their findings back to the class.
3. Students could look deeper into the science and application of this topic using these websites:

   3M

   http://solutions.3m.com/wps/portal/3M/en_US/IMPD/Roofing-Solutions/Products/CoolRoofing-Granules/

   Department of Energy

   https://www.energy.gov/energysaver/air-sealing-your-home

   https://www.energy.gov/energysaver/insulation
4. Discuss or have students research the parallels of this activity with the absorption and reflection of solar energy by Earth's atmosphere. This extension could lead to further student interest and research in global warming.

Evaluate

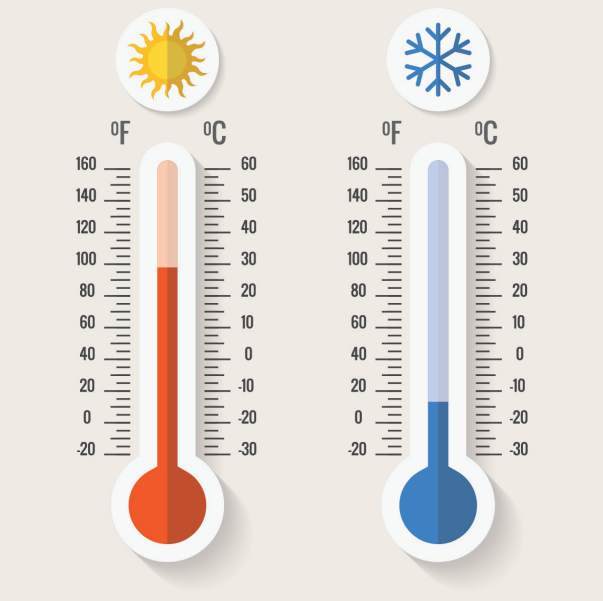
1. Explain what happens when the sun shines on the roof of a house.
2. Identify the two variables your class investigated in this solar energy investigation.
3. If you compared the shoebox in this investigation to the Earth, what part of Earth would correspond to the model roof? Why?

TEACHER SCORING KEY FOR EVALUATE

1. When the sun shines on the roof of a house, the roof material absorbs most of the energy in the heat and light from the sun and some of the energy is reflected back up into the air.
2. We investigated how the temperature in the shoebox changed when we changed the type of roof cover.
3. If the shoebox were like the Earth, then the roof would be like Earth's atmosphere because it absorbs energy from the sun.

REFLECTION

Young scientists will reflect on their learning by completing the Six Word Story summary. Print off the Six Word Story Summary Student Capture Sheet, cut them out, and distribute one to each student. Alternatively, students may create this reflection activity in their science journal:



SIX WORD STORY SUMMARY

Exit Ticket:

Summarize your learning in **six** words.

_____ _____ _____ _____ _____ _____

Explain the design process of the model your team created.

Materials used on the roof	Time	Temperature C°
	0 minutes	
	5 minutes	
	10 minutes	
	15 minutes	
	20 minutes	
	25 minutes	
	30 minutes	

IT'S GETTING HOT IN HERE CLASS DATA

Roof material						
0 minutes	C°	C°	C°	C°	C°	C°
5 minutes	C°	C°	C°	C°	C°	C°
10 minutes	C°	C°	C°	C°	C°	C°
15 minutes	C°	C°	C°	C°	C°	C°
20 minutes	C°	C°	C°	C°	C°	C°
25 minutes	C°	C°	C°	C°	C°	C°
30 minutes	C°	C°	C°	C°	C°	C°

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_____ _____ _____ _____ _____ _____

HOME CONNECTIONS

Parent Background Information

Energy comes from the sun primarily as electromagnetic radiation. Sometimes the word 'radiation' connotes something dangerous and threatening. If the radiation is of high enough energy, it can be dangerous; x-rays and gamma rays are examples. At lower energies, however, radiation is not harmful to humans; light, heat, and radio waves are examples. Most of the electromagnetic radiation striking Earth coming from the sun is in the visible or infrared (heat) range. In this lesson, light and heat from the sun will be referred to as solar energy. When light or heat shines on a surface, it can be absorbed, reflected, or transmitted. Dwelling roofs of course are directly impacted by solar energy and their properties affect the extent to which the roof mainly absorbs or reflects that energy. In a few situations, people want their roofs to transmit light such as with a skylight. Knowing the absorptive and reflective properties of roofing materials is important for the design of dwellings.

Activities to do with your young scientist:

1. Share: Your student could share the results and findings of the solar energy investigation they did at school for this lesson.
2. Short activity: Sound, like light and heat, can reflect and be absorbed by surfaces. Locate and test surfaces found around the home that are good absorbers and reflectors of sound. Which surfaces are poor at absorbing and reflecting sounds?
3. Short investigation: Paint the surface of a disposable object like a brick, rock, or water bottle black and the surface of a similar object white. After they are dry, touch both surfaces to check their temperatures then set the two objects in the sun. After several hours, again touch both surfaces to check their temperatures. Did one color do better than the other in warming the object? Why?
4. Research: You and your young scientist could use the Internet to research a new cooler shingle made by 3M with reflecting granules:
   http://solutions.3m.com/wps/portal/3M/en_US/IMPD/RoofingSolutions/Products/Cool-Roofing-Granules/

   How much solar energy do these shingles reflect back into the air? Learn more about saving energy by visiting this Web site from the Department of Energy on radiant barriers and insulation.
   https://www.energy.gov/energysaver/air-sealing-your-home
   https://www.energy.gov/energysaver/insulation
5. Discuss: Talk with your student about how this topic relates to the type and color of clothing people wear during different seasons and in different parts of the world.