

RESEARCH

On the Shortage of Scientists And Engineers

BY GERALD W. BRACEY

ABOUT the same time people decided the schools weren't working (circa 1949), they also decided that we had too few mathematicians, scientists, and engineers. Sputnik confirmed their fears — although both the shortage and Russia's putative superior technology turned out to be illusory. Before Sputnik, the most common association with the word "scientist" was "odd," but afterward science became an umbrella term for fields where exciting things happened. This produced the "Sputnik Spike," followed by a sharp decline in interest in science, followed by a gradual increase that began in the 1970s and continues today.

More recently, John Glenn's commission published the near-hysterical *Before It's Too Late*, and the National Academies came out with the pretentiously titled *Rising Above the Gathering Storm* (the title alludes to Winston Churchill's *Gathering Storm*, which describes the events leading up to World War II). The Business Roundtable chimed in with *Tapping America's Potential*, signed by 14 other business organizations.

In November 2007, a number of people testified before the House Subcommittee on Technology and Innovation that the conventional wisdom is wrong. Michael Teitelbaum, vice president of the Alfred P. Sloan Foundation, outlined the litany of the conventional complaints, which I've summarized below:

1. The U.S. suffers serious shortfalls or shortages of scientists and engineers, and this bodes ill for both creativity and international competitiveness.
2. The number of newly educated scientists and engineers is insufficient to fulfill employer needs. Thus the need to hire from overseas.

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3. The insufficient quantities are due to weaknesses — or even failure — of K-12 education.
4. U.S. students' interest in science and engineering is declining.
5. Post-doc jobs, increasingly common, offer excellent opportunities leading to later research opportunities.
6. Congress should provide more money to increase the number of science and engineering (S & E) graduates. *Tapping America's Potential* called for spending to "double the number of science, technology, engineering, and mathematics graduates by 2015."

Teitelbaum then countered each item on the list by presenting the facts. I offer them here as a dispersed list, with some supporting evidence for each counterclaim.

There are more scientists and engineers graduating from U.S. universities than can find attractive career openings.

1. *There is no shortage.* Several RAND Corporation studies found surpluses. There might be shortages in some new fields or fields growing explosively, but not overall.

2. *There are substantially more scientists and engineers graduating from U.S. universities than can find attractive career openings in S & E fields.* Indeed, the S & E opportunities seem unattractive to many holders of S & E degrees. "Into the Eye of the Storm" (no doubt a pot shot at the National Academies), a paper by Lindsay Lowell of Georgetown University and Harold Salzman of the Urban Institute, found roughly three S & E graduates for every new S & E job (not counting openings created by retirements). They also found that two years after graduation from S & E programs, 20% of the grads with bachelor's degrees were in school but not in S & E programs and 45% were in the work force but not in S & E jobs. The attrition rate for that time period for those with master's degrees was about 38%. One can only imagine how critics would howl if education lost 65% of its work force in just two years!

Nor are fewer students following S & E paths in universities. From 1977 to 2002, the number of citizens and permanent residents earning bachelor's degrees in S & E grew from about 300,000 to about 400,000, those earning master's degrees increased from about 60,000 to about 70,000, and those earning doctorates held steady at about 20,000.

Other studies have concluded that the decline in the pool of citizens and permanent residents with S & E credentials may reflect a weakening demand, a comparative decline in S & E wages, and market signals to stu-

dents about low relative wages in S & E. I'm not sure exactly what the "market signals" are, but real wages for S & E workers have declined over a 20-year period. And students can see older scientists spending more time writing grant applications, getting fewer of them funded, and having a tougher time getting tenure. They can see the post-doc headed for what science writer Dan Greenberg calls the newest title: post-doc emeritus. And students, not surprisingly, head to greener fields.

Finally, there is some evidence that the nature of the engineering profession has become less appealing. Lowell and Salzman observe that projects today are often larger team efforts that require more coordination and management. In their interviews, engineers often commented that the field was not as challenging as it once was because it contains less "real" engineering.

3. *Students emerging from K-12 have studied more science and mathematics than in the past, and their performance has been improving.* In 1982, high school graduates earned 2.6 math credits and 2.2 science credits. In 1998, the numbers had increased to 3.5 and 3.2, respectively. A larger proportion of students now takes precalculus, calculus, physics, and chemistry. In this regard, Lowell and Salzman found that students who abandoned S & E programs did so not because their K-12 experiences had left them unable to cope with the material, but because they disliked some programmatic aspect, usually the quality of instruction.

While the U.S. is middling in *ranks* in math and science assessments, the differences among countries in terms of *scores* are often quite small. The most extreme occurrence of this phenomenon was in the eighth-grade science assessment for the 1995 TIMSS (Third International Mathematics and Science Study). American students got 58% of the items correct, compared to 56% for the international average. This ranked them 19th among the 49 participating nations. Middling performance, no? Had they gotten a mere 5% more correct answers, they would have ranked fifth, and had they gotten 5% fewer correct, they'd have slumped to 30th.

Lowell and Salzman also point out that discussions of who's first among nations almost always take place in terms of average scores. But given the variability of scores around the average, and given the demand-side weakness, there are plenty of people competent enough to fill S & E positions. If average scores mattered, no one would be paying any attention to India, which has a 39% illiteracy rate and a secondary school enrollment rate of less than 50%. But in a nation of one billion people, there are sufficient numbers of high perform-

ers to make the country a technical force. Ditto China, with a much higher literacy rate, but only 40% of students enrolled beyond ninth grade.

Lowell and Salzman also observe:

Although science and math are the primary focus of policy discussion, in other areas such as literacy, U.S. scores are consistently above international averages. By excluding those tests from international comparisons, it is implied that literacy does not hold the same importance as science and math, usually by reference to science and math as drivers of innovation and economic growth. However, there is no substantial evidence to support the assertion that a nation's average levels of math and science mastery lead to a disproportionate share of innovation or economic growth.

The authors further point out that PISA (Programme for International Student Assessment) is not an apples-to-apples comparison. It tests 10th-graders. Or does it? All of Japan's sample was in 10th grade, while in Norway and Korea, 98% of those tested were. Only 61% of the American sample was in 10th grade, with most of the rest being in ninth grade or lower. According to the Organisation for Economic Co-operation and Development (OECD), which sponsors PISA, one year corresponds to about 41 points. So how does one compare the average scores of Japan (534), Korea (542), and Norway (495), where nearly all students were in the 10th grade, with the average score of the U.S. (483), where over one-third of the tested kids were below 10th grade by at least a year?

Then there is the matter of exclusions that differ across nations. Germany excluded special-needs students, and that was estimated to have affected its score by eight points.

Finally, Lowell and Salzman observe that PISA cannot be used to make inferences about school quality because it reflects the influences of school, home, and community and does not attempt to separate those influences.

4. *The proportion of freshmen entering college who say they will major in science or engineering has been stable over a long period.* About half of those who say they intend to study in a S & E field actually do.

5. *The post-doc population, which has grown very rapidly in U.S. universities and is recruited increasingly from abroad, looks more like a pool of low-cost research lab workers with limited career prospects than like a select group enrolled in a high-quality training program for soon-to-be academic researchers.* The British science journal *Nature* called the condition of newly graduated scientists "indentured servitude." In his blog for the *Chronicle of Higher Education*, long-time science writer Dan Green-

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berg asked why so many science jobs are filled with foreigners. His answer: “It’s the same reason that our lettuce field and apple orchard jobs are — long hours, low wages, and miserable working conditions that only foreigners could see as a step up.”

The calls for ever more scientists and engineers are led by employers and their industry associations that want a bigger pool so they needn’t raise wages, by some universities that want more graduate students to conduct funded research, by some funding agencies that want an argument for increased funding, and by some immigration lawyers and their associations that receive fees from employers for obtaining visas.

In his testimony to the same panel to which Teitelbaum testified, Salzman said that, when his team interviewed employers of S & E grads, they “rarely if ever noted a lack of technical skills” among their STEM (Science, Technology, Engineering and Mathematics) workers. He continued:

The skills STEM job applicants and workers lack are com-

munication skills that enable employees to work across boundaries, coordinate and integrate technical activities, and navigate the multidisciplinary nature of today’s work. . . . A broad education that incorporates a range of technical and social science and humanities knowledge is important for developing a globally competitive workforce. In this, the United States currently has an advantage over the emerging economies.

As for the U.S. compulsion to be first in the world in terms of math and science test scores, Lowell and Salzman quote a *Kappan* article by Erling Boe and Sujie Shinn from 2005: “The U.S. is not ‘first in the industrialized world’ in minimizing the percentage of its population living in poverty. . . . So why should anyone expect the U.S. to be first in the world in educational achievement?”

The Congressional testimony of Teitelbaum and Salzman can be accessed at http://science.house.gov/publications/hearings_markup_details.aspx?NewsID=2032. Lowell and Salzman’s paper is at www.urban.org/haroldsalzman. Dan Greenberg’s piece is at <http://chronicle.com/review/brainstorm/Greenberg/non-mystery-of-why-americans-shun-science-careers>. **K**

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