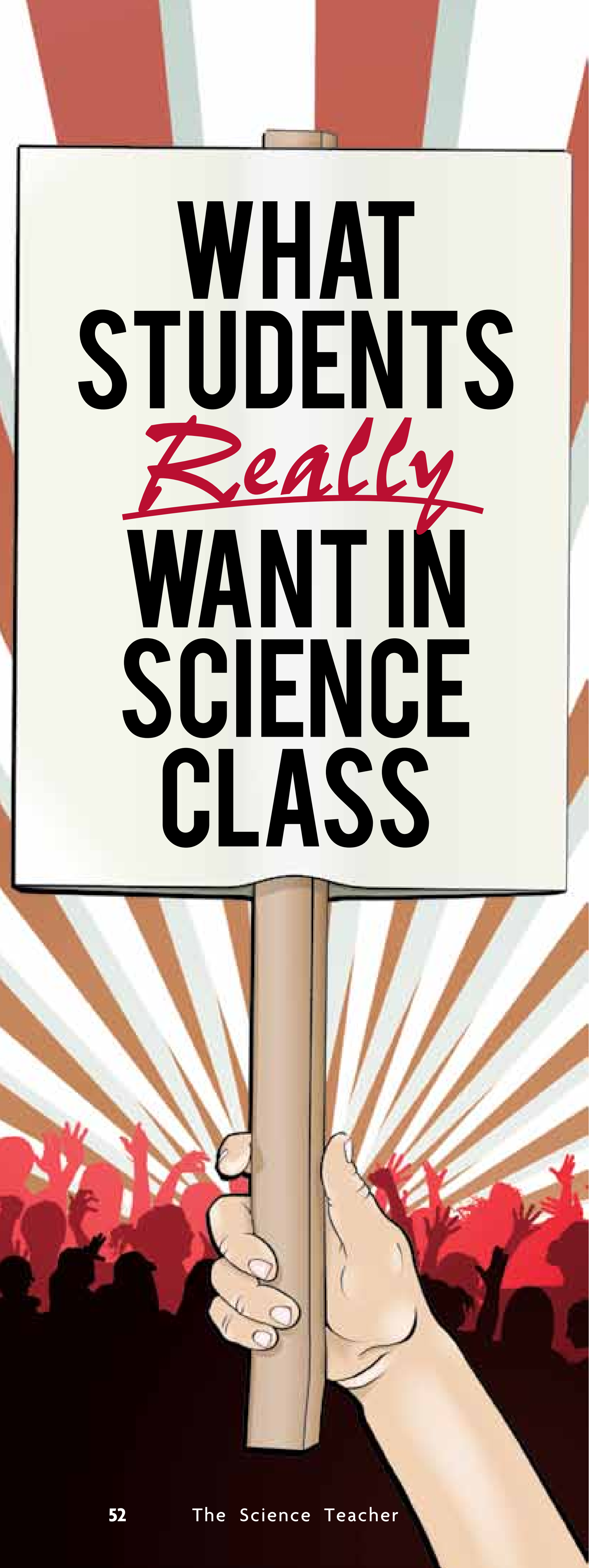

The importance of good teaching practices—with and without technology

Lauren B. Goldenberg

Nowadays, there are lots of digital resources available to teachers. Tools such as Teachers' Domain, an online digital library (see "On the web"); interactive whiteboards; computer projection devices; laptop carts; and robust wireless internet services make it easy for teachers to use technology in the classroom. In fact, in one national survey, both teachers and students identified the use of animations, simulations, interactive whiteboards, and computers as essential to quality science learning experiences (Project Tomorrow 2008).

However—with or without technology—the principles of good teaching remain the same (NRC 1996, 2000). From digital resources to inquiry-based instruction techniques, what helps high school students learn science? As part of a larger research project, my colleagues and I asked biology students in eight New York public high schools this question. Figure 1 provides information about the teachers and students who participated in our case study.

Here, we share the digital resources and other classroom activities students told us *they* think help them learn science. The results might surprise you: What students want closely resembles research on best practices in science instruction. Over and over, students said they are most engaged and motivated by hands-on activities, group work, and discussions: They value meaningful activities and want more active learning.

Digital resources: Fun and visual

As one might expect, students in our study said they enjoy learning with computers. Many students said that biology—more than any other class—exposes them to the most digital resources, including short video clips, animations of phenomena not easily observed, interactive models, and activities in which they manipulate variables or pieces of a model.

Teachers in our study most commonly used instructor-centered technology practices. Unless a laptop cart or computer lab was available, they primarily displayed digital resources with a projector or interactive whiteboard. Despite this lack of access to individual computers—and occasional technical glitches—students said they appreciate the affordances of digital resources. For example, students said it is helpful to see an animation instead of learning only from words, static images, or a teacher's voice.

For digital learning experiences to be meaningful and understandable, our study revealed that teachers must carefully select resources and incorporate them through scaffolding activities. The importance of this approach is evident from student comments. For instance, one student explained that her teacher "usually does not go in depth about videos, [we] just watch [them]...The smarter kids in the class...usually kind of understand...but then everyone else [thinks] 'What's happening?'" A student in another class commented, "Instead of showing videos that are kind of confusing, either [the teacher] needs to explain them more or...not even show the videos."

Integrating digital resources meaningfully remains a challenge for many teachers. However, when teachers weave structured, student-centered activities—based on digital resources—into lessons, students appreciate the result: This more scaffolded approach can help them understand abstract, difficult-to-grasp concepts.

For example, one teacher in our case study, Mr. Reid (a pseudonym), used digital resources to support a lesson on DNA and help students visualize the transcription stage of protein synthesis. First, he had students complete an online activity to simulate the transcription stage of protein synthesis. His plan was for each student to work individually using a laptop. He passed out a worksheet that included step-by-step directions for accessing the online material and questions for students to answer during the simulation. However, students ran into an issue during the online activity: Their laptops did not have the correct software. Mr. Reid quickly switched gears and showed the interactive to the class as a teacher demonstration instead. Then, after explaining the next stage of protein synthesis, he projected an animation that depicted the transcription and translation process in real time. Students said that even with the technical glitch, the activity facilitated their understanding of DNA transcription, and

What students want.

- Fun and visual digital resources
- More hands-on and lab activities
- Opportunities for active and interactive learning
- Consideration that they are people, not just recipients of information
- Narratives and stories to illustrate science concepts

FIGURE 1

Case-study participant description.

Teacher (pseudonyms)	Years teaching	District type*	Class description	Students** (total)	Students interviewed
Kathy Simkins	15	High need/urban	Heterogeneous, inclusion	61	4
Jeff Murphy	6	Average need/ suburban	Heterogeneous	46	5
Sam Desimone	6	Low need/suburban	Heterogeneous, inclusion	50	8
Jessica Jones	9	N/A (regional education agency)	Students with emotional and learning disabilities	5	8
Molly Janes	8	High need/suburban	Heterogeneous	51	6
Joan Hochman	6	High need/urban	English language learners	36	6
Mike Mayger	3	Average need/rural	Heterogeneous	27	4
Abby Oldham	9	High need/rural	Honors	20	7
Total				**296**	**48**

* To describe district type, we used the categories developed by the New York State Education Department (2010). Their measure, called the *Need/Resource Capacity Index,* categorizes school districts with an algorithm that takes into account indicators of relative district wealth, population density, and characteristics of students' special needs.

** Total number of 9th- and 10th-grade students for whom we have 2009–2010 school year pre- and posttest data.

the mRNA translation animation helped them comprehend the overall process; so use of these resources was a success, despite the problems encountered.

Supporting science learning

Students also expressed a desire for visual and interactive activities beyond computer-based materials. More so, they said that the following tools help them learn science.

Hands-on and lab activities

Students expressed a strong interest in hands-on and lab activities. In short, they enjoy doing activities that help them learn, remember, and understand. According to students, doing activities before a topic is introduced helps them understand subsequent lectures; doing activities after a topic is covered allows them to apply and consolidate their new knowledge.

One student, who claimed not to like science, said, "Normally all the experiments are interesting…hands-on. You are not just sitting down. [The teacher] is not telling…or showing [you]; you get to experience it yourself." A group of students in another class commented, "You get a different view if you do it yourself," "I think it is easier if you do it yourself," and "You also remember it better if you do it."

In these comments, students highlight a secondary purpose of hands-on activities: the ability to work independently. High school biology teachers, like those who participated in our study, have an advantage in this regard because biology offers many opportunities for hands-on investigations.

Active and interactive learning

Students commented that their classes provide few opportunities for whole-class and small-group discussions. However, they appreciate and learn from these opportunities when they occur. One student said, "[The teacher] lets us talk to her and give feedback instead of making us sit there and do nothing…some teachers do not let us talk or really give our opinions." Another shared that information is "easier to retain…in a group…[and] it is more fun." A third student, reflecting on a common teacher perception that students veer off topic when they work together, explained, "I like doing group work…sometimes I get off topic if I work by myself."

Being treated as people

The high school students in our focus groups appreciate when teachers appear to be interested in them as people, as opposed to simply recipients of information. Students mentioned that their science teachers make learning "fun," not only by being funny but by incorporating their "personal [lives] into topics" and relating to students' lives. In contrast, as one student described, in other classes "usually it is 'just do your work.'" Another concurred, adding, "Yeah, like we are robots." Students are more apt to pay attention to teachers who do not just "talk on and on" and "make [them] want to go to sleep."

More about the study.

The data described in this article are drawn from a larger research project that is investigating the impact of an online professional development course—Teaching High School Biology (see "On the web")—on teacher participants' and their students' learning. The course focuses on inquiry-based approaches to teaching and the use of digital resource tools for learning two challenging high school biology topics: genetics and evolution.

Data collection for the descriptive case studies focused on teaching and learning during genetics and evolution units and included two to three teacher interviews, classroom observations, the collection of instructional artifacts, student work samples, and student focus-group interviews. Researchers asked teachers to invite five to seven students who represented the range of students in their classes to participate in student focus groups. Teachers typically had a one-computer classroom with a projector or interactive whiteboard.

The quotations in this article are representative student comments for a particular theme. Because the research presented here is qualitative in nature, it is not without limitations. Since the study focused on a specific group of teachers and their students, there is no guarantee that their views are typical. Moreover, although we gave teachers guidelines for selecting students for the focus-group interviews to ensure a variety of perspectives, we cannot say whether the students are representative of their classes or schools. More information about the study is available online (see "On the web").

Stories

Narrative can be a powerful tool for learning and teaching. In high school science, this generally means sharing the story and history of science through anecdotes and documentary media. For the most part, teachers observed during our study did not use narrative. However, students definitely notice when stories are used. One student commented, "I learn better when…it has a story…[the story] just puts [the learning] together."

One case-study teacher, Mr. Desimone (a pseudonym), deliberately wove stories about science and scientists into his instruction (Kirchoff 2008). For example, when teaching about DNA, he told students the story of Rosalind Franklin—a scientist who made important contributions to understanding DNA and died of a cancer that may have been caused by her x-ray research. Mr. Desimone explained that such anecdotes about scientists show that theories are not only abstract ideas but are created by people. They also demonstrate how discoveries build on one another and illustrate that scientists are not just old, white-haired men in lab coats. Several of Mr. Desimone's students remarked on his use of stories. One said, "I like how he uses stories to teach us stuff. He usually makes observations we can relate to and…makes it easier to learn."

Conclusion

The instruction that students in our study want is remarkably consistent with current views of how people learn. They are essentially requesting that learning be active, student-centered, knowledge-centered, and community-centered (Bransford, Brown, and Cocking 2000; Brown and Adler 2008; Donovan and Bransford 2005). Moreover, students' remarks are in concert with the National Science Education Standards (NRC 1996, 2000), which encourage

- viewing science as argument,
- using evidence for developing or revising an explanation,
- communicating ideas and work to classmates,
- acquiring information from multiple sources, and
- working both individually and in groups to collect and share information and ideas.

Students in our study did not say that more technology was necessarily better. When discussing using computers for learning, students expressed a desire for meaningful and thoughtful science instruction that involves interactions with media, the teacher, and each other.

Young people are rarely asked about their classroom experiences. Preliminary findings from the Measures of Effective Teaching project (Bill & Melinda Gates Foundation 2010) suggest that gathering data from students about their perceptions of their teachers might be valuable as an additional measure to complement other teacher-performance and student-outcome data.

Although our research project was not designed for collecting large-scale data on students' perceptions of their teachers, student voices were clear: Whether they use technology or not, they respond positively to the teaching practices that the Standards and current research suggest are most effective for supporting science learning. Their voices lend support for teachers to trust in good science instruction. Students respond to learning environments and current technologies that encourage them to ask questions, be curious, use evidence, and explain their thinking—in other words, to think scientifically. ■

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On the web

More about the study: *http://cct.edc.org*

"DNA Workshop" interactive: *www.teachersdomain.org/resource/tdc02.sci.life.gen.dnaworkshop*

PBS transcription and translation animation: *www.youtube.com/watch?v=41_Ne5mS2ls*

Teachers' Domain: *www.teachersdomain.org*

Teacher's Domain genetics and evolution resources: *www.nsta.org/highschool/connections.aspx*

Teaching High School Biology online course: *www.teachersdomain.org/resource/tdpd.sci.hls and www.pbs.org/teacherline/catalog/sections/SCIE520.24*

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