No matter the weather, we'll measure together

by Margaret Blanchard and Jennifer Albert

Have you ever planned an outdoor laboratory, only to have it rain? Or be cold or windy? What if you had a laboratory that your students could conduct no matter what the weather was? Let us take you on a school-yard tour of our technology-infused weather investigation that can be done indoors or outdoors.

Begin with students' experiences

We start our tour in Ms. B.'s class. Students have shuffled in, some with wet hair, others with umbrellas or raincoats. The sky is gray, and Ms. B knows that scattered showers are predicted throughout this chilly, damp day. After students have settled into their seats, Ms. B says, "Let's take a poll. How many students are wearing jackets?" (Seventeen hands go up.) "Who has short sleeves, today?" (Two hands go up.) "How many of you are carrying umbrellas?" (Six hands go up.) "Who wore a hat to school, this morning?" (Eight hands go up.) Another student offers that she wore boots today, as did two others. Ms. B. writes these results on the board and then asks the class, "What does this tell us about the weather outside?"

Student hands go up. "I got wet waiting for my bus," offers one student. Another says, "My mom dropped me off at school. She said it was going to be chilly today, so I wore a jacket." Another student says, "The sky was really dark, and my dad said I should take an umbrella, 'just in case.'"

As students offer more personal testimonials, Ms. B records them on the board. She takes a step back and asks, "What do you notice about your experiences with the weather?" After a few seconds, one student offers, "It seems like we all noticed different things about the weather." Another student asks, "Did we all have the same weather, or was it different at our houses?"

Modeling results

Ms. B. projects a video from her laptop computer onto the large screen at the front of the room (total time of video clip is four minutes). She says, "Let's look at how we are going to find the answer to some of our weather questions."

Video transcript

(Teacher note: Create your own video using this script or using this script as an example. For additional information, see other articles in this issue for websites

FIGURE 1 Examples of available probeware/sensors

Note: For Vernier and Pasco, you will need 5 to 10 sets of materials depending on class/group size.

Brand	Product	Price
Vernier (probes can also connect to TI calculators and computer)	LabQuest	$329
	Temperature probe	$29
	Light sensor	$55
	UVA sensor	$106
	Relative humidity sensor	$69
Pasco (other operating systems available)	SPARK	$349
	6 in 1 Weather (temperature, barometric pressure, relative and absolute humidity, dew point, and altitude)	$109
Lab-Aids	Weather and Atmosphere Complete Materials Package with Teachers Guide	$1375

to help with video creation. If you are unable to make a video, use the scripts below to "act" for your students and set the scene.)

Scene 1—Inside the classroom: "Hi everyone. I am Ms. B., and I want to know what the difference is between the weather conditions in the classroom and outside."

Scene 2—Walking outside to the courtyard: "Here I am using the temperature probe to see what the temperature is outside. The reading is 20°C. My average reading for the classroom was 21°C."

Scene 3—Close-up of UVA sensor: "I have taken a series of measurements of ultraviolet A light. You can see that the readings are variable, and when the numbers 'jump around,' I choose the number in the middle of those readings. Here you can see I have a read of 36%."

Scene 4—Ms. B. outside: "I began this investigation wondering if the weather inside the classroom is different than outside. I decided to take all of the measurements by hand, holding the sensors at about shoulder height. I found that every measure taken indicated different weather conditions inside the classroom than outside. The temperature is 25°C warmer outside the classroom than inside. There is more UVA and UVB light outside. The relative humidity is lower outside (36%) than inside (45%). It's beautiful out here!"

Developing testable questions

Ms. B. uses the document camera to project the student challenge:

You woke up this morning, looked outside, and the Sun was shining. How could you have figured out what you should wear without leaving your room and without checking the weather forecast? Come up with one testable question that will help you investigate this problem (pretending the classroom is your room) and a plan to answer it. Get teacher approval of your question and plan. Answer the question in 30 minutes (or the time remaining in the class period), using one or more of the sensors. Document the data you collected and your findings on camera using the video camera. You can't start data collection until you have a testable question. Sample question (you can't use this one!): What is the temperature difference between the middle of the classroom and the area next to the window?

Students are instructed to get into their preassigned lab groups (three or four students per group), and to send one student to pick up a canvas bag that contains the following equipment: a temperature probe, a light sensor, UVA/UVB sensors, a relative humidity sensor, a data-collection device, a small video camera, a small clipboard with a pencil, and an umbrella. (Teacher note: This particular class had already used the sensors on previous investigations. If your students have not used these before, it is helpful to conduct a prelab on the previous day to practice using the equipment. This lab also may be

Temperature is usually the first thing students think about when asked about weather. However, their experience is usually limited to air temperature, which can easily be accessed on any computer and most cell phones. With probeware, students take the temperature of the classroom, outside, and of the surface of objects or the ground.

Light sensor: The reflection of light can tell us a lot about a surface. Students can use a light sensor to measure the light intensity approximately 5 cm off the ground (we attach them to pencils or rulers) in the same areas they measure with the temperature probe. Light reflects differently based on the color and material of the surface it is reflected from. For instance, concrete reflects much more light than asphalt.

Relative-humidity sensor: Relative humidity tells us how much moisture is in the air. Those of us in the southeast are all too aware that high humidity makes us hot and sticky in the summer and low humidity makes us dry and cold in the winter. However, humidity can also vary in different areas on a given day. Students in canoes on a pond quickly noticed that the relative humidity was different in the middle of the pond than it had been on the shore.

UVA/UVB sensors: Ultraviolet light is part of sunlight, but invisible to the human eye. It is responsible for summer tans and dangerous sunburns. Therefore, many of us try to remember to put on sunscreen before heading out in the summertime. But what do those numbers on the sunscreen bottle really mean? Students can compare different sunscreens with the use of UVA and UVB probes by smearing them onto overhead transparencies and holding them up to the Sun, with the probe held underneath to determine how much UVA/UVB passed through.

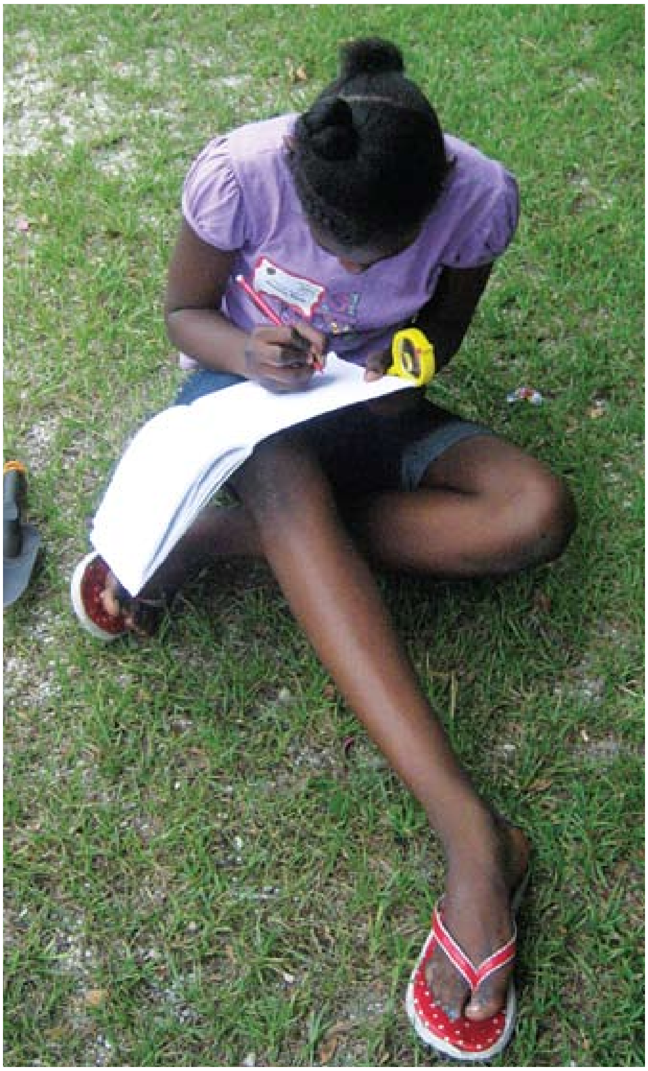
conducted using thermometers or with each group having a different piece of equipment. If your school does not have probes or sensors, they can often be loaned from other schools or colleges, or you can omit the equipment you do not have from the activity.)

Ms. B. moves among the groups to help students craft a testable question. (Teacher note: If time permits, teachers can have a whole-class brainstorming session to generate testable questions as a class and to help scaffold the process.) One team comes up with "Do relative humidity and temperature readings change if you measure close to the classroom door and farther away from the door?" Another team wants to know, "Will temperature at the floor be different than it is above the floor?" Students in this group decide to measure the temperature with the temperature probe lying on the ground, and three feet and six feet above the ground. They also decide to make repeated measures at those locations.

PHOTOS COURTESY OF THE AUTHORS

Caption tk

Another group is curious about the effect of their clothing on how warm they are. Students in this group are dressed very differently. One student is convinced the temperature near students' bodies will be the same for all students, because they all have the same basic internal temperature (98.6°F). Two other students think it will be different; otherwise, why would we wear different clothing? The fourth student is unsure. They ask, "Will temperature be different depending on the type of clothing a person is wearing?" They decide to take measurements for 60 seconds just inside each person's outer clothing (in this case, a sweater, a heavy jacket, a raincoat, and a jean jacket, near the waist). Students will take measurements inside the classroom, the first time after they have been outside 1 minute, and then again after they have been outside 10 minutes.



Caption tk

Data collection

The teams' testable questions are quickly "passed" by Ms. B., and they begin data collection. Ms. B. floats among groups and reminds them to use the video camera to document their data-collection process, and to record the preliminary answers to their research questions on a pad of paper. (**Safety note:** Students should wear safety glasses during all data collection and exercise caution by not climbing, etc., into locations or situations that could be dangerous. Students should wear Sunblock when outside and be reminded not to make direct observation of the Sun with the naked eye or with any instruments. If students go outside, they must be supervised and comply with all district/school regulations.)

Conversations in the teams include a wide range of topics. Some students are reminding others how to use the probes. Ms. B. overhears one student reminding another that he needs to wait until the temperature stabilizes: "It sort of hops around between numbers. When it stays pretty much the same, tell us that number."

In another team, students are trying to figure out if they should take the averages of the multiple UVA and UVB readings they have collected. One person is holding the video camera as another is showing the data table and describing their findings.

An all-female team has each person presenting a different segment of the study, and each person starts her section with little dance moves. They each contribute one segment of the presentation.

The final group is creating a rap to go over their findings. "I gotta reading, ya know it's 63, too cold for me, I'm about to freeze…"

Using sensors and managing data

Why use sensors? They allow students to collect their own data, which gives them ownership of the data collected and experience with real-world concepts, just like a scientist. It also makes data collection and analysis easier and faster.

Most devices used to operate sensors will collect data for you and allow you to either upload data to a computer or copy the data later (see Figure 1). We have found it useful to have one student in each group be the recorder. The recorder records the information on a data sheet as a backup to data that might be collected by the hardware hooked up to the probe. Because students are collecting more than one piece of information for several different locations, this is an excellent opportunity to show them the benefit of spreadsheets and databases. A sample data sheet may be accessed by teachers at *www.fi.ncsu.edu/project/stem_teams/teacher_resources,* but students develop higher-order thinking skills by creating their own data tables.

Data analysis

Students can analyze their own group's data and then compare it to the class as a whole (or to other classes), or the class can work with a common set of data from the teacher or a database. Spreadsheets help students compile data and either sort according to different values or categories or create graphs of specific information. The data can also be put on a map to give a better visual as to the physical relationships between the areas students tested.

Classroom tips: Make sure that students work in assigned groups to avoid excessive socialization. Each group member could have a task (e.g., recorder, data collector, videographer). It is helpful to give students time limits with a timer (e.g., 5 minutes to develop a question, 20 minutes to investigate). This lesson can be completed in a 55-minute class, or it can be extended to several days. If you have never done a lesson like this, you will need to scaffold it quite a bit for your students. This may mean having questions to pick from with brief descriptions of how students might investigate them. Lab summaries and analysis can be assigned as homework to save class time.

Why use technology to collect student data?

Not only is the integration of technology and science a key component of the National Science Education Standards (NRC 1996), but it also is vital to students' future success. We are living in a digital world, and we must teach our students to use technology for more than sharing gossip. Harris and Hofer (2009) suggest using "activity types" to help guide teachers in the use of technology. In their research-based approach, technologies are added after the lesson is designed, and the affordances of the technologies determine what is selected. Blanchard, Harris, and Hofer (2010) describe an example of science activity types to help teachers enhance instruction and also to model teaching described in national reform documents.

Presentations

Having students collect, analyze, and present their own work not only helps them develop collaborative and scientific skills, but prepares them for high school, college, and beyond. It also gives them a greater ownership of their work and adds meaning to the data they are collecting. Student presentations are also a 21st-century skill (Partnership for 21st Century Skills 2004). Students can incorporate multiple technologies, including web resources, computer software, and even cameras, to show pictures or video of the phenomenon they are presenting.

It's never overcast in this weather lesson

Students may have arrived at school cold, damp, and under gray skies. But during this weather lesson, they develop a testable question, collect data using handheld sensors, analyze data to answer their questions, and create a presentation using a video camera. If you ask students what they did in class, chances are they will say, "I did science" or "I had fun!" But we know that they also engaged in critical thinking and problem solving, and that they advanced their technical and interpersonal skills.

Weather is a topic that occurs many times in the standard course of study (NRC 1996) from elementary school through high school. This activity allows students to collect data on the questions that interest them about the weather, and learn from their peers about a range of other questions that were investigated. No matter the weather, your students will enjoy measuring it together in this technology-infused lesson. ■

References

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