32 Who Is Doing Science—and Who Will?

Daryl E. Chubin

The April 8, 2001, edition of *Parade Magazine* published the following under the title "America's High-Tech Dilemma":

> American students are disappearing from our top engineering and science schools. Nationwide, 27 percent of graduate students in these fields now come from abroad, and their number is rising. But while many foreign students once stayed here after graduation, more and more are now going home. If foreigners cannot be enticed to stay, and our own students are not interested in engineering or science, who will fill the high-tech positions needed to keep America on top in the 21st century?

Who is doing science and who will? This question is not new. Nor is it limited to graduate students or immigrant talent. The demographic trends indicate that our student population is becoming "majority minority," that is, the former minority is becoming a majority. Many of our urban schools are already there. Despite slow incremental gains, those who were historically underrepresented and underserved (defined as a fraction with various denominators, such as the U.S. population, or the number of high school graduates or baccalaureate degree recipients) lag far behind in academic and occupational achievement.

Data and Questions

Like most professions in this country, science and engineering (S&E) is composed largely of white males. As the talent pool changes in eth-

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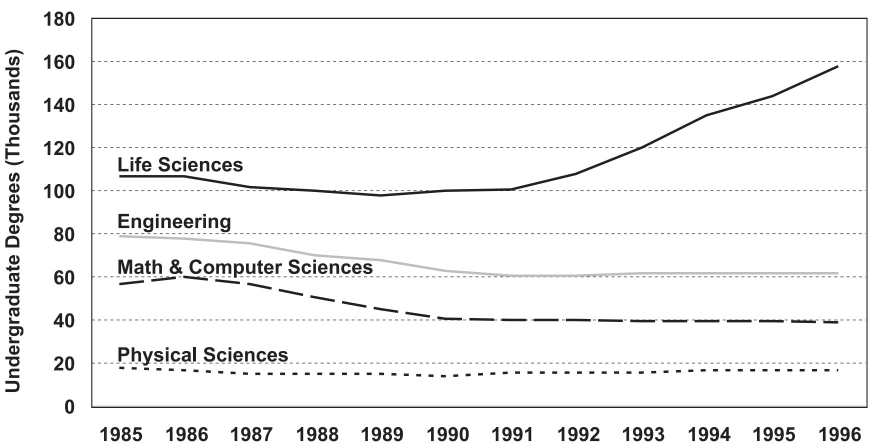
nic and racial composition, the professions of medicine, law, and business, as well as science and engineering, will all be vying for the "best and the brightest." How we define and measure the best and the brightest is contentious itself, as the debate over the use of standardized tests in the college admissions process illustrates. The National Science Foundation (see Figures 1 and 2) reports that undergraduate degrees outside of the life sciences are declining while graduate enrollments outside of the life sciences are either holding steady or declining.

Of course, these trends tell us nothing about the composition of the students in each of those curves. But I would assert that access to education has profound implications for the future of science and technology (S&T), as well as the future of the science and technology work force (which in turn is vital to a post-industrial, so-called digital economy).

Figure 3 shows the current composition of the total work force (left columns) and the S&E work force (right columns) in the United States. The underrepresentation of women and ethnic/racial minorities (except for Asians in S&T) is clear. The question, then, is not only how indi-

Figure 1
Undergraduate Degrees Are Declining Outside of Life Sciences

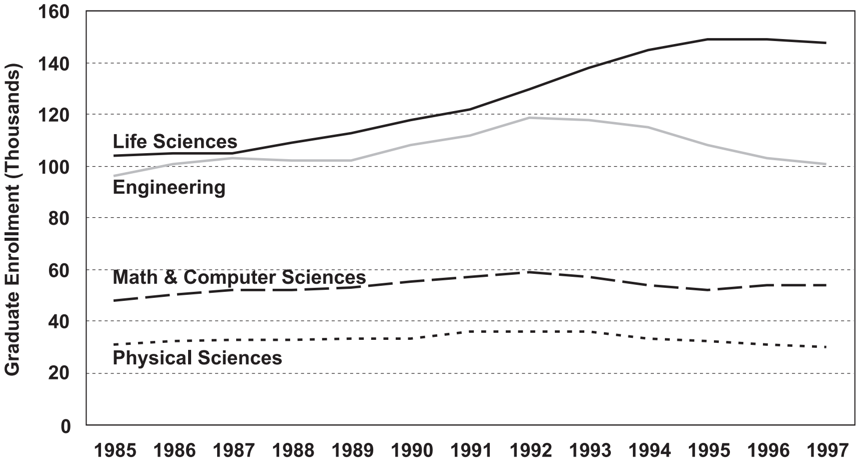
Undergraduate Degrees by Discipline, Thousands



Source: National Science Foundation, Science and Engineering Indicators 2000 *CD-ROM*

Figure 2
Graduate Enrollments Are Declining in Key Disciplines

Graduate Enrollment by Field of Study, Thousands



Source: National Science Foundation, Science and Engineering Indicators 2000 *CD-ROM*

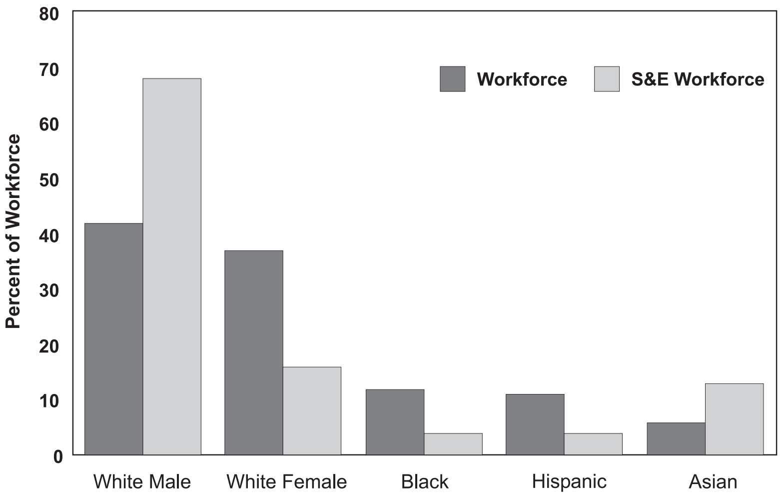
viduals will compete for those desirable positions, but also how S&T *in the aggregate* will compete with other professions in attracting students to S&T careers, and simultaneously renewing the technical work force.

In a merit-based society, some characteristics are not supposed to matter, but we know that they still do. And in the eyes of many, advantages accruing to some mean disadvantages accruing to others. This zero-sum mentality is dangerous and misleading, and it represents both bad thinking and bad policy.

How, then, do we cultivate the entire talent pool? When such questions about human resources for S&T are raised, they seem merely an afterthought to questions about funding priorities, balance across disciplines, accountability for research outcomes, and who will become the next presidential science advisor. Trained personnel have historically been seen as a byproduct of a university-centered R&D system. Consequently, we have never had a federal human resource policy for science and technology, although legislation, executive orders, commissions, and reports galore have signaled the nation's concern about who is doing science and who will do it in the years to come.

Figure 3
Women and Minorities Are Underrepresented in the Science and Engineering Workforce

Percent of Women and Minorities in the Workforce



Source: Land of Plenty, *Report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, September 2000.*

Last year, for example, the National Science and Technology Council issued the report *Ensuring a Strong U.S. Scientific, Technical, and Engineering Work Force for the 21st Century*, and the Commission on the Advancement of Women, Minorities, and People with Disabilities in Science, Technology and Engineering (CAWMSET), chaired by Rep. Connie Morella (R-MD), issued the report *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. An interagency project hosted by the Council on Competitiveness was launched under the acronym "BEST" (Building Engineering and Science Talent) to implement the recommendations in *Land of Plenty*. These are vital but modest steps. They belie bigger needs. Within the science policy community, since the passing of Rep. George Brown, Jr. (D-CA) we have heard few voices (notably Lewis Branscomb, Mary Good, and Neal Lane) on who is coming to science. We have not been predisposed *as a community* to confront the policy issue of how we grow our own rather than import the personnel we need. We have not confronted the implications of the U.S. reliance on the education and work force policies of other nations to supply our S&T needs.

A human resource development policy must plan, prepare, deploy, and account for who will do science and engineering. This is a long-term proposition, not to be confused with ad hoc measures like raising the ceiling on H-1B visas or creating new targeted programs that are vulnerable to legal challenge. Who will do science must become a mainstream concern both of the disciplinary producers and of the prospective consumers of new scientists and engineers. This is not a question of what is good for, say, the life sciences or the mission of a particular federal agency. Rather, we must consider across sectors and industries what we need to meet emerging national challenges. We must discuss skills, the knowledge base, and the continuing capacity to learn, adapt, and apply research and development.

There are other questions as well: How do we allocate limited resources to better prepare a diverse cadre of young people to participate not only in a national work force, but in a global one as well? How do we measure excellence and equity in access, in participation, and in performance in science and engineering education and employment?

How do we recruit and retain future S&T leaders? As the work force has changed, so have those entering it, but employee recruitment and retention strategies have not necessarily kept pace with those changes. Companies hire with an expectation that an employee will stay at least until the employer has recouped the recruitment, hiring, and training costs, while new high-tech workers plan to stay until they have developed new skill sets to be more marketable.

Those historically underrepresented (minorities and women) can be considered full participants in the S&T work force only when they are competitive at the highest levels. We must see them in leadership positions—heading corporations, universities, and professional societies; controlling multimillion-dollar budgets; wielding power among policymakers; and serving as senior faculty at major research institutions. Thus, we must ask what roles industry, academe, and government can play in steering minority scientists and engineers to paths that increase the likelihood that the future leadership in all sectors will more accurately reflect the population.

Immediate Needs, Provisional Responses

It is incumbent on those who raise questions to provide some at least provisional responses.

First, we must recognize the seamlessness of the formal education system. Precollege preparation in mathematics and science matters. Course work at a two-year institution is a ticket for many into the new economy. A baccalaureate degree will provide a competitive advantage for new entrants to the work force or for graduate study. All steps in the education system are important.

Second, institutions must become more committed to their student clientele. Preparation, participation, and performance of graduates in S&T disciplines will require institutional commitments and oftentimes partnerships to leverage resources, ease transitions, and build momentum for success beyond individual student cohorts.

Third, if we care about who will do science, we must better document and evaluate the factors that contribute to student success, particularly at key transition points (such as moving from recruitment to selection to retention to degree awards). We cannot afford to lose capable students and sap talent from the pool of potential leaders. If they disappear before they mature professionally, we do not have them at the senior level.

Science is supposed to be about talent—a raw material that needs to be developed and refined. It is not supposed to be about gender or ethnicity. It is about what we do, not about who we are. Attention to equity, therefore, is seen to distract from excellence, as if they cannot coexist. In a diverse community that has long welcomed citizens of foreign nationality, there is a great consciousness, reinforced by census categories and requests for self-identification, about who is participating and who is not (see U.S. Census Bureau "Census 2000" findings at www.census.gov/population/www/socdemo/race.html).

We know that some institutions produce women scientists and others produce minority scientists. The concept of diversity encompasses all groups and many categories. Yet our measurements lag. Data that display retention rates by institution separately for minority and majority students, as published for engineering undergraduates by the National Action Council for Minorities in Engineering (NACME), would remind us of which institutions are serving diversity and which are not.

According to data from the National Center for Education Statistics, the number of high school graduates is expected to rise the fastest in the following eight states over the next decade: Nevada, 70 percent growth;

Arizona, 48 percent; North Carolina, 31 percent; Florida, 28 percent; Georgia, 23 percent; Connecticut, 23 percent; California, 22 percent; and Massachusetts, 21 percent. For recruiting purposes, this is where the students will be concentrated. Think about the institutions of higher education in proximity to those states. Will science and technology be able to tap that source, that reservoir of talent?

Comparing S&E Careers with Other Careers

Science and engineering careers, but particularly science careers, have been found not to compare favorably with medicine, law, and business. This comes from an analysis that Michael Teitelbaum (from the Alfred P. Sloan Foundation) presented at the 2000 AAAS Colloquium on Science and Technology Policy (in D.E. Chubin and W. Pearson, Jr., eds., *Scientists and Engineers for the New Millennium: Renewing the Human Resource*, Commission on Professionals in Science and Technology, March 2001). Students may not be very well-informed about the costs, the returns, and the opportunities foregone by their choices. And the calculus may be quite different for foreign-born students and for those seeking a career in engineering as opposed to science.

To illustrate, a rather flippant, column called "Tell Me About It: Advice for the Under-30 Crowd," by Caroline Hax in *The Washington Post* on December 8, 2000, recently said:

> Hey, Caroline, How do I decide if I should go to law school or grad school? Law school is looking good because of job security, the challenge of trying to get in, and the fact that it is a completely different way of analyzing things, which might be interesting. If I went to grad school, it would be in a not-very-lucrative, somewhat obscure field—but it is my major, and I like the material. However, the thought of years of grad school stretching out before me and chasing after tenure is not very appealing. Any suggestions on how I can find out where I would be happiest?

Caroline responds:

> Easy—law school, because the challenge of trying to get in is the best rationale I have ever heard for spending 40 years as an attorney. You go to law school because you want to be a lawyer. You go to grad school because you want to study and teach. You don't go to school, any school, please, because a student is the only thing

> you have ever known how to be, and you yearn for pointless debt. Get a job, get to know yourself, get better acquainted with life.

She is tough, but I think she is right-on.

Policy and Collective Decision Making

Most federal agencies have paid scant attention to students' career calculus beyond considerations of undergraduate finance. This has been exacerbated as the locus of control in research-intensive universities has devolved to departments and individual faculty.

The decentralized character of graduate admissions and the persistence of professor autonomy in recruiting and integrating the best and the brightest into the laboratory structure militates against institution-wide reform in graduate education. Attrition rates tell an important story. They suggest either that our selection methods are faulty or the environment is not conducive to degree attainment. We cannot continue to blithely assert that students are ill-prepared—not if we let them in—or change their minds after they are admitted, without considering other hypotheses for why they drop out of science and engineering.

NACME (at least) understands that you cannot change the composition of the science and engineering work force by waiting until students get to college. You have to do this earlier. Mathematics is known as the gateway to science and engineering. Our technology-driven economy depends on a work force literate in math and science. But only 15 percent of American students and six percent of minority students graduate from high school with four years of math and science. (We have found that completion of Algebra II doubles the chances of earning a college degree.) Math achievement also helps with self-esteem and confidence. Also, mathematics gives you a different way of looking at the world.

So NACME developed in the mid-1990s, the "Math is Power" campaign. It started with an 800 number for students in New York City and is now a national campaign. It has leveraged $150 million of donations and a lot of pro bono work by the Ad Council. We now average 1,000 visitors a week on our Web site, www.nacme.org. The program's goal is to speak directly to students and their parents about the importance of mathematics. The program discusses how to take a college preparatory course of study in high school so that you can be competitive with those who are applying for admission to those programs.

After five years, we have found that "Math is Power" has met many of its goals. First, the program has provided information to help students and parents make informed decisions. They did not have this information before. High school guidance counselors either were not very interested in providing this information or were not very good about providing it. Second, "Math Is Power" got parents involved in their children's education (always a good thing). Third, it created demand for science and math courses in schools that previously did not offer the kinds of rigorous curricula needed for college-level S&E. Fourth, it focused national attention on the access issue. And, fifth, it helped give teachers a new appreciation for the importance of what they do.

We also found a significant difference between those who have taken advantage of this campaign and those who have not. A recent Harris poll showed that those aware of "Math Is Power" have a better understanding of the prerequisites for getting into college and about the role of mathematics if one wants to do science or engineering. The program also raised interest in taking Advanced Placement courses and going to college. In addition, attitudes about mathematics are better. Finally, the campaign seems to have humanized the image of scientists and engineers.

Conclusion

While most young people will not elect to pursue careers as scientists, doctors, engineers, mathematicians, or teachers, all deserve the chance to make their own choices. Put another way, market forces may be powerful, but they bend to certain interests and are impervious to others. This is what public policy is all about—intervening in those markets. The federal government has been involved in this since the Montgomery GI Bill.

Policy can accelerate drawing on the diversity of our student talent and developing it to populate science and engineering. If we do not do this, other competing professions will. In some cases, they are already doing it. We are competing for the same pool of talent.

Another role of policy is to expose market barriers and opportunities that federal and other interventions can act upon. We must craft a policy for science and technology that considers human and fiscal resources, that extends beyond ideology, prejudices, and presuppositions about who can and cannot do science, and that goes beyond agency missions and the localism that our country holds dear.

Such a policy must include incentives for compliance and consequences for indifference, or it will be an empty policy. It must command the attention and energy of the federal R&D agencies, their constituencies, and all of us who teach, mentor, employ, and lead knowledge workers of the 21st century.