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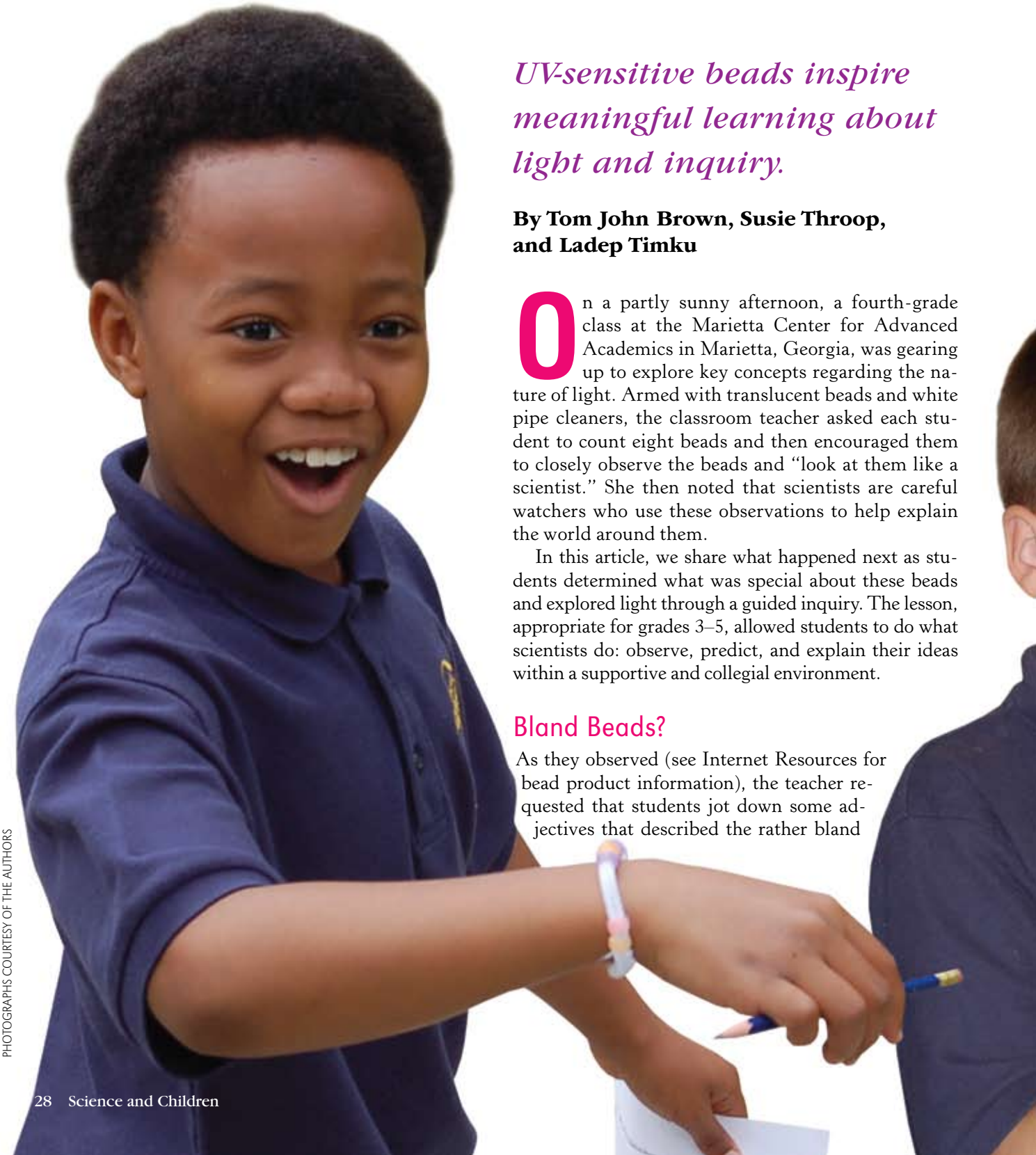

UV-sensitive beads inspire meaningful learning about light and inquiry.

By Tom John Brown, Susie Throop, and Ladep Timku

On a partly sunny afternoon, a fourth-grade class at the Marietta Center for Advanced Academics in Marietta, Georgia, was gearing up to explore key concepts regarding the nature of light. Armed with translucent beads and white pipe cleaners, the classroom teacher asked each student to count eight beads and then encouraged them to closely observe the beads and "look at them like a scientist." She then noted that scientists are careful watchers who use these observations to help explain the world around them.

In this article, we share what happened next as students determined what was special about these beads and explored light through a guided inquiry. The lesson, appropriate for grades 3–5, allowed students to do what scientists do: observe, predict, and explain their ideas within a supportive and collegial environment.

Bland Beads?

As they observed (see Internet Resources for bead product information), the teacher requested that students jot down some adjectives that described the rather bland

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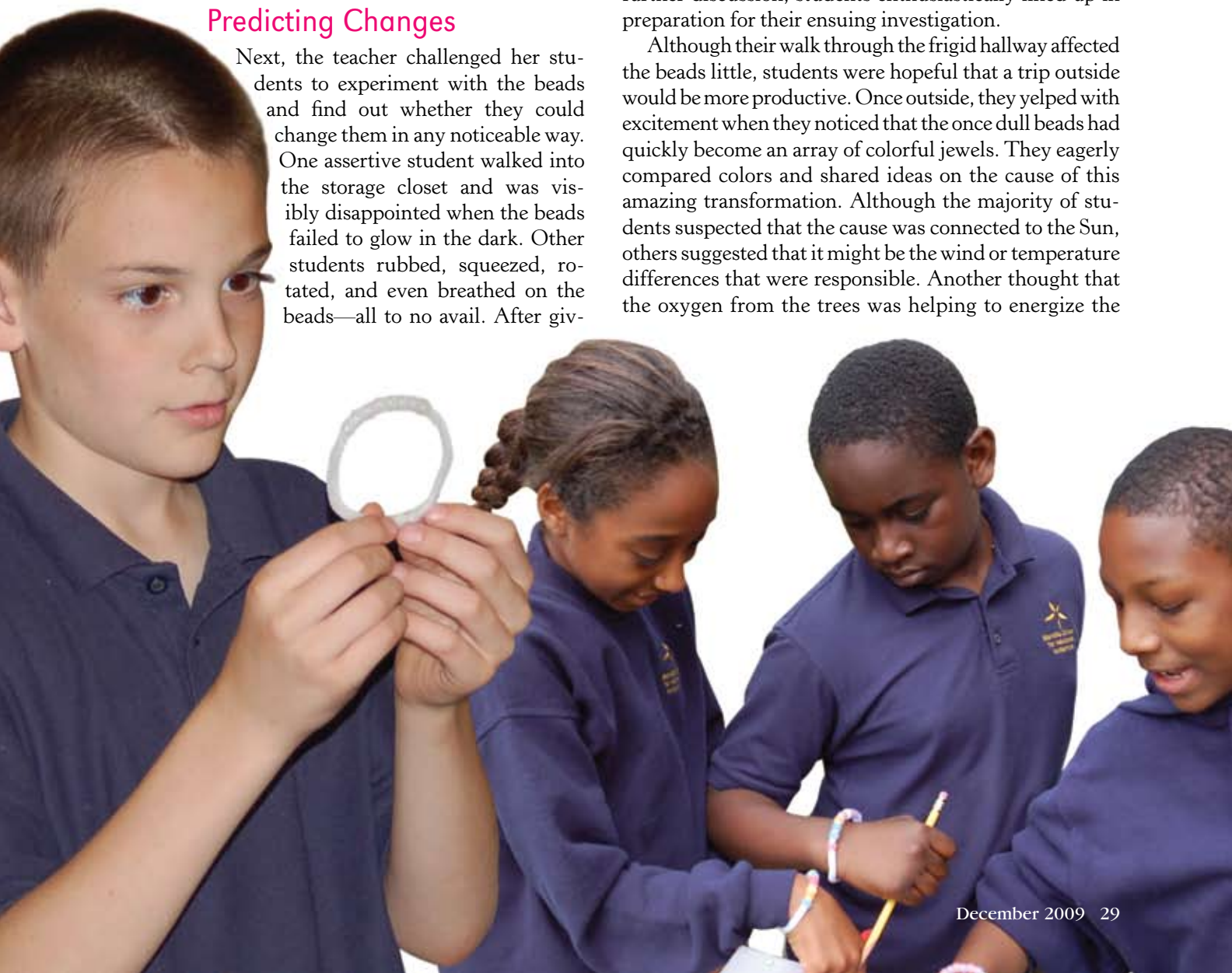
Meets the Eye

beads. They eagerly shared words such as *round, white, shiny, smooth, oily, soapy,* and *donut-shaped,* which helped to express key attributes of the beads. The teacher then solicited their ideas regarding how the beads could be changed, and their ideas included putting them in acid or hot water, breaking them into pieces, and painting them. Using their laboratory sheets they then recorded these first observations (see NSTA Connection).

Predicting Changes

Next, the teacher challenged her students to experiment with the beads and find out whether they could change them in any noticeable way. One assertive student walked into the storage closet and was visibly disappointed when the beads failed to glow in the dark. Other students rubbed, squeezed, rotated, and even breathed on the beads—all to no avail. After giving students time to exhaust their options, the teacher sensed their frustration and calmly suggested that they take a break by making a bracelet using the pipe cleaner to display the beads. After a minute or so, she asked them to think of other places where the environment might be different for these stubborn beads. A student suggested they try a hallway that was apparently famous for its frigidity. Others suggested outside where the air or light might be different than those inside the classroom. After further discussion, students enthusiastically lined up in preparation for their ensuing investigation.

Although their walk through the frigid hallway affected the beads little, students were hopeful that a trip outside would be more productive. Once outside, they yelped with excitement when they noticed that the once dull beads had quickly become an array of colorful jewels. They eagerly compared colors and shared ideas on the cause of this amazing transformation. Although the majority of students suspected that the cause was connected to the Sun, others suggested that it might be the wind or temperature differences that were responsible. Another thought that the oxygen from the trees was helping to energize the



Recording bead observations

beads. Though their teacher was quick to acknowledge their ideas, she was careful not to provide any answers.

Explaining the Changes

Once back inside, it was only a minute or so before some of the students noticed that the beads were quickly losing their brilliance. The teacher asked each student to write a hypothesis based on their observations. Students' explanations of why the beads turned bright colors were to be accompanied by diagrams illustrating the "before, "while," and "after" properties of the beads. Students then shared their explanations, which most frequently implicated the Sun as the agent of change. One student suggested that the beads were solar-powered, another suspected that it was a chemical reaction within the beads that caused the change in color. Yet another thought that something inside the beads reflected the lack of color in the classroom and only turned "colorful when the colors from outside took effect." Although these initial conceptions of light reflected their lack of experience with this difficult phenomenon, it was clear that they were actively engaged and that their understanding was growing.

Types of Light

Calling on their previous experiences, the teacher then probed students' prior knowledge and informally assessed her students' understanding of light. After asking the class to tell her what they already knew about light, one student suggested that there were different colors of light in the air. In response, others quickly recalled the idea that light consisted of a spectrum of many different colors, and multiple students exclaimed the mnemonic device "ROY G BIV," which they had learned in a previous class. This led to a fervent discussion of how the spectrum could be related to the different colors produced by the beads. After listening intently to students' thoughts and gauging their responses, the teacher shared some important things that she wanted students to learn about the behavior of light.

As a starting point, she wanted students to recognize that there are many forms of light energy. The teacher explained that there are three primary kinds of light—ultraviolet (UV), visible, and infrared—which are produced by the Sun. She explained how visible light is the type you can see, how infrared light is the kind that carries heat, and how UV light is the type that gives you a tan. She had brief descriptions of each of these written on the board. Then, narrowing the focus to UV light, she explained that overexposure to UV light can be harmful to our skin, causing things such as sunburn and even skin cancer. When she asked students whether they knew a good way to avoid this kind of damage, they knowingly piped up about avoiding overexposure and wearing sunscreen.

Hoping to connect this discussion back to the beads, she then let the cat out of the bag: These beads were actually UV sensitive. As it turns out, each bead contains a chemical—called a *pigment*—that changes color like skin can do when it absorbs UV light. In doing so, the beads can be used to measure the presence and intensity of UV light: the stronger the intensity, the deeper the colors of the beads. If you remove the source of UV light, as the students did when they went back inside, the beads quickly fade to a dull white.

This lesson was meant as a guided inquiry in which students have time to explore their thinking and ideas, but then the teacher builds on their ideas and clarifies key concepts. The teacher could have asked students to determine what type of light was stimulating the beads. Although she didn't in this lesson, the inquiry doesn't end at this point—it continued with a new focus when she asked students to begin testing the light.

Testing the Light

The teacher continued this guided inquiry by walking over to one of the windows and asking the students to consider which kinds of light were coming through the window. She then focused their thinking by asking them how they could determine whether UV light was streaming through. It only took a moment for the kids to realize they could get up, walk to the window, and use their bracelets to test their ideas. Two students quickly went over to the window, poked their bracelets into the streaming sunlight, and looked surprised to see that the light streaming through had little effect on their beads.

After other groups followed, they openly discussed possible explanations, including ideas that the window

reflected UV light or perhaps acted like a shield to absorb it. Ordinary window glass blocks most UV light from passing through it—UVB and UVC light are blocked and only UVA light can pass through—but she didn't tell students this because she wanted them to explore further. The teacher encouraged students to brainstorm other ways to modify either the light or the beads. When one student asked whether lamp light might be different than the fluorescent class lights, she was sent over to a lamp to give her bracelet a good dose. Another student suggested that they put sunscreen on the beads to see whether that had any noticeable effect. Through this dialogue, the teacher was able to gauge the depth to which each group understood key attributes of UV light.

Back Outside

Last, the teacher gave out lenses to each group, three of which were labeled as being *UV opaque* and three that were *UV transparent*. Students were asked to predict what would happen to the beads when the sunlight had to pass through the lens first. Although most of them predicted that the UV opaque lens would keep the beads from changing, they were once again eager to test their ideas as they hustled back out in the sunlight. Though the results they obtained were largely expected, they were able to confirm their ideas and solidify their growing understanding.

As a final performance task, students were encouraged to develop a simple experiment to learn something new about the beads. They were also asked to write a couple of sentences which explained the nature of this proposed experiment. One group wrote that "we can see if the Sun goes through water and still changes the color then. If it does, then UV light goes through the water and can still hit the beads." The teacher replied, "Excellent job applying your observations of the window glass to another similar material (water)." Through their active exploration and discussion, they were discovering that an understanding of light energy involves a lot more than meets the eye.

Conclusion and Reflection

The teacher concluded the lesson by having students write a paragraph in their science journals that explained what they did and what they learned during their exploration with the beads. Although analysis of student journals demonstrated intense student engagement and development of understanding, it also showed that some students were confused with respect to the characteristics of different types of light. She noted, "I realized that I need to spend more time teaching about the types of light and the light spectrum. Because this was an initial discovery lesson, it helps me to plan my instruction for later lessons." The teacher planned further explorations regarding the reflection, refraction, and absorption of light.

A few days later during a schoolwide field day, the positive effect of this lesson became apparent. When a student from another class said she did not have to wear sunscreen today because it was cloudy, she was gently corrected by a fourth-grade student who had participated in the lesson. After describing how UV light can come right through the clouds, the student proudly showed the girl his UV beads so that she could see the change for herself. At that moment, it became crystal clear—these students were building both their passion for and understanding of science. ■

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades K–4

Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry

Standard B: Physical Science

- Properties of objects and materials

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

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Internet Resources

Beads

www.stevespangler.com

www.teachersource.com

Investigating Sunscreens

www.sciencelearn.org.nz/contexts/you_me_and_uv/teaching_and_learning_approaches/investigating_sunscreens

NSTA Connection

For a blank laboratory worksheet, visit *www.nsta.org/SC0912*.