Scientist and engineer shortage: myth or reality?

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Framework of this article

With clockwork regularity, the real or perceived shortage of scientists and engineers in the US pops up as a topic of debate in academic and industry circles. Discussions of an imminent shortage have deep impact for education, career prospects, immigration, and "The American Dream." The purpose of this article is twofold. First, it will pose a somewhat alternative view of the current job market for scientists and engineers. Second, the article will explore how this issue affects our students at NCSSSMST schools: gifted and talented high school students with an interest in math and science. Post-graduate data suggest that our students do well in their chosen careers in science or science related areas, and accumulating evidence, summarized in this article, shows that there is no current shortage of scientists or engineers. The argument will be made that it is more important that our nation's most capable students meet the demand for important math and science jobs than to create a large pool of college graduates with math and science degrees. In a nutshell: quality is more important than quantity.

The Current Job Market for Engineers

1992 Nobel laureate in economics Professor Gary S. Becker (2005) wrote in the Wall Street Journal that "America needs millions more engineers and IT workers." He proposed that "H1-B visas be folded into a much larger, employment-based green card program with the emphasis on skilled workers. The annual quota should be multiplied many times beyond present limits, and there should be no upper bound on the numbers from any single country." Becker argued that the science and engineering fields are not attracting sufficient Americans and that changing immigration policy would benefit American society by attracting foreign-born scientists. Restricting the numbers of scientists and engineers coming to the US will lead, according to Becker, to research and development work being outsourced to countries like India and China. A fundamental question in such arguments that is never raised is: how many scientists and engineers do the US, or any country for that matter, actually need to ensure economic progress?

An official with the American Chemical Society recently wrote an opinion piece with the title "America's Gathering Storm" (Grob Schmidt, 2005). The article makes a plea for increasing math and science education in the US, noting that China graduated 600,000 engineers last year and India 350,000, while the US figure was 70,000. This comparison is not valid for two reasons. First of all, the population of these countries is four to five times as large as the US population and their economies are in the early stages of development, thus creating a large need for technical workers.

Furthermore it is doubtful that all these graduates find employment at the level US engineers expect. When Indian college graduates are happy with jobs in call centers, answering queries from unhappy customers in America and Europe, one may question the value of those college degrees. Do we want to train US college graduates for jobs that any reasonably intelligent high school graduate can handle?

Very recently, a Duke University study showed that the numbers quoted above were indeed based on a flawed comparison between the US, India, and China. When only B.Sc. degrees are counted, the US graduates 289.3 engineers annually per million citizens, India 103.7, and China 271.1 (News item in Science, Jan.6, 2006; www.memp.pratt.duke.edu/outsourcing). The numbers of 350,000 for India and 600,000 for China quoted above included sub-baccalaureate degrees like two- and three-year certificates. These lower degrees were not included in the US number of 70,000. When bachelors and sub-baccalaureate degrees are lumped together, the US graduates 757.6 engineers annually per million citizens, India 199.1, and China 496.8. Therefore, on a per capita basis the US still has an advantage and the situation is not nearly as dire as some would have us believe.

Ever since the author of this article arrived in 1981 from The Netherlands on an H-1 visa with a Ph.D. in physical chemistry, he has been puzzled by the regularly recurring outcry from academia and industry that the US is facing a huge shortfall in scientists and engineers. I believe the opposite to be true: there is a numeric surplus, except perhaps in a few niche areas. Statistical as well as ample anecdotal evidence indicates that there is indeed an oversupply of engineers (Begley, 2005). According to data from the American Society for Engineering Education, the number of bachelor degrees in engineering has increased from 61,553 in 1999 to 72,893 in 2004, an 18 % increase in 5 years. Based on these numbers and a career of 30 years for the average engineer, one can conservatively estimate that there must be between 1.0 and 1.5 million working engineers in the US at present. The increase in bachelor degrees awarded in computer science was even more significant: 85% from 1998 to 2004. However, total engineering employment fell 8.7% from 2000 to 2003, according to an analysis by the Center for Labor Market Studies at North-Eastern University in Boston of Bureau of Labor Statistics data (Begley, 2005). Thus, the statistics show increasing numbers of engineering graduates on the one hand and a shrinking labor market on the other. This situation is of course great for employers, but for many job seekers it is extremely frustrating. Companies are less and less willing to train otherwise excellent candidates and can pick and choose from hundreds of job applicants. “Bill Gates would never hire himself” is the saying one sometimes hears to describe the current rigidity of companies when it comes to hiring people. If you would have millions of engineers entering the US supplementing the ones already here, as Becker proposes, a few thousand may rise to the top and become successful innovators and entrepreneurs by way of a Darwinian slug fest. The rest may be doomed to under- or unemployment, as dictated by the law of supply and demand. This would certainly not be a scenario to attract young talented American students to the engineering profession.

The Situation In The Basic Sciences: Not Much Better

In the basic sciences, the same rule applies: oversupply equals under-demand (Weaver, 2005; Butler, 2005). To illustrate: the number of interviews for research chemists and chemical engineers at the annual meetings of the American Chemical Society has plummeted from 6,846 in 2000 to 2,976 in 2005, a drop of more than 56% in five years (Mehta, 2005). Total chemical industry employment has dropped from 991,700 to 879,900 during the period 1995-2005 (Heylin, 2005). Excluding pharmaceuticals makes the numbers even more ominous: a drop from 763,400 to 587,200. We don’t have data on the job market for physicists and biologists, but anecdotal evidence from fellow scientists points in the same direction: it’s tough going for young scientists just starting their careers. After obtaining a Ph.D., young scientists opting for an academic career spend a number of years in temporary low-paid post-doctoral positions, while hoping for a faculty position. Periods approaching ten years in this academic waiting room are not unheard of. Academic research is becoming more and more dependent on these post-doctoral scientists. In biomedicine the ratio of post-docs over principal investigators has doubled from 1:1 to 2:1 over the last two decades (Brumfiel, 2005). More than half of these post-docs have been recruited from abroad. A quote from this article reads: “The principal investigators need to change their ways. To create a more stable workforce and encourage home-grown researchers, postdoctoral positions should focus on education, and research labs should employ a higher proportion of permanent staff scientists”. Also, companies are now introducing post-doctoral programs as an extra selection process before hiring scientists in permanent positions. Many post-docs in academia ultimately get discouraged and leave a once-promising career choice. Less than one third of post-docs will end up in an academic, tenure-track research position. This lucky one third faces another uphill struggle, the struggle for research funding. The unwritten rule in academia is: no funding, no tenure. Most of the federal funding goes to established senior investigators, which leaves the crumbs falling off the table for the junior investigators to fight over. By necessity, junior investigators spend more energy on obtaining scarce research funds than on doing creative work.

The pressure on all scientists to publish first and obtain funding has led to some notorious cases of scientific fraud. The most recent case concerns a Korean scientist who fabricated data on 9 human stem cell lines. Some senior investigators in medicine are "too busy" (presumably with fund raising, visiting conferences, or commercializing their research) to write their own papers and use ghostwriters who are often paid by companies plugging their products (Mathews, 2005). We all know that science makes great contributions to human progress, or we wouldn't be doing the work that we do at NCSSSMST schools. What is generally less well known is that the pressure in academia to publish leads to vast amounts of research that has little or no value.

According to statistics from ISI (Institute for Scientific Information) 50% of all peer reviewed scientific publications are never cited by other scientists and only 5% have lasting value in that they are still being cited 5 years after publication.

For many college professors, research comes first and teaching is an afterthought. As a result, students interested and gifted in science are turned off by uninspired teaching and indifferent professors (Cech & Kennedy, 2005). Losing promising students this way is a sad and unnecessary loss. The predominating mindset of today's college professors was recently addressed in a discussion in *Physics Today*. The article dealt with the question: why don't we see any new Einsteins? One of the respondents wrote: "Today's scientists are jet-setting, grant swinging, favor-trading hustlers looking for civil servants who will provide them with a pipeline into the US Treasury". Another memorable quote from the same respondent: "You can't be a used-car salesman and have deep thoughts about the structure of the universe at the same time". These quotes contain some hyperbole of course, but they certainly get the point across. All in all, academia does not always offer an inspiring picture to our talented youngsters. Consequently, academic careers have lost much of their appeal over the last two or three decades. Nobody should be surprised that a large proportion of the brightest American students opt for professions like medicine, law, or finance over a career in science or engineering. The professional schools tightly regulate the labor markets in these fields, ensuring that their graduates enjoy good job prospects and financial rewards.

The Role Of NCSSSMST: How Can We Help Our Students?

With all the negative factors affecting the job market for scientists and engineers, should we still encourage our students at NCSSSMST schools to choose science and engineering careers? The answer should be a qualified yes. We should encourage them but at the same time we should inform our students of economic trends in science and engineering, so that they will learn to think about career issues. We should also make our students aware that there is a whole range of careers besides being a scientist for which a solid grounding in science is essential. Examples that come to mind are science writer, patent attorney, science educator, and many other careers that value both talent and scientific training and habits of mind.

There is evidence from post graduate research conducted among Consortium schools that Consortium school graduates are earning undergraduate degrees in mathematics and science at a significantly higher percentage than non-Consortium graduates (Thomas and Love, 2002). This finding has been consistent among schools and across time, and, since many of our students self-select into our programs and schools by virtue of interest and ability, such a finding should be affirming but not surprising. Deeper analysis of longitudinal data indicates that, while many of our graduates are pursuing degrees in more traditional math and science fields such as medicine, engineering, or math-science education, a significant number are pursuing careers and applying skills in divergent ways. Approximately 25 percent of Consortium school graduates earn double majors which combine disciplinary study in interesting ways, such as mathematics/Slavic studies, music/computer science, classic literature/biology, and political economy/computer science. One graduate commented, "I chose my double major because it allowed me to combine art and technology."

It is also important to note, however, that enrollment in a Consortium school can have an effect on choice of college major among groups that are typically underrepresented in science and technology. According to Blaisdell and Tichenor (2002) minority graduates of NCSSSMST schools, "look remarkably like their non-minority counterparts, which is exceptionally different from the college population" (p. 16).

Conclusion

Ultimately, the markets themselves should determine the number of graduates from engineering and graduate schools. To look outside the US for candidates for math, science, and technology expertise is to overlook a capable and well-trained body of scientists. To ensure that the US stays at the forefront of scientific and engineering innovation will demand a shift in emphasis from quantity to quality. To meet a need for scientists requires a shift in perspective and practice. When students graduate from a Consortium school, we hope that they see science and technology broadly: integrated and with other disciplines, rich with possibility, and not bound by traditional role stereotypes. Our best and brightest students who are passionate about science and who take a broader view of career possibilities will most certainly distinguish themselves. However, in college they should be encouraged with financial aid and enriched course work, just like we provide at NCSSSMST schools. We at NCSSSMST should make US employers in industry, academia, and elsewhere aware that our group of students is a national treasure and should be treated as such. This doesn't mean that they should be pampered, it means that they should be given every possible encouragement and opportunity to let their talents flourish.

A recent National Academy of Sciences study argued for the introduction of 25,000 new undergraduate scholarships for science and engineering (Dawson, 2005). As educators of gifted students, we know that genuine creativity, the spark of genius, is rare, even among top students. Yet it is this small group of creative individuals who will be the leaders in their fields and upon whom future economic growth depends. The NCSSSMST schools try to identify these students and help them along by getting them accepted by the best universities. Another benefit of graduating from a NCSSSMST school is that these students often receive substantial financial aid without which for many of them it would not have been possible to attend college. NCSSSMST schools challenge their students with college level courses, research programs, and internships with universities or companies, thereby stimulating curiosity and initiative. NCSSSMST has only been in existence for seventeen years, so it is too early to quantify its impact on society. However, nurturing our best and brightest is bound to be beneficial. If our efforts at NCSSSMST could work in conjunction with future government policies that focus on making the best use of our most talented students, all of America will greatly benefit.

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