MADE FOR THE SHADE

A creative task engages kindergarteners in building protective structures for UV-sensitive lizards.

By Laura Kitagawa

What is the Sun? What effect does it have on the Earth? How do we protect ourselves from the Sun's harmful rays? These are a few of the questions that I wanted my kindergarten students to explore regarding the Sun and solar energy. As a science teacher for a private K–8 school in Silicon Valley, I was familiar with the *Next Generation Science Standards*, and I knew *what* I needed to address with my students. According to the *NGSS*, kindergarten students should be able to "make observations to determine the effect of sunlight on Earth's surface" (K-PS3-1) and "use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area" (K-PS3-2) (NGSS Lead States 2013, p. 6). But *how* could I teach these concepts in a fun and engaging way? According to *A Framework for K–12 Science Education*, "the actual doing of science and engineering can pique students' curiosity, capture their interest, and motivate their continued study" (NRC 2012, p. 42). I wanted to think of a hands-on, meaningful way to connect the two *NGSS* standards to give my students a real purpose for making a shade structure. When I remembered how much my students love learning about animals, that's when the idea came to me! I decided to make lizards for my students using special UV-sensitive pony beads that change color when exposed to the Sun's ultraviolet radiation. Now, rather than building random shade structures, my students would be excited to design houses that protected their UV-sensitive lizards from the Sun.

Engage

For this three- to four-week unit, I followed the 5E instructional model: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee 2009). To pique my students' interest in solar energy, I read *Beneath the Sun* by Melissa

PHOTOS COURTESY OF THE AUTHORS

Stewart (2014). This book is a great introduction to the Sun and the different ways that humans and animals try to stay cool. I like to read picture books because they help my students make important personal connections, and they are "powerful instructional tools for meeting the needs of a variety of students with diverse learning styles" (Flippo 1999). I then asked the following preassessment questions: *What is the Sun? What kind of energy do we get from the Sun? How do we stay cool and protected from the Sun?* Several of my students already knew that the Sun is a star. If they had not, I could have also read *The Sun Is My Favorite Star* by Frank Asch (2000). Many of my students also had a good understanding of how we stay cool and protected from the Sun. They shared ideas like drinking water, going for a swim, running through the sprinklers, sitting in the shade, wearing sunglasses and hats, putting on sunscreen, and not looking directly at the Sun. But they struggled with verbalizing what kind of energy we get from the Sun or how the Sun affects the Earth. Rather than describing how the Sun provides sunlight that warms the Earth, students shared ideas like "the Sun is really hot" or "the Sun is bright."

Explore

In order for my students to observe the Sun's energy and effects firsthand, we conducted an investigation using one black and one white plastic bottle, both with a deflated balloon on top (for complete instructions, see NSTA Connection). I first asked my students to predict what would happen if we put the bottles in the direct sunlight. Some students predicted that the balloon on the black bottle would get bigger or explode. Others predicted the white bottle. One student predicted that both balloons would fill up and tip the bottles over. Within 30 seconds of placing the bottles outside, we were able to see the results. The balloon on the black bottle filled with air, while the balloon on the white bottle remained deflated. Before asking for explanations, I had my students feel the outside of both bottles. For a math extension, students could use thermometers to measure the temperatures inside the two bottles (*CCSS* K.MD.A.2). I then asked my students to describe the results. Everyone agreed that the balloon on the black bottle grew larger, the black bottle felt warmer than the white one, and these changes occurred because of the Sun, but there was some confusion about why. Some students shared that the Sun is hot and provides heat. Others shared that the black bottle felt warmer because dark colors absorb more heat. Others added that this is why the blacktop felt hot, or why it's better to wear light-colored clothing on sunny days. While my students were on the right track, I realized that they had a few misconceptions about the Sun and solar energy that I needed to address. They also needed help understanding what caused the balloon to expand.

Explain

To explain the results of the investigation, I brought my students back into the classroom, and we had an in-depth discussion about the Sun, solar energy, and its effects on the Earth. Depending on the level of your students, a detailed or simplified explanation could be provided.

Sun and Solar Energy: The Sun is our closest star. It is a giant ball of hot gases, including hydrogen and helium. Every day, the Sun emits huge amounts of solar energy, or radiant energy, which travels in rays to Earth. Most solar energy is in the form of visible light, ultraviolet radiation, or infrared radiation. A common misconception is that the Sun provides heat. While the Sun is very hot, Earth does not receive much of its warmth. Instead, when the Sun's rays hit Earth, the solar energy is converted into heat. Another common misconception is that dark colors absorb more heat. Actually, dark colors absorb more sunlight that

is *converted* into more heat, while light colors reflect sunlight and create little heat. In our investigation, the black bottle absorbed more sunlight, which was converted into more heat. When the air inside the black bottle warmed up, the hot air expanded, needed more space, and moved inside the balloon, causing it to grow.

Sun's Effect on the Earth: The Sun is our primary source of energy. It is important for several reasons. First, solar energy warms the Earth and its surrounding atmosphere, making it a viable place to live. Second, solar energy warms the water on Earth, creating the water cycle and weather. Third, plants need solar energy to create sugars during photosynthesis, and plants are the primary food source for all life on Earth.

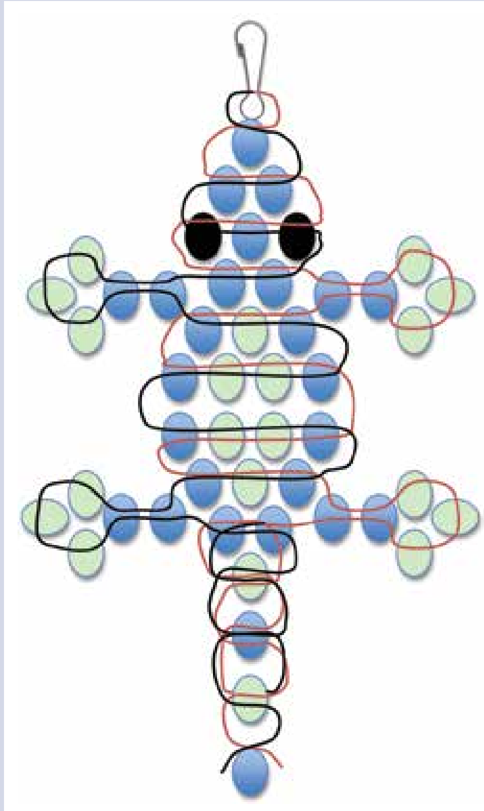
Next, I wanted to shift my students' focus to how animals protect themselves from the Sun. I read *Animals in Hot Places* by Moira Butterfield (2000). This book beautifully illustrates the cooling strategies of animals in different habitats. First, we discussed animal adaptations to live in hot, sunny places. Students provided many examples from the book, as well as others from previous knowledge (*CCSS* SL.K.2). Next, I asked my students to compare and contrast how animals and humans stay cool and protected from the Sun. They identified several similarities like sitting in the shade, drinking liquids, and swimming in water. They also identified several differences like how humans put on sunscreen or sunglasses for protection, while animals burrow underground, radiate heat from their ears, roll in the mud, or urinate on their legs (this was the favorite). For a language arts extension, students could complete a Venn diagram displaying similarities and differences (*CCSS* W.K.2).

Elaborate

In order for my students to extend their knowledge of the Sun and solar energy, they conducted an engineering design project following the steps of the Engineering Design

FIGURE 1.

Beaded lizard how-to.



Materials

- 3 ft elastic cord or lanyard string: 100 yard roll for $6–10
- 48 Multicolored UV pony beads (9 mm): Bag of 500 for $10
- 2 Black pony beads (9 mm): Bag of 500 for $6
- 1 Lanyard hook (1 in): 50 for $5

all items purchased on *Amazon.com* (see NSTA Connection for links to product pages)

Instructions

1. If you want to create a specific color pattern on your lizard, sort the UV pony beads by color in the Sun, and place the beads into labeled bowls. Or, make the lizard outside in the sunlight.
2. Cut a 3 ft piece of elastic cord or lanyard string. I like to use the elastic cord because it's easier to tie and it keeps the lizard laying flat.
3. Fold the cord in half and tie the folded end onto a one-inch lanyard hook. You should now have two cords of equal length.
4. Tape the lanyard hook onto a table, one foot from the edge. This will help keep the lizard in place as you work.
5. Follow the lacing pattern shown in the diagram. One cord is shown in red, the other in black. Notice that both cords go through the beads of the lizard's head, body, and tail. Only one cord goes through the arms and legs.
6. In the third row, be sure to place a black bead on each end for the eyes.
7. Choose colored beads of your choice to create a pattern for the belly, hands, and tail. Or, feel free to just choose them randomly and be surprised with your final product.
8. After each row, pull the cord tightly to push the beads closer together. This takes practice, especially around the arms and legs, but you'll get the hang of it.
9. After lacing the tail, tie a double knot, cut off the ends leaving one inch from the knot, and tuck the ends into the tail beads.
10. Enjoy your UV-sensitive lizard in both the sunlight and in the dark!

Process as described in *Engineering is Elementary* (Museum of Science 2015). In preparation for this project, I purchased multicolored UV-sensitive pony beads from Amazon (a bag of 500 beads for $10). I premade a beaded lizard for each of my students that took about 10 minutes each to complete. See Figure 1 for a list of materials, instructions, and a diagram, and Internet Resources for a video tutorial. Be careful using beads around small children because of choking hazards. CAUTION

Step 1: Ask

To engage my students in this project, I told my class that I had a special animal to show them. For dramatic effect, I explained that it was afraid to come out because it likes to live in the dark. Slowly, I pulled a white beaded lizard out of my pocket. Just like cold-blooded lizards, I explained that this lizard is affected by the temperature of its surroundings. Lizards like to bask in the sunlight when they are cold, but they also like to hide in the shade when they are too hot. I carefully gave each student a lizard and explained that we were going to take our lizards outside to help them get used to the light. So with our lizards cupped inside our hands, we walked to a nice sunny spot. All at once, I had my students uncover their lizards. Right away, my students noticed the effects of the Sun. They quickly exclaimed how the lizards changed from white to brilliant colors when they were exposed to the sunlight. They ea-

gerly described the colors and patterns of their own lizard and then compared it to their classmates' lizards. I encouraged my students to further explore the effects of the Sun by testing their lizards under the shade of a tree, in their own shadow, and under their clothing. When we returned to the classroom, they were amazed to see their lizards change back to white again. I then presented the class with a challenge: They needed to design and build a house for their lizard that protected it from the Sun (Scientific Practice: Ask Questions and Define Problems). I explained the criteria (houses must protect lizards from the Sun and have a front entrance) and the constraints (use only the materials provided).

Step 2: Imagine

Next, I had my students investigate which materials would work the best to protect their lizards from the Sun (Scientific Practice: Develop and Use Models). To prepare, I made 10 basic houses using a variety of roof materials (see Figure 2).

First, I displayed all 10 houses and described the different roof materials including black and white construction paper, wax paper, cardboard, aluminum foil, felt, and clear plastic sheets with and without three different strengths of sunscreen spread over the top. I also showed my students the three bottles of sunscreen (SPF 8, 30, and 50) and explained what the numbers represented. Then, I had my students predict which roof materials would protect their lizards the most and least. Several students predicted that the cardboard, felt, or foil would work the best. Others predicted that the clear plastic, regardless of sunscreens, would work the least.

Next, my students placed their lizards inside the houses and carried them outside. Immediately, they began to notice how well, or not, the houses protected their lizards. Some lizards stayed mostly white, while others became multicolored. I encouraged my students to explore the effects of different roof materials by switching houses with each other (Scientific Practice: Plan and Carry Out Investigations). At the end of class, my students discussed the strengths and weaknesses of each material. The consensus was that the cardboard worked the best because it was thick and prevented sunlight from getting through. The plastic sheet with no SPF worked the least because it provided no protection at all. But to our surprise, the plastic sheet with SPF 50 worked very well to keep the lizards

FIGURE 2.

Materials for demonstration houses and students' lizard houses.

Materials for 10 basic house models:

- Cardboard bases (10) – 12 × 12"
- Small paper cups (40) – 3 or 5 ounces
- Masking tape and pen (For roof labels)
- 10 different roof materials, for example:
  - o White paper
  - o Black paper
  - o Cardboard
  - o Aluminum foil
  - o Wax paper
  - o Felt
  - o Clear plastic (overhead transparencies or extra pieces of lamination)
  - o Clear plastic with SPF 8, 30, and 50 sunscreen

Materials provided for individual lizard houses:

- Large thick paper plate (base) – 1 per student
- Small paper cups – 4 per student
- Craft sticks
- Roof materials
  - o Construction paper (variety of colors)
  - o Cardboard
  - o Aluminum foil
  - o Wax paper
  - o Felt
  - o Clear plastic sheets
  - o Sunscreen (SPF 8, 30, 50)
- Tape/glue/glue sticks
- Markers/crayons/colored pencils

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013):

K-PS3 Energy

www.nextgenscience.org/kps3-energy

The materials/lessons/activities outlined in this article are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.

Performance Expectation	**Connections to Classroom Activity** *Students:*
K-PS3-1: Make observations to determine the effect of sunlight on the Earth's surface.	• observe and compare the effect of sunlight on a variety of different materials.
K-PS3-2: Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.	• design and build shade structures for UV-sensitive beaded lizards.
Science and Engineering Practices	
Planning and Carrying Out Investigations	• conduct solar experiments to analyze the effects of the Sun.
Developing and Using Models	• use models of house structures with different roof materials to compare and contrast the effects of the Sun.
Constructing Explanations and Designing Solutions	• design and create shade structures using the most effective building materials.
Disciplinary Core Idea	
PS3.B: Conservation of Energy and Energy Transfer • Sunlight warms Earth's surface.	• observe how the Sun provides solar energy in the form of light that travels in rays to the Earth. • observe that solar energy is converted into heat that warms the Earth (land, air, and water).
Crosscutting Concept	
Cause and Effect	• observe that sunlight has varying effects on different materials resulting in different amounts of heat. • observe that shade structures can reduce the warming effect.

mostly white. Many students shared that this is why it's so important to wear sunscreen outside (Scientific Practice: Analyze and Interpret Data).

Step 3: Plan

After reviewing the criteria and constraints for this engineering design project, I spread out the building materials for my students to see (Figure 2). As a whole class, they brainstormed possible house designs. They discussed the pros and cons of each roof material and explained their reasoning (Scientific Practice: Engage in Argument From Evidence).

For a language arts extension, students could draw and label their individual design ideas and use these diagrams as visual aids, both for sharing with peers and for reference during the next building phase (*CCSS* W.K.2, SL.K.5).

Step 4: Create

Finally, the day had come for my students to build their lizard houses. They couldn't wait to get started. They built houses with roofs, walls, windows, and doors. Some houses had furniture and rugs. Some houses had gardens and walkways. And one house even had flags.

They shared ideas freely and gave suggestions to each other along the way. During this process, they used their lizards several times to make sure that they would still fit inside and have enough room to move around (Scientific Practice: Design Solutions).

Step 5: Improve

When my students were satisfied that their houses were built to solve the problem, they took them outside to test how well they protected their lizards from the Sun. Most students went through many iterations, making improvements as necessary. For example, several students built houses with windows. But when they noticed that the Sun shone through and turned their lizards multicolored, they decided to add SPF 50 sunscreen to the windows. One student noticed that there was a gap between his roof and walls that allowed Sun to get in, so he taped the edges together. Another student added a second layer to the roof to make it thicker and block more of the Sun's rays. Although my students did not collect or record any specific data (they were much too excited to stop working), I would recommend taking lots of pictures to document their various improvements to their houses as they work through this step of the engineering design process. When everyone was finished, my students presented their houses to the class and explained what special features kept their lizards protected from the Sun's harmful rays (Scientific Practice: Obtain, Evaluate, and Communicate Information).

At the end of this unit, my students were so excited to finally take home their UV-sensitive lizards and shade structures, especially after I showed them how their lizards also glowed in the dark! For days afterward, parents shared how these lizards brought many additional hours of scientific learning at home, both day and night!

Evaluate

In order to evaluate my students' learning during this unit, I used a variety of formative and summative assessments. I started with preassessment questions to gain information about their previous knowledge. Throughout the unit, I observed my students' peer interactions and responses during class discussions, and I took note of their conversations and comments. For any struggling students, I asked additional guiding questions and paired them with peers who had a stronger understanding of the concepts. At the end of the unit, I checked for understanding as they presented their final houses. I also conducted individual student interviews to assess what they had learned using a rubric (See NSTA Connection).

Conclusion

Overall, the UV-sensitive lizards were a huge success! They helped me teach the *NGSS* kindergarten physical science standards, science and engineering practices, engineering design process, and several *CCSS* language arts and math standards. And more importantly, these cute little lizards helped my students learn about the Sun and its effect on the Earth in a fun, hands-on, and engaging way. ■

Laura Kitagawa* (Lkitagawa@a-cs.org) *is a K–2 science teacher at Almaden Country School in San Jose, California, and a curriculum developer for zSpace.

References

Bybee, R. 2009. *The BSCS 5E Instructional Model and 21st Century Skills*. Retrieved from *http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_073327.pdf*.

Flippo, R.F. 1999. *What do the experts say? Helping children learn to read*. Portsmouth, NH: Heinemann

Museum of Science. 2015. *Engineering is Elementary: The Engineering Design Process*. Retrieved from *www.eie.org/overview/engineering-design-process*.

National Governors Association Center of Best Practices and Council of Chief State School Officers (NGAC and CCSSO). 2010. *Common Core State Standards*. Washington, DC: NGAC and CCSSO.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*.

Resources

Asch, F. 2000. *The Sun is my favorite star*. Orlando, FL: Gulliver Books.

Bang, M., and P. Chisholm. 2009. *Living sunlight*. New York: The Blue Sky Press.

Branley, F. 2002. *The Sun: Our nearest star*. New York: Harper Collins.

Butterfield, M. 2000. *Animals in hot places*. Austin, TX: Raintree Steck-Vaughn.

Fowler, A. 1998. *Energy from the Sun*. New York: Children's Press.

Gibbons, G. 1983. *Sun up, Sun down*. Orlando, FL: Harcourt Brace & Company.

Stewart, M. 2014. *Beneath the Sun*. Atlanta, GA: Peachtree Pub Ltd.

Internet Resources

Beyeler, M. 2013. Pony Bead Lizard Tutorial. Retrieved from *www.youtube.com/watch?v=zhtOJMyZ2MY*

NSTA Connection

Download instructions for the bottle demonstration, the final interview questions, and the assessment rubric at *www.nsta.org/SC1601*.