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February 2017 Vol. 28 No. 6

NSTA Science Education
Conference Opens March 30 pg 8

NSTA Reports
National Science Teachers Association

JAMES BRUEGENHEMKE

Engineering
Literary Solutions pg 10

CONTENTS

Students Teaching Science to Younger Students

For more than 42 years, Manhattan High School in Manhattan, Kansas, has offered the Wide Horizons Nature Program, a science course in which high school students "work with a partner to put together a [30-minute] educational program [and] teach [it] at local elementary [schools] and preschools," says science teacher Leslie Campbell, who has taught it for five years. Wide Horizons students "report to my classroom to pick up supplies, then drive out to the schools to present. The goal is to do it all within a normal class hour," Campbell explains.

"It has grown to be two classes per day (36 students enrolled between the two this year). They present 2–3 times per week on their subject," she reports, adding, "I make sure their science instruction will enhance elementary school classes."

The course has no set curriculum. In 1974, biology teacher Gary Ward designed it "as a flexible course for juniors and seniors to pursue their [individual] nature study interests," says retired biology teacher Tish Simpson, who taught Wide Horizons from 1994 to 2011. Prerequisites include teacher recommendation, science interest, commitment to a year-long class, good character, reliability, and responsibility—"not necessarily their academic performance," she notes. Students need to have completed required lab science credits or "be taking them simultaneously" because Wide Horizons is an elective, she adds. They also need to have "some form of transportation to the elementary schools."

Campbell also relies on student recommendations because peers typically are knowledgeable about students' attitudes and social skills when "dealing with younger students, teachers, and administrators," she relates. After checking with guidance counselors and other teachers, she issues invitations to students interested in taking the course.

Students choose presentation topics based on their interests, with the caveat that the topic must be interesting to elementary students. Many use live animals as props in their presentations. "The animals are used as examples; [one] example this year is how geckos are adapted for their environment. The presentation is about conditions in different biomes; the team presents information on different geckos, and then brings out their own to demonstrate," says Campbell.

Sometimes the animal "is a personal pet, but [students] have purchased their own or even borrowed [them] from friends. The chinchillas in the program this year were adopted by one of my students," she notes.

"Once a team has been assigned to an animal, they are in charge of [its] care," including taking animals home on long weekends and holidays, says Campbell. She adheres to Kansas guidelines on animals in the classroom when instructing her students.

"The first thing that each team has to do is to learn as much as they can about their animal, about how it lives in the wild and how to take care of it as a pet. The last thing students share in their presentations is all about having

A Science Ambassador from North Forsyth High School in Cumming, Georgia, uses a tube with a marble inside it as a "roller coaster" to teach an elementary school student about gravity, force, and motion.

Students Teach Students, pg 4

Empower Science Students to Recognize, Embrace Creativity PG 3

COMMENTARY: **Lynn Diener and Teresa Holzen**

Empower Science Students to Recognize, Embrace Creativity

By Lynn Diener and Teresa Holzen

Lynn Diener

Teresa Holzen

When we tell our science students that it's time to do something creative, we often hear, "But I'm in science because I'm not creative!" This misconception, that science is not creative, is common. However, we as scientists know how central creativity is to the scientific process. Training students to apply their creativity to generate and communicate scientific knowledge is one of our class goals.

In 2013, Mount Mary University began transforming into a creative campus. As part of that process, faculty identified the specific creative attributes we felt best able to instill in our students. Many of the attributes we selected, such as an ability to experiment and explore, are inherent in any scientific pursuit. One way we have embraced this attribute in our classrooms is by giving students at all course levels, even introductory-level courses, an opportunity to ask their own questions and design their own experiments.

Two other creative attributes embraced in our science classes are agility and open-mindedness to new ideas or concepts. Agility is the ability to change course midstream, to take in new evidence and adjust your view. Students design and carry out their own experiments. If students' first attempts "fail," they try again using insights gained during their first attempt. Students practice open-mindedness by trying a variety of techniques or approaches to problem-solving and by revising their original hypotheses or their experimental approaches if experimental data do not support their hypotheses.

It is easy to see the value of teaching students to think both critically and creatively. Answers to big questions are rarely straightforward, and an ability to think outside the box is necessary. One can find many examples of creativity and scientific innovation intersecting. Who hasn't heard the story about the engineer who wondered how burrs stuck to his clothes and his dog's fur? Upon investigating the burrs under a microscope, he discovered that the heads of the burrs had hooks. He capitalized on this observation and used his creativity to introduce Velcro® to the world.

So what can we do to help our students grow their creative skills in the sciences? To learn creativity in science, students must do creative things in their science classes. We have found that implementing inquiry-based labs is one of the best ways to engage students in both critical and creative thinking. It takes a great deal of creativity to address a problem, ask a question, develop a hypothesis, and design an experiment to test that hypothesis. Incorporating even one inquiry-based lab can make a huge impact on the development of student creativity.

It is possible to do a simple inquiry-based lab from start to finish in one 60-minute class period. To encourage students to explore the physiology behind the sense of taste, for example, we provide students with equipment and basic protocols to design and perform double-blind experiments that address their own questions about artificial sweeteners. In one class period, students have explored questions such as "Which artificial sweetener tastes the most like sugar?" or "Which artificial sweetener has the sweetest taste?"

If you have more lab time to dedicate to an inquiry-based lab, you can put students in the driver's seat to develop their scientific creativity. Students can propose an experiment, perform that experiment, and present their results to their peers.

Another great way to tap into students' creative skills is to encourage them to transform content from class in a novel way. Assigning creative presentations, for instance, requires students to understand specific course content more deeply so that they can create a model, brochure, video, or other product that highlights their creativity and their understanding of scientific material. Though these sorts of projects are fairly common in K–12, they remain transformative for college students as well, reminding students and instructors that creativity is valued at any age.

Intentionality is essential when teaching students creative skills. Tell the students when they need to be creative. Tell them when they are being creative. If instructors emphasize, encourage, and reward creativity, then students will put more time and effort into developing creative skills.

Failure is also important in developing both critical and creative thinking. Being able to face failure of an experiment, an idea, or a pursuit and to persist is an important skill for anyone, but is particularly important in science. In most instances, data from student-designed experiments don't support their original hypotheses. Students need to be reminded to be open-minded about the evidence and then agile in their response, possibly revaluating their conclusions and/or changing their initial hypotheses. If time permits, students may be able to try the experiments again with modifications.

Training students to embrace both critical and creative thinking is extremely beneficial for instructors and students and for society, which will someday benefit from their creativity. We encourage all teachers to help train students to become critical and creative thinkers. ●

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Students Teach From page 1

the animal as a pet: the cost and care involved and being a responsible pet owner," Campbell explains.

"We go over what to do if [elementary] students are scared or hesitant about the animal. We have never had a student so scared that [he or she] cannot be in the same room, but we have had some [who] don't want the animal near them. If that is the case, my students station themselves at the opposite side of the room with the animal and the [elementary students] come to them… The animal is in a carrier and out of sight until the end of the presentation," says Campbell, and some animals are not removed from their carriers.

"I have only had one student [who] had to change to another class because [of the animals] in my classroom…I have had [Wide Horizons] students [who had] allergies (to the rabbit, for example), but they are fine as long as there is no contact. At the elementary schools,…[teachers] choose which presentations they want and will not book ones [involving animals students are allergic to]," she explains.

Simpson notes that Wide Horizons teachers "are insured under the school system's policy" in case of any mishaps.

"I have had [staff] from the local zoo come to our class and share how they handle animal demonstrations. We also share stories from previous students. At the end of the school year, the teams write reflections that are useful for instructing the next year's teams," says Campbell. Students are graded based on elementary teachers' rubrics and feedback, as well as on their final project for the class.

Wide Horizons began with a live animal focus, but during her tenure, Simpson needed to change the course to help elementary teachers meet "state science standards and benchmarks" and No Child Left Behind mandates, she explains. These changes included encouraging students "to research any literature involving their topic" and suggesting the younger students read it and presenting on other topics in biology and on chemistry, physics, and Earth science topics, she relates, adding, "To a little third-grade girl, seeing an older girl do chemistry and physics makes her think, 'I can do that, too.'"

The high school students "grow so much in their presentation skills and confidence," says Campbell, and "it's not uncommon for them to go into teaching."

Science Ambassadors

In Cumming, Georgia, Coal Mountain Elementary School and North Forsyth High School are partnering to stage Family Science and Engineering Nights at local elementary schools. The high school students serve as Science Ambassadors and hold family nights at 4–6 area schools annually. "We are now in [our] fourth year," says Denise Webb, K–5 science and engineering teacher at Coal Mountain, who started the program with Donna Governor, a former North Forsyth science teacher (now assistant professor of science at University of North Georgia), and current co-facilitator and North Forsyth science teacher Charlotte Stevens.

Funding for Science Ambassadors comes from local business partners, and "we charge a small fee for supplies to the elementary schools, which [parent-teacher organizations] help pay," she notes. "We wanted to make [the program] free to the elementary students and their families."

Science Ambassadors' mission "is for all [preK–5 students] and their families to engage in science and engineering activities that have real-world connections to develop [skills in] critical-thinking and problem-solving. Our goal is to inspire more students with the confidence to pursue careers in the STEM (science, technology, engineering, and math) fields," Webb explains. The elementary schools "are rural schools and need exposure to possible future careers that [students] otherwise may not be aware of…This program [also] provides high school role models of varied ethnicity and genders for the elementary students," she points out.

"A second goal is for the [Science Ambassadors] to gain leadership skills and [develop] confidence in the science and engineering [skills] that can lead to careers in STEM," she adds.

The Science Ambassador program is open to all North Forsyth High School students. "We have [advanced placement] students, special-needs students, and those who have no other niche and need service hours" among the Ambassadors, she reports. Candidates must have passing grades in their classes, a recommendation from a teacher, and no discipline referrals.

Those chosen for the program create science and engineering activities for stations they will run for elementary students on family nights. "I work with them on questioning skills and understanding the engineering design process," Webb explains. "I give them science activities that match elementary standards." Safety precautions are thoroughly covered in the practice sessions, she emphasizes.

Ambassadors must provide a list of supplies they will need for the next family night. "They have to follow through and learn to be prepared and thorough," Webb maintains. She and Stevens take the Ambassadors to the elementary schools, but Ambassadors "are responsible for cleanup and a ride home," she explains.

They also "design a brochure that explains all the science and engineering activities that were offered, steps to repeat them at home, and the science or engineering practices connected with the activity," she relates. Local businesses can buy ads in the brochure.

The program reached more than 2,000 people last year because "students from other grade levels and schools" accompanied their families to the events, says Webb.

As a result of their efforts, "the Science Ambassadors have gained confidence in themselves. They have learned leadership skills, and their teachers [say] that…they are more engaged and motivated in their classes," she reports. Representatives from the business partners have noted the Ambassadors' prowess in "21st-century workforce skills like teamwork and communication," she adds.

"Parents have told us that they are surprised at how well their elementary-aged child did in the science and engineering activities and plan to continue to look for ways to encourage them in STEM. They also commented on the professionalism and patience the high students showed their families. These are great qualities [Ambassadors] will [have] as they enter the workforce. [Parents] all overwhelmingly want us to come back again," says Webb.

"We are helping other schools in our county start their own elementary/high school partnerships with similar programs because we cannot take on any more schools, and many more want to participate. We have also presented this program during [state and national education conferences] to assist others in getting this partnership started in their own districts," she relates.

Science After School

"Youth teaching youth is [what's special about] our organization," says Jessica Yang, founder and chair of Kids Are Scientists Too (KAST; see *http://kidsarescientiststoo.org*), a nonprofit program in which high school and college students offer free hands-on science programming after school to elementary schools in Illinois, Washington, North Carolina, Maryland, Virginia, New York, New Jersey, Utah, and Ontario, Canada. Yang founded KAST because as high school students, she and CEO Jessica Sun wanted to "offer an enrichment program to make science learning experiences even better for students," Yang explains.

Yang learned how through a yearlong fellowship at LearnServe International, a Washington, D.C., nonprofit that helps high school students start social change programs. She received a $1,000 grant to start the business with support from LearnServe and Youth Venture. She also won $500 in a George Washington University business pitch competition. With these resources, Yang founded KAST Maryland in 2010. Sun established KAST Virginia soon afterward.

Yang, Sun, and other KAST volunteers created a series of one-hour lesson plans for fourth and fifth graders featuring "fun, interactive activities to get students excited about science," says Sun. They used their "unique perspective as high school and college students," their "studies in science in college," and their "experiences working with kids" to create seven units with more than 60 lesson plans on various science topics, she relates.

The lessons were inspired by elementary and middle school curricula and "science experiments we've done in the past," says Yang. During KAST's pilot phase, "we received feedback from teachers [that] helped us ensure their quality."

Since KAST volunteers usually teach students with a classroom teacher present, safety is ensured. "We have one KAST volunteer for every five elementary students, which helps us maintain a safe learning environment," say Yang and Sun. KAST alumni—those who have graduated high school—serve as mentors to high school or college students who are new to the program.

Typically, "a high school student or teacher will reach out, and we'll meet with [him or her] and [provide] all the materials needed to connect with schools and start a KAST program," they explain. "We wanted the program to be free of charge to make it accessible to students from low-income families."

In return for their service, KAST volunteers gain experience in leadership, organizing, recruiting, and public speaking, along with the satisfaction of "giving back to their community," they conclude. "It is inspiring to see…some of the younger students [become] excited about science." ●

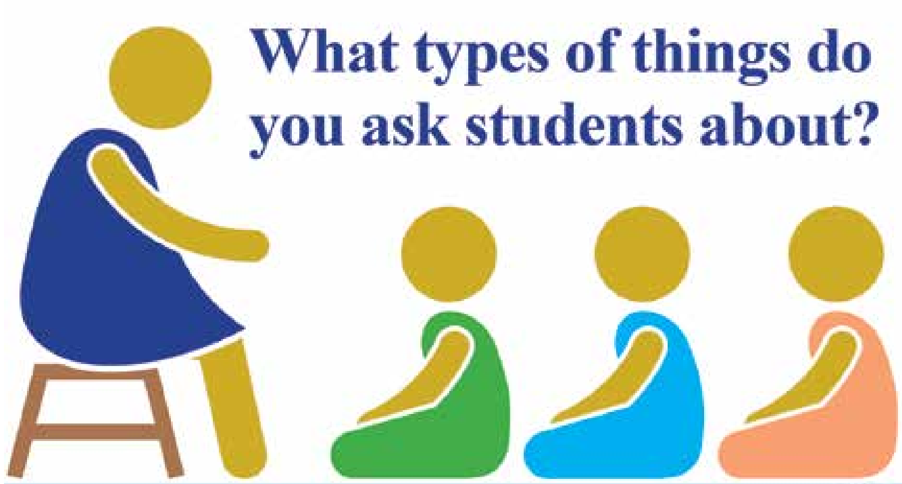
Educators Weigh In on Student Input

A recent informal *NSTA Reports* poll asked science educators if they ask students to share their thoughts on what works (and what doesn't) in the classroom. All respondents indicated they ask students for input, with 48% reporting that students know they can make a suggestion at any time, 22% asking for input once or twice a year, and 18% doing so at the end of most instructional units.

Eighty-two percent said they ask students how well they think they understand a lesson or activity; 77% ask about ways to improve instruction; 61% ask how a new instructional approach (such as flipping the classroom) is working; and 57% said they ask students about their learning styles (respondents could select multiple answers to this question). A majority (74%) said most students were appreciative of opportunities to provide feedback, while 14% said students were enthusiastic. Less than 3% reported students were either slightly negative or didn't want to bother. Surveys were the preferred method of gathering student opinions by 34%, while 30% said they prefer to solicit feedback during classroom discussions, and 19% used short answers on exit tickets. Twelve percent said they used other methods, including combinations of classroom discussions, surveys, warm-ups, and exit tickets.

Most respondents said they frequently (47%) or occasionally (52%) implement suggestions from students. Educators noted that implementing student suggestions can give students a sense of "ownership" in the classroom that can lead to greater engagement and improved learning. One middle school educator commented, "I give them input and expect change; why shouldn't they [do the same with me]?"

Seventy-four percent reported that they have had attempts to collect student input fail, most often when students made general complaints and did not provide specific input (48%) and when student suggestions weren't feasible either due to financial/time constraints (20%) or school policies (13%).



How well they think they understand a lesson or activity	82%
Ways to address behavioral issues in the classroom	32%
Their learning styles	57%
How a new instructional approach (such as flipping the classroom) is working	61%
Ways to improve instruction	77%
Whether the classroom arrangement is helpful	52%
Other	22%

*Participants could select as many responses as applied

Here's what science educators are saying about the benefits and drawbacks to asking for student input:

Treating them like adults is a good learning opportunity; treating them like adults is sometimes a head scratcher. *—Educator, High School, Virginia*

Little drawbacks [to requesting feedback], and you might get some really good ideas.*—Educator, High School, Pennsylvania*

Not many benefits, lots of drawbacks. The last time I tried to solicit feedback, students complained about not enough hands-on labs as we were preparing to run [the] Gladstone Apple Valley radio telescope.*—Educator, Middle School, Oregon*

Benefits: helps empower students and gives insight into interests. Drawbacks: some do not take it seriously or do not offer feasible suggestions.*—Educator, Middle School, Kentucky*

Student input shows students that I value their contributions, and it helps them take control of their own learning. The only drawback is having to tell them no when they ask for something silly or unrelated to the content. *—Educator, Elementary, Louisiana*

Kids are brutally honest.*—Administrator, Elementary, Maryland*

No drawbacks, but I do need to communicate expectations and norms of the conversation. They are 10-[to] 14-year-olds.*—Administrator, Middle School, Nevada*

The hard truth...some students do not hold themselves accountable and will blame the teacher for their lack of success. The hard truth provides benefits for the growth mindset and improving my instruction to make it more student-centered.*—Educator, High School, Hawaii*

[The] benefit is that you grow as a teacher, and the drawbacks are they aren't always as open as they would be if everything was always anonymous.*—Educator, Institution of Higher Learning, Michigan*

Often students reflect on the most recent activities in class instead of thinking long-term. Benefits are that each student feels [he or she] can honestly communicate what [she or he feels. We do anonymous surveys].*—Educator, High School, International School Czech Republic*

Students often want to have input, but are afraid to give their opinion in class or ask the teacher directly, or time is limited. Suggestions from students can often help to reduce their own anxiety, promote their own self-worth, and show that they are valued. *—Educator, Elementary, Texas*

I teach mostly inclusion students, behavior-problem students, and lower-ability students. They really respond well to me caring about making the class work best for them. I tend to have very good relationships with my students, which makes them more inclined to participate and behave well for me.*—Educator, High School, Institution of Higher Learning, New York*

Teacher [gains] insight [into] annoying personal mannerisms, filling in the gap between "taught" and "caught." *—Educator, Middle School, Texas*

Students get to have input (good), students have unrealistic expectations when put into context compared to state standards, local and federal mandates, needs of individual student learners, etc.*—Educator, High School, Ohio*

Students appreciate being heard. I receive useful input.*—Educator, Elementary, Middle School, California*

A lot of the suggestions they make are not about what would make the class better but about things they don't like doing. While I think their input is valuable, it's not always actionable. *—Educator, High School, Colorado*

Drawbacks: Can be a time issue, unless assigned outside the class/lab. Students may not understand the reasoning behind some pedagogy (i.e. homework *is* hard). Benefits: Some students feel empowered when their opinions are solicited, and may take a more active role in their learning when they feel I am seeing them and treating them as important people.—*Educator, Institution of Higher Learning, North Carolina*

I see it only as a smoke screen of interest to administrators in an effort to deflect responsibility from students and parents to instructors, who have absolutely no control over student effort.—*Educator, High School, Ohio*

You'll get some things that aren't practical to do (hands-on labs every day, learn about topics that aren't in your course standards); but by and large, my students want to give feedback, and they appreciate being asked and having a voice in what is taught and what will be covered.—*Educator, Middle School, High School, Washington*

Drawback: they have limited understanding of effective ways to present lessons. Benefits: I get to see what works and what doesn't, from their perspective.—*Educator, High School, Institution of Higher Learning, California*

The benefit is that you can make necessary changes to provide a better learning experience for your students. The drawback is that some do not take the survey seriously, and you have to weed through the responses to try and find truthful feedback.—*Educator, High School, Ohio*

Sometimes students can be harsh with their criticisms. It can take a thick skin sometimes, but that is also helpful. Sometimes I have gotten feedback that no one else would have given me. Sometimes the students give you all the evidence you need that what administration wants is not a good idea.—*Educator, High School, New Jersey*

Benefits: student perspectives are valuable, and they are reality for your students. Asking for their input demonstrates respect for them and their experiences. Drawbacks: time, although it doesn't have to take long. Students could be hurt if you don't implement their [suggestions], though I have not seen that happen.—*Educator, Middle School, Wisconsin*

It's helpful to know which lessons students *do* find effective, but most don't give useful constructive criticism for lessons they thought were unhelpful.—*Educator, Middle School, High School, New York* ●

Quotable

Natural science does not simply describe and explain nature; it is part of the interplay between nature and ourselves.

—Werner Heisenberg, German physicist (1901–1976)

2017 NSTA Science Education Conference Opens March 30

For the first time in more than 40 years, the NSTA National Conference on Science Education will take place in Los Angeles, opening on March 30.

"The response has been tremendous: We have a record number of workshops and short courses!" exclaims Tim Williamson, conference chair and lecturer and science credential coordinator at California State University, Long Beach. "We have a fantastic keynote speaker, and Bill Nye will be giving a speech [on March 29 sponsored] by The Planetary Society." Williamson notes that the Hollywood-themed conference strands include "hundreds of workshops [and] demonstrations." The conference will also feature "make-and-take" presentations with activities that teachers can easily replicate in their classrooms. "These are important to a lot of people, and we will have several," he adds.

Whether they teach in a state that has adopted the *Next Generation Science Standards* (*NGSS*) or are interested in learning more about the standards, educators will want to explore the strand on *NGSS*: The Next Generation of Science Teaching. Connections and collaboration will be the hallmarks of sessions focused on science, technology, engineering, and mathematics (STEM) in the 2017: A STEM Odyssey strand. In the Science and Literacy Reloaded strand, elementary teachers will learn how to integrate science in mathematics and language arts lessons. Mission Possible: Equity for Universal Access will tackle the challenges to creating equitable science education for all students by sharing the best practices to improve learning for all students.

Short courses on the *NGSS* include The Instructional Leader's Guide to *NGSS*, A Short Course on Analyzing and Adapting Three-Dimensional Assessment Tasks, and A PEEC (Primary Evaluation of Essential Criteria) Into Evaluating *NGSS* Instructional Materials Programs. Short courses on writing in science, ocean pollution, outdoor STEM, and engineering design also will be offered.

At NSTA's 2016 National Conference on Science Education in Nashville, Tennessee, attendees tried out eclipse glasses outdoors during a session on solar eclipses.

Andy Weir, author of *The Martian*, will deliver the keynote address on March 30, an event Williamson describes as "can't miss." In addition, attendees will have formal and informal opportunities to network with education colleagues from across the United States and Canada, attend a sneak preview of the 3D film *Amazon Adventure*, check out the latest offerings from hundreds of science education companies in the exhibit hall, and participate in educational field courses.

Conference attendees are encouraged to use the online session browser at *https://goo.gl/pn0xHb* to plan their schedule in advance, including some backup sessions in case a session fills up. NSTA's Ms. Mentor, Mary Bigelow, has offered advice for conference attendees on everything from what to pack to strategies to extend their learning experience in a post on the NSTA blog at *https://goo.gl/S9NNnt*. She advises all attendees to "[i]ntroduce yourself to teachers at the sessions or events. You'll meet lots of interesting people and make many new personal connections. Although it's important to keep up with your colleagues and classes back home via texts, tweets, or e-mail, take the opportunity to actually talk to the teachers in line with you or sitting next to you at a session. The value of a face-to-face conference is meeting and interacting with real people, and teachers are the most interesting people of all."

Professional Learning Institutes

NSTA's national conference will be preceded on March 29 by Professional Learning Institutes (PLIs). These intensive one-day sessions delve into key topics. This year's institutes are

- Disciplinary Core Ideas: Reshaping Teaching and Learning;
- Helping Students Make Sense of the World Using Next Generation Science and Engineering Practices;
- Uncovering Students' and Teachers' Ideas With Three-Dimensional Formative Assessment Probes and Techniques;
- Argument-Driven Inquiry: Transforming Laboratory Experiences So Students Can Use Core Ideas, Crosscutting Concepts, and Science Practices to Make Sense of Natural Phenomena;
- Moving Standards Into Practice: Five Tools and Processes for Translating the *NGSS* Into Instruction and Classroom Assessment;
- District-Level Administrators: You Are Not Alone in the *NGSS* Universe!;
- Equity in STEM Education; and
- Picture-Perfect STEM Lessons, K–5: Using Children's Books to Inspire STEM Learning

Although the conference will officially open on March 30, registration will be open on March 29 in Hall H/J of the Los Angeles Convention Center from 5 to 8 p.m. for those wishing to attend events that evening. The NSTA Science Store will also be open in the Convention Center's South Lobby on March 29 from 4 to 7 p.m. Onsite registration costs $330 for NSTA members and members of the California Science Teachers Association. For more information or to register online, go to *https://goo.gl/jZP89D*. ●

Engineering Literary Solutions

During a Washington University STEM (Science, Technology, Engineering, and Math) Teacher Quality training offered through his district, Jim Bruegenhemke, a fourth-grade teacher at Boone Trail Elementary School in Wentzville, Missouri, discovered Novel Engineering (*www.novelengineering.org*), a STEM learning program that provides a way to integrate engineering and literacy by using classroom literature as the basis for engineering design challenges. "I never really knew what an engineer did," he confesses. During the training, "it was like a light bulb went off: Engineers solve problems."

In Novel Engineering, developed by the Center for Engineering Education and Outreach at Tufts University in Medford, Massachusetts, with National Science Foundation funding, students create projects to help characters in stories and books solve problems. During pilot testing of the program, "we saw that kids who didn't like reading but liked building began to use books as evidence for their design," says Elissa Milto, project manager. "Not only does the book provide context, but it also builds on reading skills [and fosters] sharing in groups and writing activities," she contends.

More than 1,000 teachers nationwide have attended Novel Engineering workshops since the program was established in 2010, says Milto. In the workshops, teachers learn about the engineering design process, watch and discuss videos of teachers and students using Novel Engineering, and "talk about pedagogy and materials," she explains.

The program's approach "is flexible and will work with a variety of books that teachers already use in the classroom," observes Milto. While mainly elementary and middle school teachers have adopted the program, she says it could also work with high school students and with preschoolers "using picture books and with a lot of structure."

Rich Discussions

"There are so many entry points that [teachers] are afforded when [they] do this," says Jeff Govoni, fifth-grade teacher at High Tech Elementary Explorer School in San Diego, California. Teachers can choose the number and types of materials for students to build with, and the materials can be simple and recyclable to save money. Classes can form teams and choose one or more problems to solve. Most books will work as long as they "have good links to the design process," he contends.

"The goal is to have rich discussion, especially during students' critiques of [one another's design solutions]," he emphasizes. "The rounds of critique and efforts to make good working prototypes are most beneficial."

Students' designs have to be working and believable, with no magic involved, he explains. "Students have to have a way to explain their solutions to the audience and show the benefits to the [story's] characters."

He has taught Novel Engineering as a two-day unit using short stories or picture books or as a six-week unit based on a novel, such as the book *Poppy* by Avi. In the book, Poppy, a deer mouse, tries to escape Mr. Ocax, an owl predator who rules the forest. His students cited three problems from the book and created solutions for each.

- Helping Poppy cross a river safely. Students created a skateboard ramp enclosed in a tube so Poppy could skate across the river and avoid capture by Mr. Ocax.
- Protecting Poppy from Mr. Ocax and other predators. Students designed a portable trap.
- Helping Poppy get through the forest to her new house. Students created a camouflaged "mouse house" around a bicycle so Poppy could travel incognito.

After students solve the problems, Govoni has them write about how the book would end with the solutions added to the plot. "Students were really engaged throughout the whole process," he maintains. "They come out of it feeling like they're on a design team. And they have deeper connections to the story."

JAMES BRUEGENHEMKE

As part of a Novel Engineering unit, fourth graders in James Bruegenhemke's class at Boone Trail Elementary School in Wentzville, Missouri, share their engineering designs with classmates to get suggestions for improving them.

21st-Century Skills

Bruegenhemke values the program because it helps him provide students with hands-on STEM activities and "experiences that lead them into careers [and help them develop skills in] collaboration, creativity, and teamwork," he says. "They learn to make their projects and their writing better, and they're more receptive to constructive criticism...Even the shyest students all want to participate," he notes.

He once taught a unit on the book *Clementine,* by Sarah Pennypacker, in which a girl and her father, a building custodian, try to rid the building of pigeons. One of his more introverted students created a decoy baby owl for the pigeons to attack, which would prompt the owls to attack the pigeons.

"This girl typically struggles with reading, but she used her experiences to create a solution," Bruegenhemke contends, adding, "My students connect their Novel Engineering experiences to other lessons they learn later in the year."

For example, Novel Engineering helps students understand character traits and design solutions based on those traits, he notes. When he taught a unit using the book *The Snowy Day* by Ezra Jack Keats, his students came up with eight different problems based on the character traits of the hero, Peter, who is "brave, kind, and responsible," but also "easily bored" and too intimidated by older and bigger boys to join them in a snowball fight, he explains.

"My students used their creativity to design solutions based on Peter's character traits," he observes. One student created a catapult for Peter to use to launch snowballs. Another student designed an insulated glove Peter could wear so the heat of his hands wouldn't melt the snowballs. Other solutions included a refrigerator to keep the snowballs from melting, a hat that would keep snow off of Peter's head, and a snow scooper to help him make snowballs faster.

"My mission is that when students leave my class, they are better problem solvers than when they came in," Bruegenhemke declares. To succeed with the program, "you have to let go and have the classroom be messy," he advises. "You have to give students time to share their designs, get feedback from peers, and improve their design. You need lots of time, but it's worth it." ●

PULL-OUT SECTION

SCIENCE TEACHERS' GRAB BAG

Inside this Convenient Pull-Out Section you will find:

Freebies for Science Teachers

Reports From the National Academies. **K12** **HE** The Academies have produced reports to guide educators and policymakers in improving science, technology, engineering, and math (STEM) instruction at all grade levels, preschool through graduate school. STEM reports available for free downloading include

- *America's Lab Report: Investigations in High School Science;*
- *Engineering in K–12 Education: Understanding the Status and Improving the Prospects;*
- *Learning Science Through Computer Games and Simulations;* and
- *Ready, Set, Science! Putting Research to Work in K–8 Science Classrooms.*

Access the reports at *https://goo.gl/vqeLqG.*

Cornucopia. **E M H** A STEM–education simulation game from the California Academy of Sciences teaches students in grades 5–12 about resource use and management, the effects of climate conditions on water availability and food production, and the ways agricultural technologies affect water use. In the simulation, students manage a plot of land, planting crops based on a number of factors to meet a variety of food orders. The game's interdisciplinary focus helps students recognize the connections among Earth science, environmental science, and social sciences. Play it at *https://goo.gl/p0vr7x.*

CHRISTINE ZENINO FROM CHICAGO, U.S

Ice Flows. **K12** The educational game and app illustrate the impact of climate change in Antarctica in a way students of all ages can comprehend. Simple variables are used to demonstrate how ice flow reacts to two environmental factors: snowfall and ocean temperature. Players must manipulate these variables to control the degree of ice sheet coverage that blocks their penguin character from its food source. If they guess incorrectly, their penguin risks becoming bait for a hungry seal.

The website features a Science vs. Fiction section, which presents factual information about ice sheets, climate change, sea level, ice floes, icebergs, penguins, and other ice-science topics. The section also describes what has been changed in the game to make it more "fun." Access *https://goo.gl/8IvfDO.*

Computational Thinking Curriculum for Middle Level. **M** Computational Thinking is a way of solving problems using concepts from computer science, such as algorithmic thinking, decomposition, abstraction, and pattern recognition. At the website *http://ct.excelwa.org,* teachers can access lessons and projects that foster these types of thinking in middle level students. The lessons feature learning objectives; digital materials and prep instructions; suggested timelines; and connections to *Common Core* and *Next Generation Science Standards* (*NGSS*). Titles include Basketball Motion Analysis (decomposition), Rational Football League (algorithmic thinking), Mapping Earthquakes to Save the World (pattern recognition), and Body System Amusement Parks (abstraction).

Climate at a Glance: From Local to National Scale. **M H** An online activity for grades 6–12 from the American Meteorological Society and the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information teaches students how to use NOAA's Climate at a Glance (CAG) website, which allows real-time analysis of monthly temperature and precipitation data nationwide. The activity guides students through exercises navigating the CAG site and working with the data on it. Once comfortable, students can then investigate climate parameters at different locations (station, climate division, state, climate region, contiguous United States) on different time scales (monthly, seasonal, annual, decadal, entire period of record), thus deepening their understandings of climate differences nationwide. See *https://goo.gl/yOZqyk.*

OpenEd's *NGSS*–Supported Resources. **K12** This massive online library of educational resources for K–12 teachers recently added thousands of *NGSS*–supported science resources to its collection. The resources include science videos, games, homework, assessments, and lessons from educational publishers such as Scishow, CrashCourse, MinutePhysics, NASA, Bozeman Science, and PBS Learning Media. Search for resources by grade level, resource type, and learning standard (e.g., *Common Core, NGSS*) or by subject and publisher. Consult *https://goo.gl/kyi1dy.*

See Freebies, pg G2

P: PreK **E**: Elementary **M**: Middle **H**: High **HE**: Higher Ed **A**: All **K12**: K–12

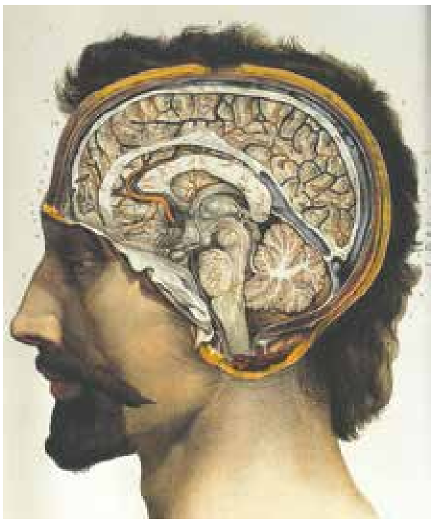
Freebies, From pg G1

Outdoor Learning Guide. **K12** The Environmental Education Alliance of Georgia's guide tells how to plan, create, use, and maintain a K–12 outdoor learning environment. Topics include What Is an Outdoor Learning Area, How to Make Your Own Outdoor Learning Area, What to Do in the Outdoor Classroom, How to Keep an Outdoor Classroom Going (or Revitalize an Abandoned One), Connecting With Kindred Spirits, and Outdoor Classrooms and the Big Picture. Educators also will find links to funding and freebies for outdoor classrooms; tips and techniques for teaching outdoors; and lessons, activities, and investigations—including nationwide field studies—that foster environmental stewardship and engage students in citizen science. Visit *https://goo.gl/jy8VMc*.

International Flipped Learning Innovation Center (IFLIC). **K12 HE** This online platform is dedicated to solving problems and fostering innovation in K–college flipped learning environments worldwide. Created through the merger of the Flipped Learning Community and the Flipped Learning Global Initiative, the center connects nearly 29,000 registered community members to a global network of flipped learning practitioners, researchers, master teachers, technologists, administrators, advocates, and thought leaders. With the IFLIC, educators have a broader set of resources available for collaboration, thus leading to improved teaching practices, additional research, and technology innovations for flipped classrooms worldwide. See *https://goo.gl/0wWci8*.

Ocean Education Resources. **E M** California's Monterey Bay Aquarium offers materials for K–8 students and teachers. The *Sea Searchers Handbook* (elementary), for example, covers everything from types of sea habitats (rocky shore, sandy shore, wetlands, kelp forest, deep sea canyons) and animals that call the ocean home (marine mammals, fish, and sharks, rays, and skates) to understanding ocean food webs and humans' role in protecting the oceans. The handbook also has a glossary and a set of Animal Fact Cards featuring the animals found in each type of ocean habitat.

Middle level teachers will appreciate the Teen Career Resources section, which presents profiles of marine-related jobs at the aquarium, including director of veterinary services, dive safety officer, education specialist, and water systems manager. The Shark School of Art, a printable for all ages, provides tips for drawing sharks and creating your own comic. Visit the website *https://goo.gl/XrZKcM*.


ERALD MECANI

Video Series: How Alcohol Affects the Brain. **E M** This animated video series and corresponding lessons for grades 5–6 were produced by the Foundation for Advancing Alcohol Responsibility as part of the Ask, Listen, Learn: Kids and Alcohol Don't Mix campaign. Videos and lessons examine the effects of alcohol on the brain, central nervous system, cerebellum, cerebral cortex, hippocampus, hypothalamus, and medulla. Content supports National Health Education Standards, *Common Core State Standards,* and *NGSS.* The website also offers interactive classroom activities, vocabulary exercises, comprehension questions, and a facilitator's guide. Consult *http://asklistenlearn.org*.

Periodic Table Lessons. **H HE** Learn something new about every element on the periodic table! Created by the Periodic Videos team using the TED-Ed platform, and most appropriate for use in high school and college chemistry classrooms, this interactive periodic table presents a short (5–10 minute) video on every element, along with a lesson that helps educators make the most of the video's content. The videos are catchy and informative, describing interesting facts about each element and its uses, and the accompanying lessons feature multiple-choice and open-ended questions that invite students to Watch, Think, Dig Deeper, and Discuss. Refer to the website *https://goo.gl/HehJmT*.

Data Nuggets. **K12 HE** A collection of engaging classroom activities co-created by K–12 teachers and scientists from Michigan State University offer an innovative approach to bringing authentic, cutting-edge research into K–college classrooms. The activities provide opportunities for students to practice interpreting quantitative information and making claims based on evidence and show students how the process of science really works. Titles include Dangerously Bold (elementary), which addresses animal predation; Is Chocolate for the Birds? (middle level), which examines issues surrounding habitat loss in the rainforest; Lizards, Iguanas, and Snakes, Oh My! (high school), which covers biodiversity and urban restoration; and The Arctic Is Melting, So What? (advanced high school and college), which explores how loss of sea ice can affect weather in the northern hemisphere.

One feature of the "nuggets" is that they are leveled—both for content and readability and for graphing skills—making them a useful tool for differentiated learning. See the website *http://datanuggets.org*.


CS CALIFORNIA

Monarchs and More. **E M** With versions for primary (grades K–2), intermediate (grades 3–5), and middle level (grades 6–8) learners, this curriculum from the University of Minnesota's Monarch Lab provides age-appropriate lessons exploring the monarch butterfly's migration behaviors and life cycle. In Migration Game, an outdoor role-play, students must think and act like a monarch as they travel from their northern state to their overwintering grounds in Mexico, following "butterfly rules" such as "drink nectar from a cup daily" and "fly only when the Sun is out." Activities exploring the monarch's life cycle include Comparing Life Stages (primary) and Measuring Larval Growth and Development (intermediate and middle level). The curriculum also contains supplemental materials, including printable illustrations of the monarch's anatomy, super-magnified images of monarchs seen through the university's Scanning Electron Microscope, and links to monarch-related citizen science projects. Visit the website *https://goo.gl/kdXNOX*.

Afterschool Alliance STEM Resources. **K12** The alliance provides K–12 educators with publications, research, program profiles, legislative policies, and a blog examining the role after-school programs play in assuring access to meaningful STEM learning experiences to diverse groups of students. Of particular interest is *Getting Started With the* Next Generation Science Standards, a how-to guide that suggests ways afterschool providers can work with partner schools and use *NGSS* to improve their practice. See the website *https://goo.gl/fhSSh5*.

Science Matters. **E M** This series of standards-based instructional units in Earth, life, and physical science is for grades 4–6. Developed by the Science Matters Institute in conjunction with K12 Alliance/WestEd, the units are built around the 5E model and designed to supplement any adopted curricula to increase effectiveness of classroom science instruction. The life science units address topics such as Ecosystems (grade 4) and Living Systems (grade 5). The physical science units explore Electricity and Magnetism (grade 4), Chemistry and Matter (grade 5), and Energy (grade 6). The Earth science units cover The Changing Earth (grade 4), Solar System and Earth's Weather (grade 5), and Plate Tectonics, Earthquakes and Volcanoes, and Weathering and Erosion (grade 6). See *http://sbsciencematters.com*. ●

P: PreK E: Elementary M: Middle H: High HE: Higher Ed A: All K12: K–12

News Bits

- **A new program at the University of California, Santa Barbara (UCSB), provides funding, outreach, and academic counseling to talented low-income engineering students. HE**

The Enhancing Success in Transfer Education for Engineering Majors (ESTEEM) program for promising transfer students in engineering builds on UCSB's previous efforts to support engineering students in their third year, when they begin taking engineering courses. This can be a challenging time for transfer students, who are coping with entering a new school and in many cases, working full time. The National Science Foundation awarded ESTEEM $4.8 million over five years to provide scholarships for transfer students so they can concentrate on their studies. The program will also provide regular consultation with faculty mentors and advisors to help students stay on track to graduation.

ESTEEM also will address the lack of diversity in STEM (science, technology, engineering, and math) fields. Read more at: *http://goo.gl/gghDaL* and *http://esteem.ucsb.edu*.

- **High school students in Washington created an app to raise awareness about climate change. H**

Three seniors in an AP Environmental Science class at Tesla STEM High School in Redmond developed the app for the Congressional App Challenge, a government-sponsored competition in which students learn coding by creating apps. In Code Carbon, the trio's climate change strategy game, players create a planet that balances the population's energy use with factors like pollution, population growth, and money. While playing, the developers say, users begin to see climate change as a multifaceted issue with political and economic implications and explore short- and long-term consequences of energy sources.

Read more at *http://goo.gl/6f3JE1*.

- **Middle school parents in Cupertino, California, are upset about a policy requiring iPads for their children. M**

Parents in the Cupertino United School District (CUSD)—located near Apple Inc. headquarters—disagree with the district's 1:1 iPad initiative, which requires middle school students to have their own iPads for school use and for homework. More than 600 parents have signed a petition on Change.org to restrict how the iPads are used. They worry about the devices' addictive nature and the effects of so much screen time on their children's health. Others dislike having to buy expensive devices; though the school doesn't require parents to buy them, it is recommended that they do so.

While the school provides tablets for families in need, some parents have felt pressured to buy them. The petition asks the CUSD to restrict the use of the devices to school grounds, to provide devices regardless of a family's financial status, and to assume liability for broken or stolen devices.

About 60% of students at the three middle schools involved own their own iPads, and Lawson Middle School Principal Kit Bragg says no one has been pressured into buying one.

CUSD Spokesperson Jeff Bowman says giving every middle schooler an iPad has improved students' behavior, quality of work, language ability, and organizational skills, though CUSD lacks hard evidence of this.

The program will expand to two more middle schools this year. Read more at *http://goo.gl/3KCcLq*. ●

What's New

FROM U.S. GOVERNMENT SOURCES

National Institutes of Health (NIH)

Open Wide and Trek Inside E

Beyond a traditional "brushing and flossing" curriculum, this dental health learning module for grades 1–2, produced as part of NIH's Curriculum Supplement Series, focuses on the science concepts relating to oral health. Students study the biology of the mouth to learn how its structures and their functions relate to human health. The module has six hands-on lessons: Open Wide! Look Inside; Let's Investigate Tooth Decay; What Do Mouths Do; What Lives Inside Your Mouth; What Keeps Your Mouth Healthy; and What Have You Learned About the Mouth?

Teachers can download the full curriculum in PDF format, or use the web version, in which students complete classroom lessons as well as an online component with mini-documentaries, animations, and interactive activities. Consult *https://goo.gl/02p7Wq*.

National Oceanic and Atmospheric Administration (NOAA)

Maritime Archaeology: Discovering and Exploring Shipwrecks M H

Introduce middle level and high school students (grades 6–12) to maritime archaeology and the tools scientists use to investigate shipwrecks. Produced by NOAA's National Marine Sanctuaries, the curriculum guide contains 22 lessons addressing side scan and multibeam sonar, remotely operated vehicles, magnetometers, SCUBA diving, and other topics. The lessons can be taught as a unit, used as stand-alone activities, or combined in multiple ways to meet students' specific needs. Access the guide at *https://goo.gl/AoEMZK*.

Voices of the Bay Fisheries Education Program M H HE

Focusing on Monterey Bay fisheries as a case study, the Voices of the Bay Fisheries Education Curriculum uses engaging, hands-on activities to provide a deeper understanding of the marine ecology, economy, and culture that surrounds fisheries. Developed by NOAA's National Marine Sanctuaries, the curriculum meets a range of science, math, social studies, and communications educational standards for students in grades 6–college. For example, Balance in the Bay, a science-themed module, involves students in a simulated fishery where they make regulation decisions and address natural and human-made challenges in the fishery and the squid populations.

Additional fisheries-related curriculum and activities are presented in the Resources section. View the curriculum at *https://goo.gl/unja5g*.

U.S. Fish and Wildlife Service (FWS)

Endangered Species Act Success Stories A

The Endangered Species Act (ESA) has helped stabilize populations of species at risk, prevent the extinction of others, and conserve the habitats on which many animals depend. Under the ESA, California condor, grizzly bear, Okaloosa darter, whooping crane, and black-footed ferret have been brought back from the brink of extinction. Other species, such as the bald eagle, no longer need the ESA's protection and have been removed from the list of endangered and threatened species.

FWS has created an interactive map of the United States that presents information about the endangered species in each state and what is being done to help conserve them. View it at this website: *https://goo.gl/6mWWH0*.

U.S. Geological Survey (USGS)

Mud Fossils Teaching Kit E

This kit includes lesson plans, activities, and other resources to teach K–3 students about fossils. Activities are presented in three phases. In the first (Exploration), students examine real fossils and create a model of a fossil from mud to learn how a fossil forms and to practice extracting it. In the second phase (Concept Development), teachers ask questions to help students reflect on their exploration: What are fossils? How do fossils get preserved? What are some problems in recovering fossils from hardened mud? What would it be like to remove fossils from a rock?

The final phase (Application) asks students to consider how geologists use fossils to study Earth's history. The kit also includes background information for teachers and extension ideas. You'll find the kit at the website *https://goo.gl/bOMO1M*.

U.S. Environmental Protection Agency (EPA)

Air Now: Air Quality Resources for Teachers K12

At AirNow.gov, EPA's air-quality education website, K–12 educators can access curriculum, links, teacher workshops, and classroom activities to explore pollution and other air-quality issues with students. Curriculum highlights include the Air Quality Index (AQI) Teacher Toolkit, which offers age-appropriate lessons in three grade bands (K–2, 3–5, and 6–8), background information, fact sheets, and student handouts to explore the meaning of the AQI and how students, families, and communities can use the tool to

P: PreK E: Elementary M: Middle H: High HE: Higher Ed A: All K12: K–12

protect their health. Another notable toolkit is the Air Quality Workshop for Teachers (click on Environmental Education for Teachers), which includes everything you need to facilitate a K–12 teacher workshop on the topic from resources to strengthen background knowledge of air quality issues to PowerPoint presentations and hands-on activities that provide insight into climate change, show teachers how to calculate a carbon footprint, and discuss negative health effects of air pollution. Visit *https://goo.gl/kFyt9D.*

U.S. Department of Education (ED)

NAEP Science State Snapshot Reports E M H

Each state and jurisdiction that participated in the National Assessment of Educational Progress (NAEP) 2015 Science assessment receives a one-page snapshot report that presents key findings and trends in a condensed format. The reports in this series provide bulleted text describing overall student results, bar charts showing NAEP achievement levels for selected years in which the state participated, and tables displaying results by gender, race/ethnicity, and eligibility for free/reduced-price lunch. In addition, bulleted text describes the trends in average scale score gaps by gender, race/ethnicity, and eligibility for free/reduced-price lunch.

A map comparing the average score in 2015 to those of other states/jurisdictions is also displayed. Learn more and read the reports at the website *https://goo.gl/nJEMfd*.

National Aeronautics and Space Administration (NASA)

EO Kids M

EO Kids, an e-publication from NASA's Earth Observatory, brings engaging science stories and activities to the middle level audience. Featuring "chunkable" text and plenty of kid-friendly photographs and illustrations, the premier issue—themed "Fresh Water: Satellites See Everything From Raindrops to Great Lakes"—focuses on how NASA observes and measures fresh water from space. Find out why Lake Mead appears to have a bathtub ring around its shoreline and how less snow in the mountains means less drinking water for California. Explore satellite images of where fresh water is stored in and on the Earth. Check in with scientists on the Olympic Mountain Experiment (OLYMPEX) campaign, and see what working scientists do in the field.

The issue also includes several hands-on activities and experiments that can make the content real for students. In Snowmelt Science, for example, students conduct an experiment to see for themselves how much water snow (or crushed ice) produces, while in Data Viz, students create their own data visualization by coloring in a map showing ice thickness on Greenland. The Maker Corner provides instructions for making a model aquifer and a self-watering planter. Download the issue at *https://goo.gl/gY0Xg2*.

2017 Solar Eclipse Resources K12

Are you ready for the August 21 solar eclipse? Along a path 60 to 70 miles wide stretching from Oregon to South Carolina, observers will be able to see a total solar eclipse. Others across North America will see a partial eclipse. The eclipse offers a prime opportunity to engage diverse audiences in astronomy and other science topics, and NASA has many resources to help you make the most of this celestial event in K–12 classrooms.

Browse the websites below to access an interactive map with timing information along the path of the eclipse; tips for safely viewing the solar eclipse; interviews with NASA scientists, mission specialists, and eclipse path communities; online eclipse videos; public challenges and engagement activities; citizen science campaigns in partnership with NASA mission observations; and more.

- NASA Eclipse Website (refer to *https://goo.gl/QKfA0R*);
- Total Eclipse 2017—Through the Eyes of NASA (see the website *http://eclipse2017.nasa.gov*);
- Eclipses and Transits (visit the website *www.nasa.gov/eclipse*); and
- The Solar Eclipse 2017 PREVIEW Show with NASA EDGE (consult *https://youtu.be/6DDICymjhg0*).

National Park Service (NPS)

Lights, Camera, Nest! K12

The live bald eagle webcam at Channel Islands National Park in California is incredibly engaging to watch: See the progression starting with adult eagles sprucing up the nest in January and concluding with young eagles fledging in June or July. The webcam provides opportunities for students of all ages to observe breeding and nesting behaviors of live eagles. In addition, teachers can access the site's Bald Eagle Web Page and Archives, which include information, videos, and images of bald eagle restoration efforts at the park, as well as images of chicks feeding and their first flight. Refer to the website *https://goo.gl/3QbLGQ*.

A companion resource that teachers can use while students are watching the nest happenings is the Cycles of Life unit from California's Education and the Environment Initiative. While the unit is targeted for second grade, it's adaptable for other levels and includes a Reader focusing on the life cycle of a bald eagle family. Find the unit at *https://goo.gl/HwgIAJ*. (To access the Teacher's Edition, the password for everyone is "teacheei.") ●

P: PreK E: Elementary M: Middle H: High HE: Higher Ed A: All K12: K–12

In Your Pocket

Editor's Note

Visit ***www.nsta.org/calendar*** *to learn about more grants, awards, fellowships, and competitions.*

February 24–28

American Electric Power Teacher Vision Grants P K12

These grants go to preK–12 teachers who live or teach in American Electric Power (AEP) service areas, located in Arkansas, Indiana, Kentucky, Louisiana, Michigan, Ohio, Oklahoma, Tennessee, Texas, Virginia, and West Virginia. Grants of $100 to $500 are available for projects with an academic focus that improve student achievement; those with an emphasis on science, math, technology, electrical safety, energy, or the environment are preferred.

Priority is given to teachers who have attended an AEP Workshop for Educators, participated in the National Energy Education Development project, or are affiliated with an AEP school–business partnership. Apply by **February 24** at *http://goo.gl/76t9mv.*

Directpackages.com Teacher Grants K12

These $1,000 grants go to K–12 teachers who want to purchase new technology for their classrooms. Teachers write a 400- to 500-word essay explaining how the new technology would address a learning challenge they face in the classroom and what kind of impact it might have on their students.

Three awards are available for teachers at schools appearing in the National Center for Education Statistics database at *https://goo.gl/JvmxeA*. Apply by **February 24** at *https://goo.gl/cNH8yT.*

Monsanto Fund Grants K12

These grants aim to encourage and support communities in which Monsanto employees live and work. Grants are available for K–12 schools, libraries, science centers, and academic enrichment programs across rural America. Proposed projects might include science and technology fairs, family science nights, robotics programs, and school gardens.

Grants of up to $20,000 are available. Apply by **February 28.** Applicants must request an invitation code before applying at *http://goo.gl/1OpiHW.*

ISTE Outstanding Young Educator Award K12

The International Society for Technology in Education (ISTE) presents this award to a teacher who is age 35 or younger as of July 15 and uses technology in the classroom in creative ways. The awardee will receive a complimentary registration to the ISTE Conference and Expo, up to $1,000 in travel expenses, a $1,500 cash prize, and a one-year ISTE membership. Nominate yourself or a colleague with a curriculum vitae (CV), letter of support, and one- to two-minute video by **February 28** at *http://goo.gl/vUhLa3.*

ISTE's Kay L. Bitter Vision Award P E

This award honors Kay L. Bitter, an early childhood educator for more than 20 years who used cutting-edge technology with her students. The award recognizes a preK–2 teacher who uses technology with students in innovative ways. The honoree will receive a complimentary registration to the ISTE Conference and Expo, up to $1,000 in travel expenses, and a one-year ISTE membership. Nominate yourself or a colleague with a CV, letter of support, and lesson plan by **February 28;** see *http://goo.gl/Qw5AqK.*

March 1

Association of American Educators Classroom Grants K12

These grants of up to $500 fund a variety of classroom projects and materials, including books, software, calculators, audiovisual equipment, and lab supplies. Full-time educators who have not received a scholarship or grant from the Association of American Educators (AAE) in the last 18 months are eligible, though AAE members receive additional consideration. Teachers in Arkansas, Colorado, Idaho, Kansas, Oregon, and Washington compete for state-specific funds and complete a separate application. Apply by **March 1;** consult *http://goo.gl/eWCd5N.*

Dr. Scholl Foundation Education Grants K12

The foundation provides these grants to organizations committed to improving our world through education. The average grant amount ranges from $5,000 to $25,000, though any amount may be requested. Applicants must be nonprofit organizations with at least three years of financial activity, but publicly supported state, local, and federal organizations—such as public schools and municipalities—are rarely considered.

Apply by **March 1.** Application forms must be requested on the foundation's website: *https://goo.gl/qZSnfp.*

Pilcrow Foundation Children's Book Project Program Grants K12

The foundation provides a 2-to-1 match for rural public libraries that receive a grant through its Children's Book Project and contributes $200–$400 through local sponsors for the purchase of up to $1,200 worth of new, quality, hardcover children's books. The foundation provides a list of 500 such books libraries can choose from.

To qualify, libraries must be located in rural areas, have a limited operating budget and an active children's department, and raise $200–$400 through a local sponsor. Those with operating budgets of less than $50,000 receive priority, though town libraries with budgets of more than $150,000 and country libraries with budgets of more than $450,000 may also apply. Applications must be postmarked by **March 1.** Visit *http://goo.gl/DpEh2U.*

Arthur Holly Compton Award in Education A

This award, sponsored by the American Nuclear Society (ANS) to honor physics Nobel Prize–winner Arthur Holly Compton, recognizes outstanding contributions to nuclear science and engineering education. The honoree will receive $2,000 and an additional $2,000 for his or her academic institution. Nominees need not be ANS members nor work primarily in education. Submit nominations and a letter of recommendation by **March 1;** consult *http://goo.gl/YqpZUe.*

Bradley Stoughton Award for Young Teachers A

To honor former ASM International president Bradley Stoughton, the organization presents this award to a young materials science, materials engineering, design, or processing teacher who educates and inspires students. Nominees must be age 35 or younger by May 15 and be ASM International members. The awardee receives $3,000 and a certificate. ASM members or alumni and faculty groups can submit nominations by **March 1** at *http://goo.gl/KFRFWk.*

Presidential Innovation Award for Environmental Educators K12

The Environmental Protection Agency (EPA) provides this award to recognize outstanding K–12 environmental education teachers. Up to two teachers from each of the EPA's 10 regions, in different states, will receive this national honor. Awardees receive $2,000 to further their professional development in environmental education, and their local education organization receives $2,000 as well to fund activities and programs that support the teacher.

K–12 educators at public schools are eligible; applicants must have a current teaching license and at least five years of teaching experience, including three years of teaching environmental education. Apply by **March 1** at *http://goo.gl/f1t8AT.*

P: PreK E: Elementary M: Middle H: High HE: Higher Ed A: All K12: K–12

March 15–31

NABT Awards A

The National Association of Biology Teachers (NABT) offers awards to recognize outstanding educators in the field:

- the Ecology/Environmental Science Teaching Award;
- the Evolution Education Award;
- the Genetics Education Award;
- the Kim Foglia AP Biology Service Award;
- the Ron Mardigian Biotechnology Teaching Award;
- the Vernier and NABT Ecology/Environmental Science Teaching Award;
- the Outstanding New Biology Teacher Achievement Award; and
- the Outstanding Biology Teacher Award (OBTA). (One OBTA is available in each state and in Canada, Puerto Rico, overseas territories, and Washington, D.C. Nomination deadlines and criteria vary by state. Contact your state OBTA director for details about the award in your location.)

Awardees are recognized at the NABT Professional Development Conference each year and often receive financial rewards and complimentary NABT memberships. Nominate yourself or a colleague by **March 15.** Each award has different criteria; learn more at *http://goo.gl/kMkokx.*

Captain Planet Foundation EcoTech Grants K12

These grants go to projects that explore the role technology might play in addressing environmental challenges. Past grants have funded projects that used robotics and sensors to explore water bodies, collect data, and organize cleanups, for example. Funds should encourage students to use technology or nature-based design to address environmental problems in their own communities.

Grants of $2,500 are available for such youth-led projects that result in real environmental change. Schools and nonprofit programs in the United States with operating budgets of less than $3 million are eligible.

Submit applications by **March 15** at *https://goo.gl/IoiMed.*

Charles Edwin Bessey Teaching Award A

Charles Edwin Bessey is best known for his contributions to botanical education in the United States. This award—sponsored by the Botanical Society of America (BSA)—recognizes those whose work, like Bessey's, has impacted botany education at the regional, national, or international level. The recipient should have a passion for teaching botany, demonstrate innovative methods, and be a BSA member. This year's award will be presented at the BOTANY 2017 conference in Fort Worth, Texas, June 24–28.

Applications should include a CV, a formal letter of nomination, and letters of support. Apply by **March 15;** consult *http://goo.gl/x4eSbI.*

EJK Mini-Grants P K12

The Ezra Jack Keats (EJK) Foundation, named for the children's book author and illustrator, provides these $500 grants to public schools and libraries with creative, innovative programs that support or extend the *Common Core* for preK–12 students. Projects should foster creative expression, collaboration, and interaction with a diverse community and be informed by Keats' books, life, and vision. Previously funded projects have included story walks, quilts, theater productions, newspaper projects, and intergenerational activities.

Public schools, public libraries, and public preschool programs, such as Head Start, in the United States and its territories, including Puerto Rico and Guam, are eligible. Apply by **March 31** at *http://goo.gl/ZH8G9Q.* ●

P: PreK E: Elementary M: Middle H: High HE: Higher Ed A: All K12: K–12

Summer Programs

Editor's Note

Visit www.nsta.org/calendar to learn about other summer professional development opportunities.

National WWII Museum's Real-World Science Summer Teacher Seminar M

Middle school teachers with two to 10 years of experience can participate in this week-long professional development opportunity at the National WWII Museum in New Orleans. During July 23–28, participants will experience firsthand how necessity, perseverance, and skills can lead to innovations and careers in science, technology, engineering, and math (STEM)—just as it did during World War II.

Fifth- through eighth-grade teachers at public, charter, private, and parochial schools may attend. Participants receive free room and board, a travel stipend, and all seminar materials needed to complete the program. Apply by **February 24** at *http://goo.gl/jd8OQ6*.

America's Industrial Revolution Workshop K12

This teacher workshop is sponsored by the National Endowment for the Humanities (NEH), in partnership with the Henry Ford in Dearborn, Michigan. Participants will explore America's journey from agricultural colonies to industrial nation by discussing U.S. history with university scholars and museum curators; touring historic farms, mills, and laboratories; and developing lesson plans.

Two one-week workshops will be held during July 9–14 and July 16–21. Commuters will receive a $600 stipend for travel costs; those staying in residence receive $1,200 to help cover housing costs. Apply by **March 1.** Learn more at *http://goo.gl/WDCbNw*.

Re-Enchanting Nature: Humanities Perspectives K12

This three-week NEH seminar will take place at Carroll College in Helena, Montana, and Yellowstone National Park during July 10–28. Participants will examine our relationship with nature and draw upon cultural, literary, fine arts, and cinematic perspectives to evaluate the role of the humanities in public discourse about the environment. Teachers will engage with the question of whether or not the humanities can deepen that relationship in ways that complement scientific study.

Participants seeking collaborations between humanities and STEM fields are particularly encouraged to attend. Apply by **March 1.** For more details, see *http://goo.gl/jFGi01*.

From Mesa Verde to Santa Fe: Pueblo Identity in the Southwest K12

In this three-week NEH Summer Landmarks workshop, sponsored by Crow Canyon Archaeological Center in Colorado, K–12 teachers will explore Pueblo Indian history from 2000 B.C. to the present, the many ways to interpret that history, and its relationship to Pueblo identity. Participants will attempt to answer these questions:

- How and why did Pueblo people leave their ancestral homeland at Mesa Verde?
- What happened when Pueblo people arrived and settled in the northern Rio Grande Valley of New Mexico?
- How did the arrival of the Spanish affect Pueblo options and responses to the challenges presented by their new homeland? and
- How did these early experiences contribute to the resilience of Pueblo culture today?

During June 25–July 15, participants will answer these questions by exploring Mesa Verde National Park and historic Pueblo communities in New Mexico with Pueblo scholars and Western scientists. They will use findings from archaeology, ethnohistory, and oral history to examine how these interpretations influence Pueblo identity and the way it's taught in today's classrooms.

Apply by **March 1.** To learn more, visit *http://goo.gl/1sV4dt*.

The American Skyscraper: Transforming Chicago and the Nation E M H

During this week-long NEH workshop, teachers will explore the rise of the skyscraper, how it changed American life, and what this indicates about the future of countries building large numbers of tall buildings. Teachers will work with scholars, take walking and river tours, and develop lesson plans for teaching science, mathematics, social sciences, language arts, and fine and visual arts. Teachers of grades 3–12 can choose from one of two sessions. Session 1 (July 9–15) is open to 36 teachers from across the country. Session 2 (July 23–29) is open to 36 teachers from Chicago and Cook, DuPage, Kane, Lake, McHenry, and Will Counties. Teachers in Session 1 receive $1,200 stipends to help offset housing costs; those in Session 2 receive $600 to defray the cost of travel.

Apply by **March 1.** Learn more at *http://goo.gl/7GKC3O*.

Monterey Bay Aquarium Splash Zone Teacher Institute P E

This year-long institute, sponsored by the Monterey Bay Aquarium, invites preK–2 teachers to explore the habitats in their own backyards and to inspire conservation efforts among their students. The institute encourages science discourse in the classroom by connecting science notebooks, language arts, inquiry, and technology.

Participants must attend the summer session, taking place July 30–August 4, and three Saturday follow-up sessions on September 30; January 20, 2018; and April 14, 2018. They must also use the curriculum presented with their students, participate in the aquarium's online professional development community, and lead an inservice or action project at their school or district.

Daily stipends of $50 are available upon completion of the institute, as are California State University, Monterey Bay, credit units. Register by **March 13** at *http://goo.gl/RkCIfn*.

2017 Modeling Workshops M H

The American Modeling Teachers Association (AMTA) will conduct a series of two- to three-week workshops for middle school science and high school physics, chemistry, biology, and physical science teachers. Participants receive a set of course materials and work through activities as they practice guided inquiry and cooperative learning.

Workshops will take place in Arizona, Illinois, Maine, Michigan, Minnesota, New York, Ohio, Texas, Virginia, and Hong Kong. (Other locations may be added before June 1.) At most workshop sites, teachers receive stipends or tuition waivers and reduced-rate housing. Participants also qualify for a free one-year AMTA membership.

Program dates vary by location. For more information, check *http://goo.gl/6pgNT5*.

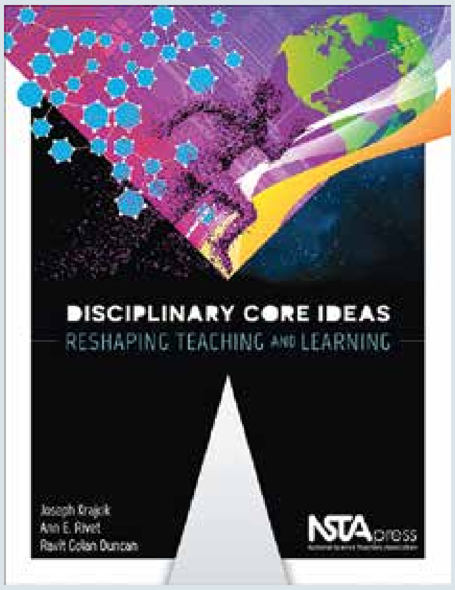
Technical Writing for Science Class K12

The Lawrence Livermore National Laboratory in Livermore, California, offers this two-day (June 22–23) professional development course to help K–12 science teachers meet *Common Core State Standards* for technical communication. Participants will learn how to explain usability and text-design techniques to their students and how to incorporate these ideas in lab instructions, technical descriptions, abstracts, notes, science posters, and other forms of technical writing. Register online at *http://goo.gl/76ffrc*. ●

P: PreK E: Elementary M: Middle H: High HE: Higher Ed A: All K12: K–12

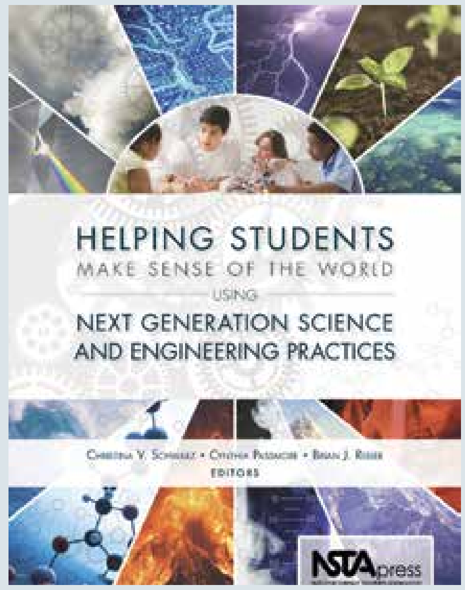
"I'm a new STEM teacher and would love to learn more so that I can better serve the diverse needs of my students. I'm excited to explore the great resources NSTA has to offer!"

—NSTA Press reader Kellie C.



Grades K–12

Book: Member Price: $31.96 | Nonmember Price: $39.95
E-book: Member Price: $23.97 | Nonmember Price: $29.96
Book/E-book Set: Member Price: $38.35 | Nonmember Price: $47.94



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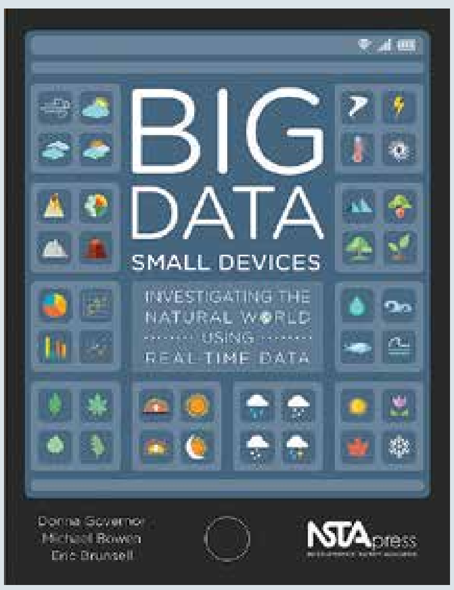
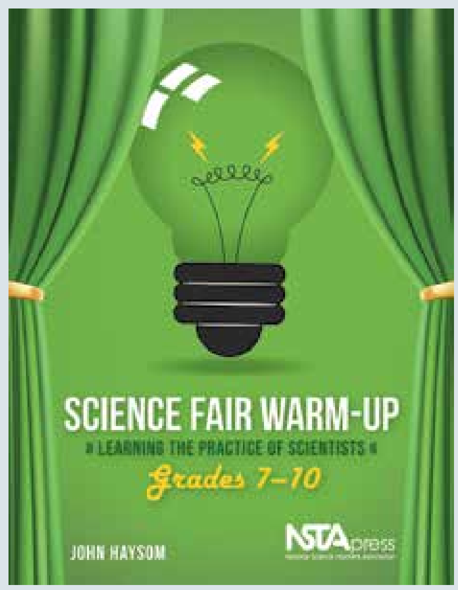


Grades PreK–2

Book: Member Price: $31.96 | Nonmember Price: $39.95
E-book: Member Price: $23.97 | Nonmember Price: $29.96
Book/E-book Set: Member Price: $38.35 | Nonmember Price: $47.94



Grades 3–6

Book: Member Price: $10.36 | Nonmember Price: $12.95
E-book: Member Price: $8.42 | Nonmember Price: $9.71
Book/E-book Set: Member Price: $12.43 | Nonmember Price: $15.54

To place an order or download a free chapter, visit
www.nsta.org/store

NSTA National Science Teachers Association

BLICK ON TV

Faster Than a Tornado?

By Jacob Clark Blickenstaff, PhD

I do not have a lifelong background in comic book heroes, so as new films and TV series based in the DC or Marvel universe debut, I do some research to catch up. Such is the case with *The Flash,* currently in its third season on the CW Television Network. I haven't watched the whole series, but I did find a few things in some early episodes that teachers could use in the classroom.

Like most superheroes, Barry Allen lost a parent at a young age when his mother was killed by a man surrounded by a "ball of lightning." Police didn't believe young Barry's account of the attack, and instead arrested Barry's father for the murder. Neighbor and police detective Joe West (played by Jesse L. Martin) takes Barry in and raises him alongside his daughter, Iris.

The story then jumps to the present, when Barry (played by Grant Gustin) is a young crime scene technician working with Joe in the Central City Police Department. Barry, a science geek, deeply admires the famous leader of S.T.A.R. Labs, Harrison Wells (played by Tom Cavanaugh). As might be expected, Barry has feelings for Iris, but is unable to express them, and Iris sees Barry as her best friend. He's just a normal guy working crime scenes.

Then the crucial day arrives: S.T.A.R. Labs is opening a new particle accelerator, when a freak storm causes an accident. A pulse of "dark energy" spreads out from the accelerator, and a lightning bolt knocks Barry unconscious. Nine months later, he awakens from a coma and discovers he has gained super powers.

Barry's metabolism is extremely fast, he can run up to 700 mph (about 300 meters per second), and he heals quickly when injured. We learn that others in Central City were also changed by the energy pulse, but many are using their powers to steal and take revenge. It is up to Barry, working with the police and S.T.A.R. Labs, to save the city from the super-criminals.

It is easy to ridicule comic book superheroes and their origin stories. The writers use scientific language and scientific-sounding language to create a mysterious phenomenon that imbues people with unusual powers. Pointing out errors can be fun, but it's not always a good method to use in the classroom. I'll explore a few incidents from early episodes that teachers could use for calculations or examples in physics or chemistry.

Tornado

The first episode features super-villain Clyde Mardon, who has the ability to control the weather, at least locally. Mardon summons fog and thunderstorms when robbing banks to hide his getaway from the authorities. Late in this episode, he creates a tornado, supposedly to attack Central City and lay waste to the buildings. Flash is able to dissipate the tornado by running around it opposite its direction of rotation. Barry's team is initially worried that he won't be able to run fast enough, mentioning 700 mph.

Travelling in a circle isn't easy, especially when going really fast. A force toward the center of the circle is needed to keep an object from veering off in a straight line. So I thought it would be interesting to calculate how much force would be needed to keep Flash circling that tornado at 700 mph (or 300 meters/second). The acceleration of an object moving is a circle is

$$a = \frac{v^2}{r}$$

I estimate the tornado's diameter to be 10 meters, with a radius of 5 meters:

$$a = \frac{(300\,\frac{m}{s})^2}{5m} = 3600\,\frac{m}{s^2}$$

That is more than 360g (more than 360 times larger than the acceleration due to gravity on Earth). A normal human can survive very short accelerations up to about 100g, and sustained accelerations of only up to about 10g. Flash needs a robust body to withstand that kind of acceleration. The rest of us probably only approach these speeds when flying in an airplane (some passenger jets can exceed 500 mph), but you may have noticed that those planes don't change direction very quickly. When moving that fast, rapid changes in direction require huge amounts of energy, and can be harmful to passengers.

Food Energy

When I started watching *The Flash,* I wondered if the side effects of having a rapid metabolism—most particularly, the need to eat a lot of food—would be mentioned. I was slightly surprised to see it come up in the second episode, when Barry starts having fainting spells due to low blood sugar. Running very fast would consume a lot of energy, so it makes sense that he needs to consume more food calories. But other complications go unaddressed. Digesting that much food quickly enough would likely generate a fair amount of waste heat, so Barry's body temperature would likely be higher than normal, and that has consequences for other physiological systems. Normal adults run into serious neurological problems if their core body temperature gets too high, just five or six degrees F above normal.

Gas Volume

In another early episode, one supervillain (Kyle Nimbus) has the ability to change himself into a gas, which just happens to be poisonous hydrogen cyanide. (He was being executed when the particle accelerator accident happened.) One of the surprising properties of gasses is just how far apart the particles in a gas are from one another. As a rough estimate, the atoms or molecules in a gas are about 10 times farther apart than they are in a liquid or solid. Since there is 10 times more space in all three directions (forward/back, left/right, up/down), the volume of a gas is about 10x10x10 = 1,000 times larger than the liquid or solid it came from.

A person has just about the same density as water, so a 70 kg person has a volume of about 70 liters. If that person were to change to a gas, he'd suddenly have a volume of about 70 cubic meters, and that's pretty big: It would be a cube of just more than 4 meters (12+ feet) on each side. If Nimbus were to transform from solid to gas inside a closed container, he'd likely cause it to explode from the sudden increase in pressure. This explains why putting dry ice or baking soda and vinegar into empty plastic soda bottles is such a *bad idea.*

The Flash is a fun comic-based TV series that teachers can use for physics and chemistry conversations or calculations in the classroom. ●

Jacob Clark Blickenstaff is Director of K–12 Engagement at the Pacific Science Center in Seattle. Read more Blick at http://goo.gl/6CeBzq, *or e-mail him at* jclarkblickenstaff@pacsci.org.

MS. MENTOR, **Advice Column**

Busy vs. Engaged; Statistics for Younger Students; Expanding Recycling

After a recent observation, my supervisor commented that the students did not seem engaged in the activity. I was surprised because the students were busy working. How can you tell if students are really "engaged"?

—P., Oklahoma

Ask your supervisor what he or she saw (or did not see). What indicators would have determined "engagement" in your class? How does this differ from your observation of being busy?

In the meantime, here's some food for thought. I asked at a workshop: Can you be visibly busy but not intellectually engaged in a task? The attendees generally responded yes, with examples of chores such as housecleaning.

The follow-up question required more thought: Can you be intellectually engaged without being visibly busy? We had a great discussion on creativity, reflecting, and thinking about a topic but appearing to others as daydreaming or not paying attention (i.e., not busy).

I found it was easy to keep students visibly busy with low-level tasks (filling in a worksheet, following directions in a cookbook lab activity). They usually complied with my instructions.

But students had a motivation beyond compliance during other activities—especially those that involved student choices, challenges, creativity, or other higher-level thinking. I noticed several indicators of this in my middle school classes, including

- Electricity and excitement in the classroom (unquantifiable, but you'll know it when it happens);
- Conversations including questions like "What if we try this?", "I wonder if…?";
- "Bums" in the air—during cooperative activities, students pushed the desks together, and some were kneeling on the chairs or bending over the tables to get their heads closer to their partners; and
- Fewer requests for the restrooms or water fountains.

And best of all— "Is class over already? Can we finish this tomorrow?"

Our math department wants students in all subjects and grade levels to do more with statistics and graphing. I do graphing with my students in elementary science, but are younger students ready for statistics?

—G., Pennsylvania

The science and engineering practices in the *Next Generation Science Standards* (*NGSS*) include several that incorporate statistics and graphing: Analyzing and Interpreting Data, Using Mathematics and Computational Thinking, and Obtaining, Evaluating, and Communicating Information.

I shared your question with a colleague who is a data specialist and researcher (and a former elementary teacher). She agreed it's all in the strategies you use and how you present problems to younger students. Keep it simple, to start!

We brainstormed some concepts that younger students could understand and use as part of their science investigations:

- Determine central tendencies—mean, median, mode—using concrete examples such as the length of their hands or the height of plants they are growing. They could calculate the mean (numerical average), the median (list all values from lowest to highest and determine the midpoint value), and mode (the most common value). How close are these to one another? What is the range of values (highest and lowest)?
- Fine-tune (or disaggregate) these values by gender, age, type of plant, etc. The questions they ask will determine how they analyze this. (Are boys' hands larger than girls'?)
- Doing a scatter plot is a good way to introduce correlation. Do some values increase together (positive correlation)? And emphasize that correlation is not causation!

Many teachers panic at the beginning of the required statistics class in grad school. But with the apps and websites available today, a lot of the arithmetic is easy. The more important and more interesting challenge continues to be understanding the underlying concepts and choosing the right process.

I sponsor an after-school science club for upper-elementary students. They'd like to expand the recycling program at the school. I'm looking for suggestions on what they can do.
– C., Pennsylvania

It may help to add a context to your students' efforts. In a "garbology" lesson, the teacher collects the classroom trash for a week. Students weigh the contents and separate it (wearing gloves) into actual trash and recyclable materials such as paper, cans, and bottles. They then weigh the recyclables. By extrapolating this to the number of classrooms in the school, they estimate how much trash was generated in their school and what percentage could be recycled. (See also the lessons in "Teaching the Three R's: Reduce, Reuse, Recycle" in the March 2012 issue of NSTA's elementary-level journal *Science & Children* at *https://goo.gl/ZVFn4t*.)

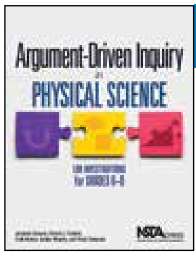
The amount of paper used in the school might be a good start for students' efforts to reduce, reuse, and recycle. Teachers could save old handouts or outdated materials that were printed on one side. Students could put a box next to the copier for any "mistake" copies with blank sides. Students could then collect and cut the paper in halves or quarters for quizzes, notes, or practice work. This would be one last use before recycling the paper.

Do students drink from water bottles in the classroom? In addition to installing containers to recycle them, club members could begin an awareness program to encourage reusable bottles. (Bottles with the school logo could be a fundraiser.)

Your members could be "recycling monitors" in their classrooms, reminding others to put materials that could be reused or recycled in the proper containers.

For more ideas, NSTA's high school journal *The Science Teacher* features the monthly column The Green Room (*https://goo.gl/8XE1eI*), with suggestions for making classrooms and teaching more environmentally friendly. These ideas could be adapted for any grade level.

Check out more of Ms. Mentor's advice on diverse topics or ask a question at www.nsta.org/msmentor.



NSTA PRESS: *Argument-Driven Inquiry in Physical Science: Lab Investigations for Grades 6–8*

Argument-Driven Inquiry (ADI)

Editor's Note

NSTA Press publishes high-quality resources for science educators. This series features just a few of the books recently released. The following excerpt is from Argument-Driven Inquiry in Physical Science: Lab Investigations for Grades 6–8, *by Jonathon Grooms, Patrick J. Enderle, Todd Hutner, Ashley Murphy, and Victor Sampson, edited for publication here. To download the full text of this chapter, go to* https://goo.gl/QuSllI. *NSTA Press publications are available online through the NSTA Science Store at* www.nsta.org/store.

Stage 3: Data Analysis and Development of a Tentative Argument

The next stage of the instructional model calls for students to develop a tentative argument in response to the guiding question. Each group needs to be encouraged to first make sense of the measurements (e.g., temperature and mass) and/or observations (e.g., appearance and location) they collected during stage 2. Once the groups have analyzed and interpreted their data, they can create a tentative argument. The argument consists of a claim, evidence to support the claim, and a justification of the evidence. The *claim* is their answer to the guiding question. The *evidence* consists of the data (measurements or observations) they collected, an analysis of the data, and an interpretation of the analysis. The *justification of the evidence* is a statement that defends their choice of evidence by explaining why it is important and relevant and makes the concepts or assumptions underlying the analysis and interpretation explicit. To illustrate each of the structural components of a scientific argument, consider the following example. This argument was made in response to the guiding question, "What type of metal are objects A, B, and C?"

Claim: Objects A and B are tin. Object C is lead.

Evidence: The density of object A is 7.44 g/cm^3, and the density of object B is 7.34 g/cm^3. These objects have almost the same density as the known density of tin, which is 7.36 g/cm^3. The density of object C is 11.12 g/cm^3. This object has almost the same density as the known density of lead, which is 11.34 g/cm^3.

Justification of the evidence: Density is a physical property of matter and remains constant, regardless of the amount of the object present. Therefore, density can be used to identify the substance that makes up an unknown object. The difference in the calculated densities and the known densities is likely due to measurement error.

The claim in this argument provides an answer to the guiding question. The author uses genuine evidence to support the claim by providing an analysis of the data collected (density of each substance) and an interpretation of the analysis (an inference based on known and unknown density values). Finally, the author provides a justification of the evidence in the argument by making explicit the underlying concept and assumptions (density as an inherent physical property and the likelihood that the difference between the calculated and known values is due to measurement error) guiding the analysis of the data and the interpretation of the analysis.

It is important for students to understand that in science, some arguments are better than others. An important aspect of science and scientific argumentation involves the evaluation of the various components of the arguments put forward by others. Two types of criteria that students can and should use to evaluate an argument in science are empirical criteria and theoretical criteria. *Empirical criteria* include

- how well the claim fits with all available evidence,
- the sufficiency of the evidence,
- the quality of the evidence,
- the appropriateness of the method used to collect the data, and
- the appropriateness of the method used to analyze the data.

Theoretical criteria, on the other hand, refer to standards that are important in science but are not empirical in nature; examples of these criteria are

- the sufficiency of the claim (i.e., Does it include everything needed?);
- the usefulness of the claim (i.e., Does it allow us to engage in new inquiries or understand a phenomenon?);
- the consistency of the claim and the reasoning in terms of other accepted theories, laws, or models; and
- the manner in which the data analysis was conducted.

What counts as quality within these different components, however, varies from discipline to discipline (e.g., physics, chemistry, geology) and within the specific fields of each discipline (e.g., astrophysics, biophysics, optics, thermodynamics). This variation is due to differences in the types of phenomena investigated, what counts as an accepted mode of inquiry, and the theory-laden nature of scientific inquiry. It is important to keep in mind that what counts as a quality argument in science is discipline- and field-dependent.

To allow for the critique and refinement of the tentative argument during the next stage of ADI, each group of students should create their tentative argument in a medium that can easily be viewed by the other groups. We recommend using a 2' x 3' whiteboard or large piece of butcher paper. Students should lay out each component of the argument on the board or paper. Students can also create their tentative arguments using presentation software and devote one slide to each component of an argument. The choice of medium is not important, as long as students are able to easily modify the content of their argument as they work and it enables others to easily view their argument.

The intention of this stage of the model is to provide groups with an opportunity to make sense of what they are seeing or doing during the investigation. As students work together to create a tentative argument, they must talk with one another and determine how to analyze the data and how to best interpret the trends, differences, or relationships they identify. They must also decide if the evidence (data that have been analyzed and interpreted) that they chose to include in their argument is relevant, sufficient, and convincing enough to support their claim. This process, in turn, enables the groups of students to evaluate competing ideas and weed out any claim that is inaccurate, does not fit with all the available data, or contains contradictions.

This stage is challenging for students because they are rarely asked to make sense of a phenomenon based on raw data. It is important for teachers to actively support their sense-making. Teachers should circulate from group to group, asking questions that urge them to think about what they are doing and why. To help students remember the activity's goal, ask "What are you trying to figure out?"; to encourage them to think about whether or not the data are relevant, ask "Why is that information important?"; to help them remember to use rigorous criteria to evaluate the merits of a tentative idea, ask "Does that fit with all the data or what we know about a particular phenomenon?"

It is important to remember that at the beginning of the school year, students will struggle to develop arguments and will often rely on inappropriate criteria, such as plausibility or fit with personal experience, as they attempt to make sense of their data. However, with enough practice, *students will improve their skills*. This is an important principle underlying the ADI instructional model. ●

Mark Your Calendar
NSTA Dates to Remember

(All dates are deadlines unless otherwise specified.)

March 1—Share your best activities and practices for teaching **"Global Climate Change"** with your fellow high school teachers in *The Science Teacher* (*TST*), NSTA's peer-reviewed high school–level journal. In addition, the journal accepts articles unrelated to a theme at any time. For more information on writing for *TST*, issue themes, and more, go to *https://goo.gl/u6JTM6*. For help preparing a manuscript, see an annotated sample manuscript at *https://goo.gl/EwzlLG*.

March 30—The **2017 NSTA Los Angeles National Conference on Science Education** opens today! The conference features strands on *NGSS*: The Next Generation of Science Teaching; 2017: A STEM (science, technology, engineering, and math) Odyssey, Science and Literacy Reloaded; and Mission Possible: Equity for Universal Access. Andy Weir, author of the *New York Times* best seller *The Martian* and a lifelong space nerd, will deliver the keynote presentation. For more information or to register, go to *www.nsta.org/la*.

April 1—***Science and Children*** (*S&C*), NSTA's peer-reviewed journal for elementary science education, **is accepting manuscripts** on the theme **"Developing and Using Vocabulary in Context"** for the November issue. Share how you help students develop their vocabulary and connect science investigations to literacy. Manuscripts of general interest may be submitted at any time. Read the call for papers at *https://goo.gl/UXBmlh*.

April 1—How have you used **informal learning** to enhance students' science learning? Share your ideas and methods with your fellow middle level science educators by submitting a manuscript today for the November issue of ***Science Scope***, NSTA's peer-reviewed journal for middle level science teachers! General-interest manuscripts, commentaries, and column submissions may be submitted at any time. Read the call for papers and access submission guidelines at *https://goo.gl/l6bNbz*.

April 15—Proposals for **sessions at the 2018 NSTA Atlanta National Conference on Science Education** are due now. The national conference will be held March 15–18, 2018. For more information on submitting a session proposal, visit *https://goo.gl/eTVbJK*.

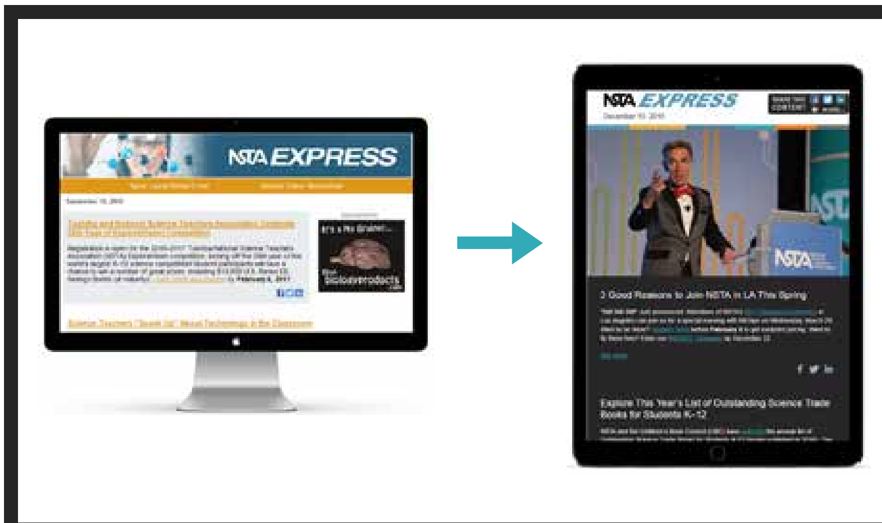
May 1—Submit your manuscript today to help ***S&C*** explore how educators are **"Using the 5E in Alignment With the *Next Generation Science Standards*"** in its December issue. Manuscripts of general interest may be submitted at any time. Read the call for papers at *https://goo.gl/UXBmlh*.

May 1—Submit your best **modeling methods** to show cause and effect, address misconceptions, and more in a manuscript to ***Science Scope*** today for consideration for the December issue. General-interest manuscripts, commentaries, and column submissions may be submitted at any time. Read the call for papers and access submission guidelines at *https://goo.gl/l6bNbz*.

May 12—Register today for the **Sixth Annual STEM Forum & Expo**, hosted by NSTA, to be held July 12–14 at the Gaylord Palms Resort & Convention Center in Kissimmee, Florida. The forum will feature strands targeting early childhood and lower-elementary educators; upper-elementary, middle level, and high school educators; and administrators. The event will also feature a strand devoted to exploring successful partnerships among community, business/industry, and education members that enhanced STEM education for preK–16 learners. Earlybird registration for NSTA members costs just $180. For more information or to register, go to *https://goo.gl/dTLN6j*.

June 1—Share how you are **"Meeting the Needs of *All* Students With Physical Disabilities"** with your fellow elementary educators by submitting a manuscript today for the January 2018 issue of ***S&C***. General-interest manuscripts may be submitted at any time. Read the call for papers at *https://goo.gl/UXBmlh*.

June 1—Good **assessment strategies** are essential to effective instruction. ***Science Scope***'s January 2018 issue will feature educators' best assessment strategies—if you submit a manuscript today! General-interest manuscripts, commentaries, and column submissions may be submitted at any time. Read the call for papers and access submission guidelines at *https://goo.gl/l6bNbz*. ●



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Researchers Find Clues for Cancer Treatment

Finding a way to reduce—or even prevent—the spread of tumors has long been a goal of cancer researchers. Scientists at the Wellcome Trust Sanger Institute in the United Kingdom have identified 23 genes that affect a tumor's ability to metastasize, including 19 genes that had not been shown to influence metastasis before.

Using mice genetically engineered to not carry specific genes, the study screened 810 genes to locate ones that play a role in the metastasis of skin cancer to the lungs, whether by increasing or decreasing it. They found that mice without the sphingosine-1-phosphate transporter spinster homologue 2 (Spns2) gene had up to 75% fewer cancer metastases.

In an article in the January 12 issue of *Nature,* the researchers suggest that deleting Spns2 could increase a patient's percentage of effector T cells and natural killer cells. This discovery could lead to new immunotherapy treatments.

Read the article preview online at *http://goo.gl/6VQYQe.* ●