STEM Substitute Teaching: Making a Contribution After Retirement?

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After retiring from my academic position at The Pennsylvania State University, University Park, I returned to California to resume my life on the Monterey Peninsula. I was surprised by how much I liked Salinas, my neighbors, the bilingual culture, and the excellent fresh food that comes with having the most expensive agricultural land/acre in the United States and a very large fraction of the population with roots in Mexico. As a retiree, I wanted to contribute to this community but knew that with a half-century of academic experience, there must be a better use of my experience than collecting trash along the highway.

Like almost every town in the United States, Salinas had a shortage of STEM (Science, Technology, Engineering, and Math) teachers in their public schools. I thought my most valuable form of "community service" might be as a substitute teacher when the regular teacher was absent. After two years of working as a substitute in the Salinas Union High School District, I am still pleasantly surprised by how much I enjoy every assignment I accept. The purpose of this "Sound Perspectives" essay is to tell other retired (or soon to be retired) *Acoustics Today* readers about some of my experiences in the hope that others might give this option a try.

Before relating a few personal anecdotes, the first thing worthy of mention is that substitute teaching is a perfect "job" for a retiree; you only take the assignments you want, when you want, for as long as you want, and you also get paid for your service. In my district, substitute teacher vacancies are "advertised" on a website that tells the name of the teacher you will be replacing, their "specialty area" (e.g., math, science, physics, astronomy, English, history, construction technology, special education), the teacher's email address, and how long you will be needed. My shortest assignment was just two classes on one afternoon and my longest was four consecutive full days (which was too long because I needed to wake up at 6:00 a.m. to be ready for class at 8:00 a.m.); I really only have sufficient stamina for a rare three-consecutive-day assignment.

Although the "job requirements" (beyond the degree and teaching experience) vary among different school districts, the qualification process was rather easy and not particularly burdensome. I needed to get fingerprinted (for a background check) and get tested for tuberculosis. I had to take six online courses that ranged from 10 minutes to 1 half-hour each, then pass an online test after watching each presentation. As you might suspect, those courses covered sexual harassment, suicide prevention, "trafficking" (i.e., the exploitation of poor or immigrant students for illicit purposes), reporting suspected child abuse, coronavirus, and accident protocols (e.g., blood, urine, or vomit in the classroom). The test questions mostly just required a commonsense choice among a multiple-choice list of responses. After that, it's just you and the substitute vacancy website.

Finally, being a substitute is not like being a real classroom teacher. You don't make lesson plans, grade papers, or serve on committees. As far as I can tell, the only official duty required of a substitute is to take the roll at the start of each class. Because you know the regular teacher's email address, you can communicate in advance and discover the topic for each class you'll be covering.

As an example, I signed up for a math class and the teacher said that day's topic was graphing. With that advanced notice, I decided to bring one of my laboratory notebooks to class because it contained at least one graph per page on average. I made some comments about the history of graphing (i.e., the genius of Rène Descartes), which is a fairly new concept in human history, the importance of graphical data representation, and the role of least-squares fitting of a function (usually linear). Then I passed my notebook around the class while they were working at their desks on that day's in-class exercise. A few students looked

https://doi.org/10.1121/AT.2023.19.3.69

through more than just one or two pages, but one student, an agricultural mechanics major, spent at least 10 minutes asking me about the graphs as well as the schematic diagrams of op-amp signal-conditioning circuits, apparatus sketches, and transducer calibrations.

Another example is an earth science course that I was told would be covering volcanos. With that advance knowledge, I got a copy of Tom Gabrielson's brilliant animations of the infrasonic pressure wave that was detected on barometers and traveled around the globe five times after the eruption of Krakatoa in 1883 (Gabrielson, 2010). That animation and the idea that a sound wave could travel around the Earth five times is something those students would probably never have seen or thought about if a member of the Acoustical Society of America (ASA) wasn't their substitute that day.

In the United States, Black History Month is celebrated in February. One class that month had a "Black Minds Matter" assignment. The students had to identify a black scientist or inventor to study. James West came to the rescue that day! He's both a scientist and an inventor (Bush, 2007), and I got to talk to them about the electret condenser microphone and my visit to Bell Labs to see Jim. Every student knows what a microphone is, but none know how it works. Again, something to motivate students that they would likely not have occurred had an ASA member not been in their high-school classroom.

Does this matter? I've not attempted a scientific randomized study, but I know that students in every one of those classes appreciated the enthusiasm I had for each of those topics and they learned a little extra about something that wasn't in their textbooks.

Possibly the most rewarding part of this experience is summarized in the words of the great contemporary stand-up philosopher, Allan Stewart Kronigsberg (also known as the as the American comedian, actor, and Oscar-winning filmmaker, Woody Allen): "80% of success in life is just showing up." One day, an assignment appeared on the substitute vacancy website for a teacher whose specialization was listed as "pre-engineering." Having placed experiments on navy ships and submarines, had an experiment go into low-Earth orbit on the Space Shuttle *Discovery*, put a fission-heated thermoacoustic engine in the core of a nuclear reactor, and built

Figure 1. *Two students in a pre-engineering class during their aerospace engineering unit with their exploded rocket (**left**) that was destroyed by the launcher (**right**). That launcher was powered by 60 psig (500 kPa) of air pressure to accelerate the rocket. The blue handle on the launcher actuates a quick-release valve.*

two thermoacoustically cooled ice cream sale cabinets for Ben & Jerry's with my research group, I figured I was a good enough engineer to take that assignment, at least by high-school standards.

It turned out that the teacher's pre-engineering classes had students fabricate and test devices that introduced them to various engineering fields. For aeronautical engineering, they built paper rocket ships, sized to fit around a 1.5-inch PVC pipe. (The room must have had at least 40 pieces of pipe for them to wind their construction paper into tubes of the correct diameter and several hot glue guns.) The rockets were launched with 60 psig (500 kPa) of air pressure. **Figure 1**, *left*, shows two students and the rocket that exploded, which was their failed first attempt. Some of those rockets actually flew more than 100 m. It made for a very exciting morning, whether those rockets glided gracefully through the air, almost out of sight, or exploded on the launcher (**Figure 1**, *right*).

In another pre-engineering class for the hydraulic engineering module, the students were constructing the hydraulically actuated scissors jack (**Figure 2**, *top*). You know the students are enthusiastic about learning in those hands-on classes because they start working on their projects *before* the bell rings to announce the start of class. In that classroom/lab, they have access two drill presses and two band saws plus a nice variety of hand tools, soldering irons, and measuring instruments (**Figure 2**, *bottom*).

I really had to marvel at the cleverness of those projects. They were challenging at the appropriate level but also inexpensive enough so that 80 students could build them every semester. I also was pleased to see that the enrollment was about equally split between those students who were in a "vocational education" curriculum and those who were planning to attend college.

What I didn't know was that the pre-engineering teacher also taught two classes of Construction Technology (i.e., woodshop) after lunch. I also did not know that any high-school woodshop would be as well-equipped as what I found (**Figure 3**). (None of the other four high schools in the district have anything comparable.) I have so much fun helping those students with their projects that I needed to set the alarm on my cellphone so I don't forget to call "clean-up" 10 minutes before the end of class period.

Figure 2. ***Top:*** *hydraulically actuated scissor jack that uses two 10-ml syringes to raise and lower the jack.* ***Bottom:*** *a student is drilling the holes used as bearings (with copper wire) in all eight tongue depressors at once.*

A further step was required before I was able to supervise students using power tools, but it was well worth the day of on-site "training." Because I'm now one of only a few substitutes in the district who holds that qualification, all engineering and shop assignments are now offered

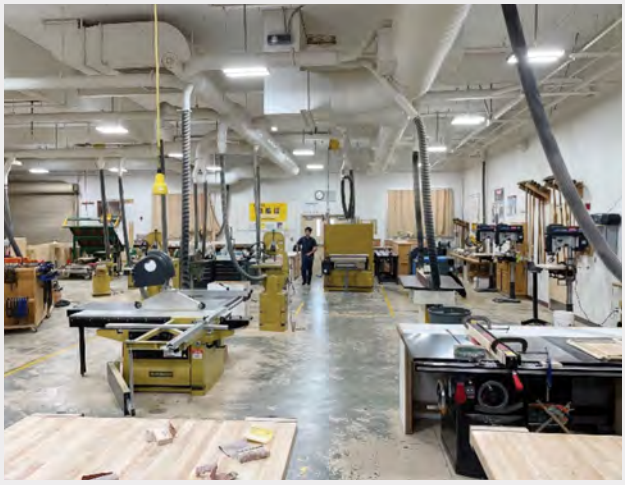

Figure 3. *I was amazed by the woodworking machinery (with active sawdust capture hoses) that was available in this high school. In the foreground are two of three table saws. Behind the right one is a 6-foot-long 6-inch-wide belt sander and behind the sliding table saw are two band saws. Against the right wall are three drill presses and a couple of chop saws, then to the left are six router tables and a surface sander.*

directly to me before they would be posted on the substitute website.

I cannot say that substitute teaching is the best or only approach to giving K-12 students exposure to practicing scientists and engineers. I also cannot claim that anything I've done has helped any student. That would take a long-term controlled study of a randomized group of students to see if they seek further STEM education after leaving high school and what they chose as their careers. I can say that I always find each assignment to be personally rewarding in some way, and I have plenty of anecdotal evidence that the students *feel* that they receive some immediate added benefit from my interventions. Several have told me I'm "the best substitute they ever had"; some have written letters to thank me. One such letter said, "Listening to you talk about the cool things you were able to accomplish, where you taught, and where you got your degrees made me superhopeful and want to study physics further. It was like a spark ignited when you talked." Occasionally, a student will tell me that (s)he wishes I were their regular teacher. All that definitely makes me feel good but that doesn't prove that there was any long-term benefit to any student.

There are organized programs that bring retired scientists and engineers into the classroom. The American Association for the Advancement of Science (AAAS) has a "STEM Volunteer Program" that began in 2004 (see aaas.org/programs/STEM-volunteers). It currently has 110 retired volunteers in 4 school districts in the Washington, DC, metropolitan area (Rea, 2023). Each volunteer commits to a few hours once each week throughout the school year. In early September, the list of new volunteers is sent to the science supervisor. (S)He makes assignments to teachers, and a training session is held in late September or early October. The teachers attend a lunch to enable them to chat with their new volunteers and explore joint activities. This requires coordination with the teacher to arrange the times and attempts to integrate the "special topics" with curricular goals. There is substantial administrative overhead!

A similar program is run by the Santa Fe Alliance for Science, New Mexico (see sfafs.org). Again, like the DC program, it relies on the large local engineering and scientific population created by the Los Alamos National Laboratory. These two examples exist in areas with a large existing indigenous concentration of STEM professionals. Anyone, anywhere, can do what I do on an individual basis. Integrating into an ordinary classroom environment is a much stealthier way to influence potential STEM students by "swimming under the sonar."

I suspect becoming a STEM substitute may not be a good option for some retirees, but the administrative overhead (e.g., fingerprinting) is not extensive and the opportunities are flexible, so you can try it out. See if you feel the same way as I do when I walk home after a day teaching high school?

References

Bush, George W. (2007). *Presentation of the 2005 National Medal of Technology to James E. West*. White House Press Release, Office of the Press Secretary. Available at https://bit.ly/43QaVQP.

Gabrielson, T. B. (2010). Krakatoa and the Royal Society: The Krakatoa explosion of 1883. *Acoustics Today* 6(2), 14-19.

Rea, D. (2023). STEM volunteers. *Physics Today* 76(2), 11.

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