

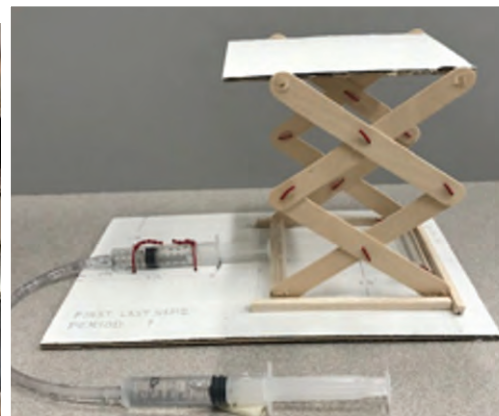
Retired? Become a sub

I am grateful to Don Rea for his February 2023 letter (PHYSICS TODAY, page 11), which describes the American Association for the Advancement of Science's STEM Volunteer Program. That said, he gives no actual data to support his argument that "a consortium of STEM societies is the best approach for implementing a program in support of K-12 STEM education." The clearest indication of success that he provides is anecdotal: an email from a teacher to a volunteer in which she thanked him, said it was an "absolute pleasure" to work with him, and expressed that she would encourage more schools to use the program.

I have found a way to support STEM (science, technology, engineering, and mathematics) education that is quite simple and does not require the consortium that Rea describes.¹ As a retired physics professor, I have become a substitute teacher in a local high school district, in a city where 80% of the population is Hispanic or Latino, according to the US Census Bureau.²

To become a substitute in my district, I had to provide my university transcripts, pass a background check, and get tested for tuberculosis. I also had to take online courses that covered topics such as sexual harassment and accident protocols.

For retirees, substitute teaching is an ideal setup. In my district, vacancies are listed on a website that includes the duration of the assignment. Some are as



IN A PRE-ENGINEERING CLASS for which the author was the substitute teacher, a student uses a drill (left) to create the holes for bearings in a hydraulic scissor jack (right). The students used the jack to lift a cup of liquid without any spilling out.

short as an hour-long class, while the longest time I spent covering an individual teacher's classes was four consecutive days (which was a bit rough for a retiree, since it required me to wake up each day at 6:00am). I take an assignment only on a day I want to work. Sometimes I'll just work two or three classes in an afternoon. On average I work three to five times per month when I'm not traveling or doing experiments.

The website for the district names the teacher, lists the teacher's primary subject area (for example, math, pre-engineering, or construction technology), and provides the teacher's email address so the sub can ask questions.

I cannot say that substitute teaching is the "best approach" for supporting STEM education, but I can say that every class has been a fulfilling experience for me, and several students have provided feedback expressing how I have helped them in some way. I've heard from some that I'm "the best substitute they ever had." I've received thank-you letters from others, with one saying, "Listening to you talk about the

cool things you were able to accomplish, where you taught, and where you got your degrees made me super hopeful and want to study physics further. It was like a spark ignited when you talked." Now and then I've even heard feedback along the lines of "I wish you were my regular teacher."

As soon as I accept a job, ordinarily I contact the teacher I'll be filling in for and ask the topic to be covered on that day. That allows me to plan accordingly. For example, in a pre-engineering class, I brought a few small acoustics demonstrations. For one math class, I was told the topic would be graphing equations, so I brought a laboratory notebook that had an average of at least one graph per page and passed it around. One student was really enthusiastic and asked me several questions about the content of my lab book, which also included schematic circuit drawings, photos, and sketches of apparatuses. Not all students will be so eager, but if you inspire even one student per class or one per day, you're still making a difference.

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Ellipse, College Park, MD 20740-3842. Please include your name, work affiliation, mailing address, email address, and daytime phone number on your letter and attachments. You can also contact us online at <https://contact.physicstoday.org>. We reserve the right to edit submissions.

No matter where you retire, you will find a school district that needs substitute teachers for STEM classes. If you were a physicist for 40 years, you'll find that you have plenty of material to inject into almost any class. No larger organization is required!

Reference

1. S. L. Garrett, *Acoustics Today*, Fall 2023, p. 69.
2. US Census Bureau, "QuickFacts: Salinas city, California," <https://www.census.gov/quickfacts/fact/table/salinascitycalifornia>.

Steven L. Garrett
(sxg185@psu.edu)
Salinas, California

CO₂ pipelines: A way forward?

David Kramer's piece "Capture alone isn't sufficient to bottle up carbon dioxide" (*PHYSICS TODAY*, July 2023, page 22) focuses on the need in the US to create a massive CO₂ sequestration capacity, which is indeed in need of attention. But the story was deficient in one respect and inaccurate in another.

In Oklahoma, induced earthquakes over the past decade have mainly been attributed to wastewater disposal—in particular, high injection rates—but some have been associated with hydraulic fracturing, or "fracking."^{1,2} Those relationships suggest that high-rate injection of supercritical CO₂ into deep saline aquifers may lead to seismicity. Indeed, the Intergovernmental Panel on Climate Change foresaw that possibility in 2005.³ Because the physical properties of supercritical CO₂ differ from those of wastewater, it's uncertain whether they will have identical seismogenic effects. But there is a need for regulations, guided by independent research, that ensure that CO₂ sequestration is performed in a manner that does not lead to earthquakes.

Carbon dioxide is heavier than air, and therefore its airborne dispersion characteristics are altogether different from those of natural gas, and CO₂ presents an increased danger to both land-based and aquatic life. Indeed, contrary to Kramer's assertion that no one was injured in the 2020 CO₂ pipeline rupture near Sartartia, Mississippi, the event

led to the hospitalization of at least 45 people in addition to the evacuation of over 200.⁴

Given that risk, the environmental hazards, and the potential for violating the rights of Indigenous communities, CO₂ pipelines have unsurprisingly been met with public opposition. The carbon capture and sequestration community should respond by building trust with the public—starting with repurposing existing natural gas pipelines to transport CO₂—and by strictly adhering to environmental protection regulations, treaties with Indigenous communities, and existing legal requirements. Rules and regulations must be changed to ensure that the characteristics of CO₂ are fully accounted for, both in its transportation and in its sequestration, and not to accelerate the laying of new pipelines.

References

1. M. Weingarten et al., *Science* **348**, 1336 (2015).
2. R. J. Skoumal et al., *J. Geophys. Res. Solid Earth* **123**, 10918 (2018).
3. Intergovernmental Panel on Climate

Change, *Carbon Dioxide Capture and Storage*, B. Mertz et al., eds., Cambridge U. Press (2005), p. 249.

4. J. Simon, "The U.S. is expanding CO₂ pipelines. One poisoned town wants you to know its story," NPR, 21 May 2023, updated 25 September 2023.

Stephen Schiff
(schiff@mailaps.org)
Aldie, Virginia

A fulfilling career

I admired how the obituary of Benjamin Breneman Snavelly (*PHYSICS TODAY*, October 2023, page 69) shines a light not just on his research accomplishments but also on his life of service in the private and public sectors. I did not know Snavelly, but I am grateful for how my life has been touched by many scientists like him. The authors' remembrance shows how a career in physics offers us—beyond moments of breathtaking joy in a new discovery—a path toward sustained happiness while we help those around us live enriched and fulfilling lives as we engage in our



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