Feel the Heat

Description

Students explore the warming effects of sunlight on Earth's surface by comparing the temperatures of sunny surfaces and shady surfaces on their school grounds. Then, they design, build, and test models of shade structures that could provide a place to cool off on the playground.

Suggested Grade Levels: K–2

LESSON OBJECTIVES Connecting to the *Framework*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Using Mathematics and Computational Thinking Constructing Explanations and Designing Solutions	**PS3.B:** Conservation of Energy and Energy Transfer **ETS1.B:** Developing Possible Solutions	Cause and Effect Scale, Proportion, and Quantity

Featured Picture Books

TITLE: ***Summer Sun Risin'***
AUTHOR: **W. Nikola-Lisa**
ILLUSTRATOR: **Don Tate**
PUBLISHER: **Lee & Low Books**
YEAR: **2002**
GENRE: **Story**
SUMMARY: *Rhythmic poetry and beautiful paintings depict a little boy enjoying a summer day on his family's farm in Texas in the 1950s. The illustrations trace the Sun as it travels across the sky from sunrise to sunset, while the text describes the family's daily ritual of chores and how the hot Sun affects their lives.*

TITLE: ***The Sun: Our Nearest Star***
AUTHOR: **Franklyn M. Branley**
ILLUSTRATOR: **Edward Miller**
PUBLISHER: **HarperTrophy**
YEAR: **2002**
GENRE: **Non-Narrative Information**
SUMMARY: *This book describes characteristics of the Sun and how it provides all of the light energy needed for life on Earth.*

Time Needed

This lesson will take several class periods and will need to be taught on sunny days during the warmer months of the school year. Suggested scheduling is as follows:

Day 1: **Engage** with *Summer Sun Risin'* Read-Aloud and **Explore** with Comparing Temperatures

Day 2: **Explain** with Comparing Temperatures Graph and *The Sun: Our Nearest Star* Anticipation Guide and Read-Aloud

Day 3: **Elaborate** with Keep It Cool Design Challenge: Building Our Models

Day 4: **Evaluate** with Keep It Cool Design Challenge: Testing Our Models

Materials

For Comparing Temperatures (for teacher use only)

- Infrared digital thermometer (non-contact, not designed for measuring body temperature) (*Note:* Infrared, non-contact digital thermometer "temperature guns" with laser pointers can be purchased at Amazon.com, Walmart, or hardware and home improvement stores for $20–$60.)

For Keep It Cool Design Challenge

- Cooler of ice (*Note:* Take the cooler of ice outside with you and hand out the ice cubes when it is time to begin testing designs.)
- 2 ice cubes of the same size and shape (per pair)
- Lunch-sized paper bag that includes a variety of shade-structure building supplies such as the following (per pair):
    - Construction paper
    - Index cards, cardboard, or both
    - Pieces of cloth or felt
    - 4 or more straws
    - 4 or more craft sticks
    - Roll of masking tape
    - Scissors

Student Pages

- Comparing Temperatures
- Let's Learn About the Sun
- Keep It Cool Design Challenge
- STEM at Home

SAFETY

INFRARED THERMOMETER

An *infrared laser thermometer* is a device that can measure the temperature of an object or surface. The laser beam included in this type of device does not measure the temperature; it helps the user aim the device at the desired object. Because a laser beam is involved, you should be very cautious when using it.

- Follow all usage and safety guidelines included in the packaging.
- Do not allow students to use the device. Do not point it toward people.
- Do not point it at a highly reflective surface, such as a mirror.
- Some school districts and states prohibit the use of lasers in the classroom or field. Always check school district policy and state regulations relative to laser use before doing this activity.
- Use caution in working with scissors, sticks, and so on. They can be sharp and cut or puncture eyes and skin.
- Immediately wipe up any spilled water to avoid a slip-and-fall hazard.

Background for Teachers

The Sun, our nearest star, is the source of virtually all energy on our planet. Without the Sun's energy, there would be no light, no heat, and no life on Earth. The Sun is an enormous burning ball of gases nearly a million miles across. In terms of scale, if Earth were the size of a pea, the Sun would be about the size of a beach ball! By studying the color and brightness of the light emitted from the Sun, scientists have concluded that the surface of the Sun is about 10000°F. The Sun is very far from Earth—about 93 million miles away—but it appears so big and bright to us because it is much closer than neighboring stars.

We can feel the Sun's heat warm our skin and the sand at the beach, we can see the visible light that comes from the Sun, and we can see the effects of damaging ultraviolet light on our skin. But how do all these types of energy get to the Earth when the Sun is so far away? The Sun transfers energy to Earth through empty space by *radiation,* a form of energy transfer that does not require direct contact. Traveling at the speed of light, energy released by the Sun reaches the Earth in a little more than 8 min. This energy is known as *electromagnetic radiation* and takes many forms, including visible light, ultraviolet light, radio waves, and even x-rays. Fortunately, the atmosphere prevents most of the dangerous forms of energy from the Sun from reaching Earth's surface. Different surfaces can either reflect or absorb sunlight to various degrees. As a surface (such as your skin or the sand at the beach) absorbs sunlight, the sunlight forces the molecules in the material to move faster, thus warming the surface. Lighter-colored surfaces tend to reflect more sunlight, whereas darker surfaces tend to absorb more sunlight. In general, the darker the surface, the faster it warms up and the hotter it gets relative to surrounding surfaces. The temperatures of land and water in the same area may differ, even when they are exposed to the same amount of energy from the Sun. Land warms up at a faster rate than water and gets hotter. It also cools down faster than water. Different types of land (green grass, beach sand, bare soil) can have different temperatures within the same area. It is this uneven heating of the Earth's surface that contributes to an imbalance of air pressure across the Earth, which in turn causes wind and weather.

The amount of energy from the Sun that reaches a single location on the surface of Earth over a given period of time is called *insolation* (incoming solar radiation). The intensity of insolation on Earth varies according to such factors as the time of year, the time of day, and the latitude. In places with high average temperatures, high insolation can be a big problem for city dwellers. Urban planners and architects are finding ways to make cities cooler by selecting building materials that are more reflective and by using trees and engineered shade structures. Creating shade over an area can greatly reduce the warming effects of insolation. Installing engineered shade structures in public areas can help lower insolation and keep people feeling more comfortable when it is very hot outside (as well as protect people from the Sun's damaging ultraviolet rays). Although the air temperature in the Sun is about the same as the air temperature in a shaded area nearby, shade blocks insolation, which in turn makes surfaces cooler.

For primary students, laying a foundation for eventually learning about sunlight, weather and climate, global warming, and other concepts pertaining to the transfer of the Sun's energy to Earth systems involves making simple observations about the warming effects of the Sun. In this lesson, students will make qualitative observations of how warm it "feels" in the Sun versus the shade and collect quantitative data by measuring the temperature of the same surfaces in the shade and then in the Sun. Temperature data is collected using a handheld device called an *infrared laser thermometer,* which measures surface temperatures more quickly and accurately than traditional classroom thermometers (see safety notes in the Materials section).

This lesson also incorporates the engineering design practice of building a model. A *model* is a representation of a real object. A model can show how a design will look and how different parts work

together. Models can be maps, diagrams, blueprints, or three-dimensional physical models. Engineers use models to plan, test, and show others their ideas. Using their knowledge of the warming effects of sunlight, students build and test a physical model of a shade structure to keep cooler on the playground.

A simple extension of this lesson might be to walk around the school grounds and brainstorm ideas for keeping the area cooler during the hotter months (e.g., by replacing darker surfaces with lighter-colored materials and installing shade structures or planting trees in certain places). Exploring ways that scientists and engineers are working to design solutions for problems such as helping people stay cooler in outside areas brings science and engineering together in the classroom.

Engaging with Summer Sun Risin'

engage

Summer Sun Risin' Read-Aloud

Connecting to the Common Core
Reading: Literature
Key Ideas and Details: K.1, 1.1, 2.1

Inferring

Show students the cover of *Summer Sun Risin'* and introduce the author, W. Nikola-Lisa, and illustrator, Don Tate. Show them the front and back covers and *ask*

- ? Where do you think this story takes place? (Students will likely guess that the story takes place on a farm.)
- ? What clues from the cover make you think that? (There are chickens, crops, and a scarecrow.)

Read the book aloud, or share the pictures as you have the author sing the book aloud! You can find his SoundCloud version at *https://soundcloud.com/nikolaplays/summer-sun-risin.*

Questioning

After reading, *ask*

- ? What did you notice about the pictures of the Sun in the book? (Answers will vary. Flip through the pages to show how the Sun starts on the left-hand page near the horizon, travels across the sky, and ends up on the right-hand side sinking down into the horizon.)
- ? Why do you think the Sun appears again in the very last picture? (It is the next day, so the Sun is rising again.)
- ? Why do you think the author used words such as *shinin', glarin', blazin',* and *burnin'* to describe the Sun? (The Sun is very hot. Heat comes from the Sun.)
- ? What do you think the author was trying to show about the Sun in his poem? (how the Sun makes things hot on a summer day; how it is a big part of our lives, especially in the summer; how it affects people all day long, etc.)

Making Connections: Text to Self

Ask

- Have you ever felt the Sun blazin', burnin', and glarin'? (Answers will vary. Remind students to never look directly at the Sun!)
- How do you keep cool on a hot summer day? (sit in the shade, drink cold water, swim, eat ice pops)
- Are some areas of the playground hotter than others? (Answers will vary. Students may have noticed that some places on the playground get hotter than others, such as the surface of the slide, the blacktop area, seats of the swings, etc.)

Tell students that, next, they are going to have the opportunity to explore how the Sun heats different surfaces in different ways.

COMPARING TEMPERATURES

explore

Comparing Temperatures

Ahead of time, identify four separate surfaces on the playground or elsewhere on school grounds that are partly shaded (e.g., grass, blacktop, cement, shade).

Give each student a copy of the Comparing Temperatures student page and a clipboard, and have them write the names of the four surfaces you have selected in the first column of the table. Tell them that they will be investigating the temperatures of these four surfaces. *Ask*

- What ways could we measure the temperatures of these four surfaces? (by feeling and then comparing them or by measuring their temperature with a thermometer)

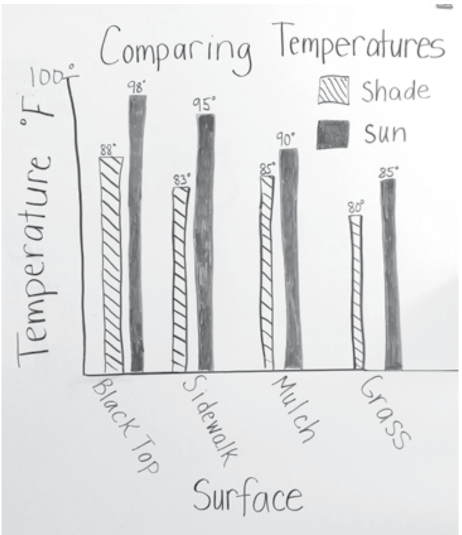
Tell students that they will be comparing how warm these surfaces feel *and* measuring the surfaces' temperatures with a special type of thermometer. The temperatures will be recorded on their data tables in degrees Fahrenheit. Point out the °F symbol on the data table. Demonstrate how the infrared laser thermometer works by aiming it at the floor and measuring the temperature (follow all usage and safety guidelines included in the packaging). Tell them that because the thermometer uses a laser beam for precise aiming, students may not use it. Laser beams, even small ones such as those used in classroom pointers, cat toys, and the infrared laser thermometer, can be dangerous if pointed at the eye.

Turn and Talk

Before you take the students outside, *ask*

- Which surface do you think will be the warmest? (Answers will vary.)
- Why do you think so? (Students will likely have had prior experience with shady versus sunny surfaces and may also have noticed relative temperature differences between darker and lighter surfaces.)

Have students discuss their thoughts with a partner, then ask a few pairs to share with the entire class.



COMPARING TEMPERATURES BAR GRAPH

Next, take students outside with their clipboards. Visit the shaded part of the first area together, and have students place their hands on the surface. Ask them to describe how the temperature feels to the touch—cold, cool, warm, or hot. Measure the surface with the infrared laser thermometer, and have students record the temperature in the "Temperature in Shade" column. Then, move to the sunny part of the same area and have students place their hands on the same surface in the Sun. Ask them to compare how the temperature of the same surface feels in the Sun. Is it colder, cooler, warmer, or hotter in the Sun than in the shade? Then, measure with the infrared laser thermometer, and have students record the temperature in the "Temperature in Sun" column. Repeat the procedure for the rest of the surfaces.

explain

Comparing Temperatures Graph

Connecting to the Common Core
Mathematics
MEASUREMENT AND DATA: K.MD.2, 1.MD.4, 2.MD.10

Next, return to the classroom and discuss the data together. Ask students to identify patterns in their data (i.e., Were the sunny surfaces typically warmer than the shaded surfaces? Were lighter surfaces cooler than darker surfaces? Was the blacktop in the Sun the warmest of all the surfaces?). Then, explain that sometimes it is helpful to graph data to find patterns. Create a bar graph titled "Comparing Temperatures" to display the data with "Surface" on the *x*-axis and "Temperature" on the *y*-axis. For each surface, there will be two bars of data, so have students help you create a key for "Sun" and "shade" (e.g., yellow for Sun and a darker color for shade). Have students help you determine how to draw the bars on the graph.

After completing the graph together, *ask*

? Which surface was the warmest? What is your evidence? (Students should know to choose their answer by observing which bar is the highest.)

? Why do you think so? (Answers will vary.)

? Which surface was the coolest? What is your evidence? (Students should know to choose their answer by observing which bar is the lowest.)

? Why do you think so? (Answers will vary.)

? What other observations can you make about our graph? (Answers will vary.)

Then, *ask*

? What is warming these surfaces outside our school? (the Sun)

The Sun: Our Nearest Star Anticipation Guide and Read-Aloud

Determining Importance

Connecting to the Common Core
Reading: Informational Text
KEY IDEAS AND DETAILS: K.1, 1.1, 2.1

Tell students that they are going to learn more about how the Sun warms the Earth by reading a nonfiction book titled *The Sun: Our Nearest Star.* Show students the cover and introduce the author, Franklyn M. Branley, and the illustrator, Edward Miller. Tell students that Dr. Branley is an astronomer, a scientist who studies stars, planets, and space.

Project a copy of *The Sun* anticipation guide, Let's Learn About the Sun. Pre-assess the students' understanding of the Sun by having them signal (thumbs-up or thumbs-down) to indicate whether they agree or disagree with each of the following statements. They should also write their guesses in the blanks on the student page. Tell them that at this point, they should just make their best guesses. After reading the book, they will be revisiting the anticipation guide to see if their guesses were correct.

1. The Sun is a star.
2. The Sun is much smaller than Earth.
3. The Sun is much farther away than the Moon.
4. A spaceship has been to the Sun.
5. Without the Sun, Earth would be cold and dark.

Have students signal when they hear evidence from the text for or against any of the six statements. Stop and discuss each one as you read the book aloud. The correct answers are as follows:

1. The Sun is a star. (true—p. 6)
2. The Sun is much smaller than Earth. (false—p. 9; the Sun is much bigger than Earth)
3. The Sun is much farther away than the Moon. (true—p. 10; the Sun is 93 million miles away)
4. A spaceship has been to the Sun. (false—p. 14; the Sun is so hot that a spaceship could not get close to it without burning up)
5. Without the Sun, Earth would be cold and dark. (true—p. 16)

Explain that although the Sun is so far away from us (93 million miles), we can feel the heat it produces. It heats us, the air, the ground—everything on Earth. Refer to the Comparing Temperatures activity in the explore section and *ask*

- ? Were all the surfaces the same temperature outside our school? (no)
- ? What was different about the surfaces? (They were in different places, some were in the Sun and some were in the shade, and they were different textures and colors.)

Explain that some surfaces absorb more sunlight than others, and that makes them warmer than the surrounding surfaces. For example, darker colors (such as blacktop) *absorb,* or take in, more sunlight than lighter colors (such as concrete). *Ask*

- ? Why do you think the shade was cooler than the other surfaces? (The sunlight was blocked.)
- ? What was blocking the sunlight in the shady area? (Answers will vary.)

elaborate

Keep It Cool Design Challenge: Building Our Models

Ask

- ? Do you ever get hot playing on our school's playground?
- ? Where do you go to cool off?
- ? Do you think you could design a structure for the playground that would reduce the warming effect of the Sun on you and your classmates?
- ? What kind of structure would help you cool on the playground? (something that makes shade, something that is covered with a light-colored material)

Present the following problem to students by writing it on the board and reading it aloud: "Problem: We need a place to cool off on the playground."

Tell students that they are going to have the opportunity to solve this problem through engineering. They will be working with a partner to design a structure to provide a place to cool off when they are on the playground. Tell students that when engineers design something, they often build a model and test it before they build the real thing. Explain that a *model* is a representation of a real object. The model they build will not be big enough for real people to be underneath. It will be small, no bigger than a shoebox, but it will show

Testing a shade structure

the shape and features of a real structure. Explain that they will be testing their structure by placing one ice cube in the structure and another ice cube outside of it to see which melts first.

Next, show students the supplies they will be using to build their models. Show them an ice cube and tell them that they need to make sure that it can fit underneath their structure. Then, brainstorm some ideas together. Ask guiding questions, such as the following:

- ? What shape will your structure be?
- ? What materials will you use?
- ? What color will you use for the roof of the structure? Why?
- ? Where will you place the ice cubes?

Provide each pair of students with a bag of supplies (see Materials section), and let them begin building. Set a time limit, and visit groups as they work, reminding them that the structure must be tall enough for an ice cube to fit underneath.

evaluate

Keep It Cool Design Challenge: Testing Our Models

When all students have finished their structures, go outside on a sunny day to test them. Remember to take a cooler of ice with you! Give each student the Keep It Cool Design Challenge student page and a clipboard. *Ask*

- ? How will we know if our models solved the problem of providing a place to cool off on the playground? (If it works, the ice cube inside the structure will stay frozen longer or be less melted than the one beside the structure.)

Have students set up their models in a sunny area. Encourage them to rotate their models and find the best angle to position it (the angle that provides the most shade). Then, give each pair two ice cubes of the same size and shape. Tell them to place one ice cube inside the model and one beside it. As students are waiting for the ice cubes to melt, have them each draw a picture of their model on the student page.

> Connecting to the Common Core
> **Writing**
> Text Types and Purposes: K.2, 1.2, 2.2

Writing

After waiting long enough to see a difference, have students compare the two ice cubes and answer the questions on the student page. For the first question, they need to circle which ice cube took longer to melt. For the second question, they need to write "yes" or "no" about whether their structure worked. For the third question, they need to write a sentence explaining how they know it did or didn't work. An example of an acceptable response would be "I know it worked because the ice cube in the model did not melt as fast as the ice cube in the Sun."

Have students compare their designs and discuss what they think worked the best. Then, have them brainstorm some ideas to improve their designs. If time allows, give students an opportunity to improve their designs and test the models again.

STEM at Home

Have students complete the "I learned that …" and "My favorite part of the lesson was …" portions of the STEM at Home student page as a reflection on their learning. They may choose to do the following at-home activity with an adult helper and share their results with the class. If students do not have access to the internet at home, you may choose to have them complete this activity at school.

"At home, we can experiment to find out which will melt faster: an ice cube on black paper or an ice cube on white paper. This experiment should be done outside in a sunny spot on a warm day. We will need the following materials:

- 2 clear plastic containers
- 1 sheet of black construction paper
- 1 sheet of white construction paper
- 2 ice cubes of the same size and shape
- 1 watch or timer

Lay the papers next to each other in the Sun. Put an ice cube in each container, and place the containers on the papers. Then, record the time it takes for each ice cube to melt completely."

For Further Exploration

This section is provided to help you encourage your students to use the science and engineering practices in a more student-directed format. This box lists questions and challenges related to the lesson that students may select to research, investigate, or innovate. Students may also use the questions as examples to help them generate their own questions. After selecting one of the questions in the box or formulating their own questions, students can individually or collaboratively make predictions, design investigations or surveys to test their predictions, collect evidence, devise explanations, design solutions, or examine related resources. They can communicate their findings through a science notebook, at a poster session or gallery walk, or by producing a media project.

Research

Have students brainstorm researchable questions:

- ? What is inside a glass thermometer? How does it work?
- ? What does the color of a star tell you about its temperature?
- ? What are some ways engineers are designing buildings and parking lots to keep cities cooler?

Investigate

Have students brainstorm testable questions to be solved through science or math:

- ? Does the shape or size of an ice cube affect how fast it melts?
- ? What heats up faster in the Sun: a cup of water or a cup of sand?
- ? Do different-colored T-shirts have different surface temperatures in the Sun?

Innovate

Have students brainstorm problems to be solved through engineering:

- ? Can you design a way to make s'mores with the Sun's energy?
- ? Can you design a cup to keep your drink cold on a hot day?
- ? Can you design a container to keep an ice pop frozen on a hot day?

More Books to Read

Miller, R. 2014. *Engineers build models.* New York: Crabtree.

Summary: Clear, concise text and photographs featuring child engineers introduce the importance of building models in engineering. Featured models include map models, diagrams, blueprints, and three-dimensional models.

Sherman, J. 2004. *Sunshine: A book about sunlight.* Minneapolis: Picture Window Books.

Summary: Simple text and colorful illustrations describe how the Sun heats Earth and causes our weather. It also explains rainbows, day and night, and moonlight.

Name: ______________________________

Comparing Temperatures

Directions: Write the names of four different outside surfaces in the "Surface" column. Your teacher will measure the temperature of each surface in the shade and in the Sun. Write the temperatures in the chart.

Surface	Temperature in Shade (°F)	Temperature in Sun (°F)
1.		
2.		
3.		
4.		

Circle the highest temperature. Why do you think it was the highest?

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____

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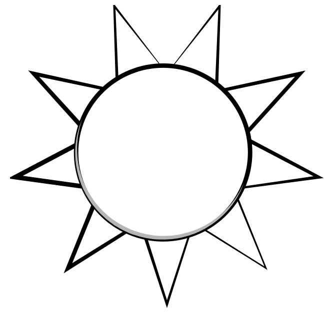
Name: ______________________________

Let's Learn About the Sun



Before Reading
True or False

After Reading
True or False

________ 1. The Sun is a star. ________

________ 2. The Sun is much smaller than Earth. ________

________ 3. The Sun is much farther away than the Moon. ________

________ 4. A spaceship has been to the Sun. ________

________ 5. Without the Sun, Earth would be cold and dark. ________

Name: ________________________________

Keep It Cool Design Challenge

Challenge: Design a structure to provide a place to cool off on the playground.

Draw your model. Show the Sun in your picture.

Which ice cube took longer to melt? (circle)

In the model **In the Sun**

Did your model work? ____________________________

How do you know?

____

____

____

____

Name: ______________________________________

STEM at Home

Dear _________________________,

At school, we have been learning about how **the Sun warms the Earth.**

I learned that: ____

____

My favorite part of the lesson was: _____________________________________

____

____

At home, we can experiment to find out which will melt faster: an ice cube on black paper or an ice cube on white paper. This experiment should be done outside in a sunny spot on a warm day. We will need the following materials:

- 2 clear plastic containers
- 1 sheet of black construction paper
- 1 sheet of white construction paper
- 2 ice cubes of the same size and shape
- 1 watch or timer

Lay the papers next to each other in the Sun. Put an ice cube in each container, and place the containers on the papers. Then, record the time it takes for each ice cube to melt completely.

Black Paper	White Paper
_______ min.	_______ min.

Our conclusion: The ice cube on _____________ paper melted faster because

____

____

____