I

magine two fourth-grade classes. Both contain students of comparable demographics and highly respected teachers each with four to five years of experience. Both classes engage in science curricula that emphasize science and engineering practices as outlined in the Next Generation Science Standards (NGSS Lead States 2013). Both classes earn similar scores on tests that assess acquisition of science content knowledge. Yet, despite these likenesses, at the year’s end, all of the students from one class view themselves to have some characteristics of a “smart science student” while only half of the students from the other class do so. You are probably already wondering what teaching practices might account for the differing outcomes in these two imagined classrooms. Fortunately, we do not have to just imagine: a recent research study (Carlone, Haun-Frank, and Webb 2011) reports on this very situation and offers an accounting of the small-group work and whole-class discussions that occurred in the two classrooms. Both vignettes illustrate students’ work in small groups during a magnetism and electricity unit, focused on the NGSS: Disciplinary core ideas PS3.A (Definitions of energy), PS3.B (Conservation of energy and energy transfer), and PS2.B (Types of interactions); crosscutting concept Energy and Matter; and multiple science and engineering practices. We ask the reader to reflect on these two vignettes and decide which practices, enacted over time with other curricular topics, would most likely lead to the research findings mentioned earlier. Finally, after revealing which classroom is which, we unpack the teaching practices and present specific strategies to illustrate how each supports or constrains students in affiliating with being a science person.

Creating a “We” Culture
Strategies to ensure all students connect with science.

By Heidi Carlone and Dennis Smithenry

not only help students construct science content knowledge and acquire inquiry skills, but also enable more students to affiliate themselves with the idea of being a “science person.”

To do so, we first present brief vignettes of sample practices that were representative of the small-group work and whole-class discussions that occurred in the two classrooms. Both vignettes illustrate students’ work in small groups during a magnetism and electricity unit, focused on the NGSS: Disciplinary core ideas PS3.A (Definitions of energy), PS3.B (Conservation of energy and energy transfer), and PS2.B (Types of interactions); crosscutting concept Energy and Matter; and multiple science and engineering practices. We ask the reader to reflect on these two vignettes and decide which practices, enacted over time with other curricular topics, would most likely lead to the research findings mentioned earlier. Finally, after revealing which classroom is which, we unpack the teaching practices and present specific strategies to illustrate how each supports or constrains students in affiliating with being a science person.
Vignette 1: Sample Practices in Mrs. Sparrow’s Class

Sharing Materials by Taking Turns

Near the beginning of a unit on electricity and magnetism, Mrs. Sparrow has her students work in small groups to light a bulb on a circuit board (i.e., a battery holder, a bulb holder, clips, wires, battery, and a bulb). Each group crowds around its materials at a table, and students energetically take turns trying out different combinations. They are polite and generally respectful with one another as they share materials and take turns. For example, in one group, three students take turns fiddling with the circuit board:

Caitlin: Guys, can I try something?
Neil: Hey. Let me try an idea.
Caitlin: Can I try something real quick?
Max: Sure.

(Caitlin disconnects and reconnects wires.)

Max: I got an idea.
Neil: After Caitlin is my idea, Max.
Max: Okay, but then my idea.
Caitlin: This one doesn’t light at all.
Neil: Okay, my turn. I’m assuming that there’s a wire, that this wire is connected here and we may as well see if there is—
Max: I’ll just test.

Helping Students Identify the Main Concept

Later in the unit, Mrs. Sparrow leads a whole-class discussion on what the students found in a recent inquiry where they examined the relationship between the force exerted by a magnet on a magnetic object and the distance from which the object is placed from the magnet. As shown in the following dialogue, Mrs. Sparrow guides students toward identifying the main concept to be learned from the inquiry:

Colin: [We were supposed] to figure out how many spacers you could put in and how many washers you could put in to see how strong the magnets are.
Mrs. Sparrow: Ok.
Colin: We were trying to see how strong the magnets were attracted together.
Mrs. Sparrow: Ok.
Colin: The more spacers, the less washers.
Mrs. Sparrow: Let’s stick to the more space between the magnets, the—?
Colin: Less attractions!
(Mrs. Sparrow looks to the next student with hand raised.)
Forrest: When there’s more space, the weaker the magnet. It’s not as powerful.
Mrs. Sparrow: Well not the magnet, but the—?
Forrest: Force!
Mrs. Sparrow: So the more space between the magnets, the weaker the—?
Forrest: Force.
Mrs. Sparrow: Very good. We will continue talking about magnets next week.

Vignette 2: Sample Practices in Ms. Wolfe’s Class

Sharing Ideas and Explanations

As in Mrs. Sparrow’s class, Ms. Wolfe has her students work in pairs or small groups on the same challenge of lighting a bulb. Several days later, after discussing all the ways that the students found to light the bulb, Ms. Wolfe prompts the students to think about how the incorporation of new components (e.g., switches, additional batteries, length of wires, and so on) might impact the circuit’s functioning. The class then decides to test these new components. As the students cluster around their materials and complete their tests, they share ideas with each other (and sometimes with other groups) and offer explanations to justify their ideas. For example, a pair of students constructs a circuit with a switch and are surprised by the bulb’s brightness when they close the switch:

Alejandro: Oh my that [light] is so bright.
Alejandro: (to someone else in a nearby group) Look! Ours is really bright.
Student: (from another group) It’s not as bright as ours.
Jeremy: Look at this—it’s got a switch though.
Alejandro: (to Jeremy) But how could we make it brighter?
Jeremy: With more batteries.
Alejandro: Explain.
Jeremy: More batteries, less wire.
Student: (from the other group) Why do you want to use less wires?

Jeremy: Because the wires just make a longer place for the electricity to go and then that means that the electricity travels more and doesn’t have as much strength.

Generating New Investigations

After students complete one investigation, Ms. Wolfe encourages students to share what they have found with the rest of the class and to discuss how their findings compare with others. During these whole-class discussions, Ms. Wolfe also grapples with the students’ ideas and uses them to generate new investigations. For example, in the following excerpt, the students discuss what they found when they were testing how many magnets were needed to induce magnetism to form a paper clip chain for a specific number of paper clips:

Sanchez: We also noticed that it was not possible (to form a paper clip chain) with just one or two magnets.

Ms. Wolfe: Hmm.

Sanchez: It was only possible with three magnets.

Ms. Wolfe: That is interesting. What would you add, Christine?

Christine: Well, I kind of disagree with Sanchez, because me and Ramón got six magnets to do that.

(About five minutes later in the discussion, Jeremy picks up this thread).

Jeremy: May I say something that I really [want to share]?

Ms. Wolfe: Yes.

Jeremy: Like Christine was saying that you could get it (form a paper clip chain) with what Sanchez said of magnets (3 magnets), I got it with less. I got it with one and two magnets.

Ms. Wolfe: You mean when [the magnet] was vertical? Okay. That’s a whole other interesting entity. Interesting. You did? Amy, I haven’t heard from you.

Amy: I disagree with Sanchez. Because we only used one and two magnets and we got about the same thing. There was only like a two or three difference (in number of paper clips in the paper clip chain).

Ms. Wolfe: Okay. Well Sanchez’s definitely found a pattern that he was able to prove. Now, something that you did could have been slightly different from what he did. But he was onto something, and I thought that was interesting.

(The next day’s investigation centered on testing Sanchez’s idea with a consistent protocol across groups, created in a class discussion.)

Now that you have read brief descriptions of sample practices in Mrs. Sparrow’s and Ms. Wolfe’s classes, take a few minutes to reflect on any distinctions between the two and then decide which class produced more students who affiliated with characteristics of a “smart science student.” Once you have completed this reflection, look at the next page to find out which class connects to which outcome (see Table 1).

Unveiling Which Class Is Which

The practices in Mrs. Sparrow’s class (Class B) can be described as (a) turn-taking and (b) getting to the right answer. On the other hand, the practices in Ms. Wolfe’s class (Class A) can be described as (a) working together to solve problems and (b) demonstrating curiosity through the sharing of observations, ideas, and explanations. In other words, Ms. Wolfe helped create a “we” classroom culture. This “we” culture increased accountability for all students to learn and engage in scientific investigations. Such a culture also addresses the Framework’s concerns that “equity should be at the forefront of any effort to improve the goals, structures, and practices that support learning and educational attainment for all students” (NRC 2012, p. 277).

The Teacher’s Role and Strategies

What did Ms. Wolfe do to create a “we” culture? How did she set the tone for acceptable behaviors, for what got celebrated and marginalized, and for what kinds of thinking and contributions got rewarded and ignored? We describe three strategies that Ms. Wolfe used over and over again to cultivate a “we” culture. Though we realize that these strategies may not work equally well in all classrooms and that teachers may use other strategies to create a “we” culture. Nonetheless, we highlight Ms. Wolfe’s strategies here as a way to get teachers thinking about the inex-
tricable connections between their practices and the implicit meanings of “being scientific” and “doing science” that accompany those practices.

**Strategy 1**

*Ms. Wolfe made explicit and accessible what it meant to be scientific.*

Before beginning any investigation, she held a class discussion so that students had a say in defining what counts as “good scientific work.” She helped students realize that science practices such as those outlined in the NGSS (e.g., asking questions, planning and carrying out investigations, engaging in argument from evidence) may look different depending on the activity. Nearly every investigation demanded a new conversation about expectations for “good scientific work.” Students clearly understood what was expected for quality work and, because they had a voice in defining those criteria, felt capable of meeting expectations.

Example: Before embarking upon their investigation of fiddler crabs, Ms. Wolfe asked students to jointly contribute to a conversation about what will count as a “detailed observation” of and a “good question” about their habitats. These ideas were then used to set the criteria for the students’ drawings, observations, and questions in their science notebooks.

**Strategy 2**

*Ms. Wolfe held every child accountable for expressing scientific thinking.*

She set the expectation that all students verbally share their observations, inferences, explanations, and questions during group work and whole-class discussions. To do so, she used generative questions that began with “why,” “what if,” or “how else.” She requested that all students provide justification and evidence for their reasoning before they proceeded to the next investigative step. She encouraged students to both listen to one another’s ideas and ask each other questions in a friendly, respectful tone. By doing so, she sent the message that no student is excluded from engaging in scientific practices—i.e., asking questions, constructing scientific explanations from evidence, and communicating their scientific ideas. Further, this strategy signaled that every student’s contribution was important and valued.

Example: Ms. Wolfe stated, “I’m gonna pick the least talkative person who probably has not stood up for themselves and say, ‘The group can’t start until this person tells me what the plan is. All people in a group are responsible for being able to share out.’”

**Strategy 3**

*Ms. Wolfe reinforced and praised the diverse ways students performed scientifically.*

She acknowledged and celebrated many students’ ideas that helped the class construct a scientifically acceptable explanation for the results obtained during an investigation, explicitly drawing out different and relevant contributions students made. In her classroom, being scientific not only meant obtaining the right answer, but also included, for instance, thinking divergently, solving problems, asking questions, making unique observations, and thinking of new investigations. Finally, she provided time for students to compare and make sense of all the groups’ findings and then identify questions that could lead to new investigations.

**TABLE 1.**

The percentage of students in each class that identified with some characteristics of “smart science students.”

<table>
<thead>
<tr>
<th>Identified self as sharing some characteristics with smart science students</th>
<th>Did not identify any characteristics shared with smart science students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class A: Ms. Wolfe’s class</strong></td>
<td>100%</td>
</tr>
<tr>
<td><strong>Class B: Mrs. Sparrow’s class</strong></td>
<td>54%</td>
</tr>
</tbody>
</table>
In Figure 1, we summarize students’ descriptions during end-of-year interviews of “smart science people.” There is a keen difference between the ways “smart science person” got defined in each classroom. Ms. Sparrow’s students defined a smart science person as someone who knows a lot of facts and can answer the teacher’s questions correctly, while Ms. Wolfe’s students focused on more generative practices like being good observers, thinkers, and question-askers.

We think the children’s definitions of “smart science kids,” coupled with the practices in Ms. Wolfe’s class described earlier, provide a good first step for teachers to reflect on the “we” cultures in their own classrooms (see NSTA Connection for the reflection checklist). By completing this checklist, we expect that teachers will be able to identify which strategies are currently present in their practice and then set goals for implementing those specific strategies that are not.

In Ms. Wolfe’s class, when asked to identify the three “smartest” science people in their class, a few children responded, “We are all smart science people!” This is the ideal outcome—that all children consider themselves and their peers to be smart in science. A “we” culture can help facilitate that outcome. However, creating

**FIGURE 1.**

A comparison of the total times students mentioned various characteristics when prompted to describe “smart science kids.”

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sparrow’s Students</th>
<th>Wolfe’s Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is naturally smart / Knows facts</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Answers teacher’s questions correctly</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Does science outside of school</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Is a good observer</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Is a good thinker</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Asks questions / Is curious</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

**Shared Assumptions About Smart Science Students**

Creating a “we” culture begins with two underlying assumptions: (1) all children can be scientific and (2) children are scientific in different ways and therefore make unique, enriching contributions to the community’s collective scientific endeavors and knowledge.

Example: Ms. Wolfe encouraged careful observation by “valuing all the small pieces of things that people notice.” We saw this in the second discussion of Vignette 2 when Ms. Wolfe elicited a range of observations from students as they discussed the diverse results obtained in the initial investigation that explored how many magnets were needed to form a paper clip chain.
a “we” culture demands ongoing self-examination of our daily practices, the accessibility of those practices for all learners, and the implicit meanings of what counts as “being scientific” prompted by those practices.

Heidi Carlone (hbcarlon@uncg.edu) is an associate professor at the University of North Carolina at Greensboro in Greensboro, North Carolina. Dennis Smithenry (smithenryd@elmhurst.edu) is an associate professor at Elmhurst College in Elmhurst, Illinois.

References