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August 12, 2008

Dr. James J. McCarthy, President
American Association for the Advancement of Science
Harvard University – Museum of Natural History
24 Oxford St.
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Dear Dr. McCarthy:

Fareed Zakaria criticizes flawed work of the National Academy of Sciences in the enclosed excerpt from The Post-American World (2008).[1] His summary sheds light on the stagnation of the federal science budget. AAAS may be able to correct these problems.

In brief: Historically, scientists have been trusted advisers and partners of government. This privileged status has eroded. The behavior of the National Academy of Sciences and the National Science Foundation has caused scientists to be seen as "just another interest group."

Background: The "Gathering Storm" (2005) and the K-12 crisis.

In 2005 Congress asked the National Academy of Sciences to recommend "specific steps that can best strengthen the quality of life in America – our prosperity, our health, and our security." The Augustine Report (Rising Above the Gathering Story: Energizing and Employing America for a Brighter Economy) sounded a loud (and highly selective) alarm about international business competition.[2] The National Academy of Sciences endorsed the Report and its urgent twenty recommendations of billions of dollars for a wide range of well-intentioned projects for science, engineering, and mathematics (also, large federal expenditures to change the choice of majors by our nation's undergraduates.) [3] The National Science Board/NSF wrote a companion "national crisis" report recommending "aggressive steps" for K-12 national science, technology, engineering and mathematics education.[4]

However (as Mr. Zakaria discusses) both Reports were unreliable and fell apart upon independent examination of their data and analysis. For example, Gathering Storm was alarmed by "600,000 Chinese engineering graduates/year" but its numbers were wrong and wildly exaggerated. (And there is no shortage of U.S. engineers – only about 10% of American engineering graduates are currently employed in engineering jobs by American companies.)

And there are deeper flaws: Gathering Storm purported to be about national economic growth but it was used as a lobbying opportunity. The National Academy of Sciences has 52 economists (including several winners of the Nobel Prize). They did not review the Report.[5]As the enclosed columns by the economist Robert Samuelson illustrate, the National Academy of Sciences – rather than be a guarantor of scientific integrity - provided a one-sided and selective case.[6] Nor did it provide a model of the causal pathways and estimate the coefficients involved in successful international business competition – and thus, it was impossible to evaluate responsibly, or defend, how public funds were to be allocated. . . .[7] Economists are potted plants in an attractive atrium through which the inner circle of the National Academy passes on their way to the elevators and the executive conference room on the top floor.

Accelerating Toward the Cliff

Neither organization withdrew its work to repair the scientific deficiencies. The National Academy of Sciences quietly published and transmitted to Congress a final version of Gathering Storm in 2007, declaring "the recommendations remain unchanged."[8] Both organizations began to operate more boldly outside their civic charters to rally national political support to secure funding for the cornucopia from Congress and the President.[9] They organized a major lobbying campaign (including the CEO's of fifteen major corporations)[10] to pass and fund an America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Sciences [COMPETES] Act.[11] There was a great deal of genuine pro-science idealism, enthusiastic symbolic posturing (Double this, increase that,"10,000 teachers for 10 million minds," everything should be "more" and "better," 25,000 new 4-year scholarships to be allocated to states on the basis of the size of their Congressional delegations), and social pressures for pro-science loyalty and public silence by critics. However independent, skeptical, and more reliable scientists communicated directly with Congress and opinion leaders. (Dr. Harold Varmus, former Director of NIH, also was an effective public whistle-blower. He told the truth to a national television audience, on The Charlie Rose Show (4/7/2008), that the evidence contradicted the NAS/NSF/NSB claims about a K-12 crisis: public education has been upgraded substantially since the days of Sputnik and there is no national crisis for students who are gifted and talented.)[12]

At this point, a trial has been held and the defendants found guilty. The National Academy of Sciences and the National Science Board/NSF have been demoted from the privileged status of trusted advisers.

Doing Favors for Exxon

[Under separate cover, I will forward a discussion of three ethical problems that also illustrate the changed perception in Washington that these organizations – rather than making simple or hasty errors – have evolved from trustworthy scientific advisers to become political/lobbying organizations. For example, the Augustine Commission included the CEO's and other top current/former officials from Exxon and six other large corporations. They received a *quid pro quo* by the National Academy's endorsement for their agenda of a huge increase in tax subsidies and an accompanying one-sided, uncritical discussion.[13] (I.e., disregarding its 52 economists, the National Academy's inner circle awarded Exxon et al. and their stockholders a huge, permanent doubling of an annual investment tax subsidy, from 20% to 40%, and extra billions of dollars via expansion (inserted in Gathering Storm without discussion) of the expenditures covered. . . . Corporate America has underwritten many earlier lobbying reports over the years to promote this handout. *Caveat emptor*: not even Republican Congresses and Presidents have been persuaded!)[14]]

What AAAS Can Do

We face a critical choice about the future of American science and how trustworthy scientific advice can be available to the government and to the public. I recommend that AAAS take three corrective steps:

1.) A "No Confidence" Resolution and Securing Transparency.

At this point, the ball is in the court of the scientific community. AAAS is the only national organization that can take effective action. We should formally recognize that a loss of confidence exists and ask Congress to assist with securing full transparency and disclosure about these breakdowns.[15] We need full transparency and disclosure: 1.) To give the scientific community a fully-informed basis to adopt systemic improvements and recommend systemic improvements to Congress and to the next Administration; 2.) To assure justice for everyone involved. (We cannot assume that the professional staffs of the National Academy and NSF should take the blame for one-sided documents and selective use of evidence. Ralph Cicerone, the President of the National Academy of Sciences, Charles Vest, the President of the National Academy of Engineering, and Norman Augustine may have indicated the case that they wished to make); 3.) To deter future scientific misconduct, especially when secrecy and claims of privacy are being used to cover up embarrassing or illegal discussions and behavior; 4.) To teach important lessons to students: The Augustine and K-12 cases will be prominently studied by undergraduates across

many fields, in the US and abroad, for many years. They provide realistic and timely insights into the making of American science policy about important national questions, elite and organizational behavior, *hubris*, belief and evidence, temptation and integrity, ethics and scandal; 5.) To send messages to Congress, the news media, the new Administration, and the wider academic community that scientists care about, and want to regain, the role of trusted advisers.

2.) Special Issues of Science.

Congress has not yet received a trustworthy answer to the questions that it asked. The old National Academy/NSF advisory system has reached an impasse and unless AAAS takes action, thoughtful and reliable advice and well-conceived plans will be delayed for many years. I recommend that AAAS organize special issues of Science, with guest editors and advisory Boards, to provide independent, scientific evaluations of recommendations in the Gathering Storm and K-12 Reports. These special issues should include the right of Norman Augustine et al., and the National Science Board, who put their reputations on the line earlier, to defend their individual recommendations; and opportunities to build upon and improve recommendations and offer more innovative ideas for discussion. Special issues also should be devoted to ethics and to systemic-reform: the nation deserves a trusted scientific adviser.

Concerning what went wrong: Many people – including traditional friends of science in Congress – apparently assumed that we had a responsible national science Establishment – i.e., that the National Academy of Sciences and National Science Board/NSF had the needed data systems for strategic planning in their areas of stewardship. But even members of the Augustine Commission eventually discovered that needed data systems are not there. They wrote, in a small print caution in 2007: "[T]he available information is only partly adequate for the committee's needs . . . definitive analyses of many issues are not possible." (p. 2). . . . The recent institutional train wrecks notwithstanding, everyone hopes for rapid scientific progress. Thus, one of the tasks for the special issues could be the design of data systems for fast-discovery learning and reality-based government policy.

3.) Pressing these issues to resolution.

I believe that AAAS must press these issues. The Gathering Storm Report (especially with eighteen months for revisions) was a Final Exam. When Harvard's Board of Overseers discovered rationalized unethical and unreliable behavior at the senior levels of the Harvard Development Institute and its USAID projects in Russia, they decided that they were unwilling to spend the resources to micro-manage the needed corrections. They terminated the Institute. The National Academy system was created in the 19th century with extraordinary civic guarantees against out-

side interference – e.g., the right to elect its own lifetime members. It operates behind closed doors. It cannot be verifiably corrected from the outside. And its internal politics – e.g., its treatment of economists – is obscure and probably cannot be reformed from within. For the 21st century, I think that we will want a more open and transparent system, possibly relying more upon ideas drawn from the Federalist Papers.

At this point, successful leadership is critical. Now there are two data points, the Luce Commission scandal and the Augustine Commission problems. It is easy for people (including lawyers, journalists, a new Administration, and members of Congress) to connect the points and observe the downward arc. And there is a substantial history (partly, already known to the AAAS Governing Council) of off-the-record warnings and shots across the bow (e.g., by the former AAAS President, David Hamburg and the Carnegie Commission; by the Times Editorial Board; now *inter alia*, from Newsweek International, the Wall Street Journal, and the Washington Post) about the draw of these organizations to become Washington-centered and disregard scientific integrity. They have had many warnings and second chances.[16] If AAAS does not handle this, I believe that others will. Right now, most scientists here and abroad (and the next generation of scientists in our colleges and universities) still trust the governance and integrity of scientific institutions and the self-correction of science. But things could become a great deal worse. And – for the future of science and everyone who can benefit from scientific progress – things should get a great deal better.

Yours truly

Lloyd S. Etheredge

Dr. Lloyd S. Etheredge, Director
Government Learning Project

Enclosures: Excerpt from Zakaria, The Post-American World, pp. 187-189.
Robert Samuelson, "Sputnik Scare, Updated," Washington Post, May 26, 2005 and "A Phony Science Gap?" Washington Post, February 22, 2006.
Yudhijit Bhattacharjee, "New Analysis Questions Push for More Degrees," Science, November 16, 2007, p. 1052.

cc: AAAS Council

[1] Mr. Zakaria is Editor of Newsweek International, a member of the Trilateral Commission, and a Trustee of Yale University.

[2] (Washington, DC: National Academy Press, 2007), p. 2. Online at http://www7. nationalacademies.org/cosepup/COSEPUP_Publications.html. The online version, misidentified on the Publications Page as the 2005 Report, is the 2007 "final" report. The 2007 report has to be evaluated carefully because the text includes changes that probably misrepresent the actual basis for the original recommendations.

[3] The National Academy of Sciences and the National Science Foundation did not engage the scientific integrity to analyze alternative theories. For example, an important competing theory is that American undergraduates should select their majors based on comparative advantage – i.e., selecting fields in which they have interest, ability, and love to do the work well. Thus, in the long run, rather than imitating a possibly mistaken and temporary Asia zeal and intense societal pressure for science and mathematics, America's comparative advantage might be educational institutions that help to maximize the potential of each individual.

[4] National Science Board, National Action Plan: Science, Technology, Engineering and Mathematics Education System. October 30, 2007. The Chair of the National Science Board, Steven Beering, wrote that America "is *failing* [emphasis added] to meet the [STEM] education needs of U. S. students" and urged annual expenditure increases of billions of dollars as "*absolutely essential* [emphasis added] for the continued economic success of the Nation and its national security." (p. v).

[5] There is a troubling correlation between fields whose federal support was recommended to double and those who were represented prominently in the Commission processes v. those fields that were not included.

[6] Robert J. Samuelson, "Sputnik Scare, Updated," Washington Post, May 26, 2005, p. A27. See also his "A Phony Science Gap?" on February 22, 2006, p. A15, Sebastian Mallaby, "The Fake Science Threat" in the Washington Post of February 6, 2006, p. A15, and Yudhijit Bhattacharjee, "New Analysis Questions Push for More Degrees," Science, November 16, 2007, p. 1052.

[7] In earlier years, when Congress received a recommendation to build the COBE satellite, scientists could be relied upon to have done their homework. There was a rigorous and thoughtful analysis of more than 100 competing theories that would be tested. The National Academy has implied that it had to do a rushed job, and that the Augustine Commission was required to recommend national policies without public hearings or enough time for good analysis, but the reasons are not fully persuasive. And the reasons do not apply to the eighteen months between the 2005 document (that the National Academy now calls a "draft") and the 2007 version.

[8] Gathering Storm (2007), p. 2.

[9] The NAS organized a national meeting on August 10, 2006 to bring together "leadership of the industry, government, research and educational community from all 50 states and the federal government" and a follow-up convocation was held in Washington, DC on April 29, 2008. Press releases are online at http://www7.nationalacademies.org/gatheringstorm/.

[10] See also: "Endorsements: Conference Report. H. R. 2272, the America COMPETES Act" online at http://democrats.science.house.gov/Media/File/ Commdocs/ hr2272_ org_support.pdf. Corporate support and pressure helped to pass the Act, but the Administration and members of Congress have been unwilling to move beyond this symbolic statement to provide funding.

[11] See also Justin Pope, "Report: US Behind in Doubling Science Grads," Associated Press - Yahoo News. July 15, 2008. Fifteen CEO's are supporting the Augustine/NSF Reports and have told Congress [i.e., without yet providing a persuasive analysis – LE] that the country will need "400,000 new graduates in the so-called STEM (science, technology, engineering and math) fields by 2015 . . . but the number of degrees has flattened out at about 225,000 per year." However, note that one of the rationales of "need" – by a company that says it spends $780 million/year on training - is to reduce its training costs. The National Academy's political initiative includes both idealistic "science is good" advocates (who hope for scientific breakthroughs) – but, also, there are corporations with very different, prosaic bottom-line agendas (a better disciplined US workforce, a doubling of the number of engineering graduates that will permit lower wages, and corporate training costs that are partly reassigned to colleges and universities.) The (continuing) ambiguities and stonewalling and lack of rigorous, corrective scientific analysis by the National Academy and NSF may help to create and hold together such a broad and diverse political coalition, but we do not yet know if either agenda will be well-served by the Augustine projects.

[12] Dr. Varmus received the Nobel Prize in 1989. His honesty and candor probably contributed to his ability, as NIH Director (1993 – 1999), to double the NIH budget. Varmus said that the K-12 STEM initiatives were "cultural." This may be right but – if so – the NAS/NSF/NRC case needs to be rewritten and based on models of culture and, then, cost-effective policies need to be identified on the basis of data and analysis of causal pathways and coefficients.

[13] Seven of the twenty members came from the corporate world: Exxon, DuPont, Intel, Eli Lilly, Merck & Co, Lucent Technologies and Lockheed Martin. Others served concurrently as Board members of beneficiaries – e.g., two members of the Augustine Commission (Shirley Ann Jackson and Charles Vest) were on the Board of Directors of IBM in 2005. Anita K. Jones was elected to the Board of BBN in 2004. At the time of his chairmanship, Norman Augustine also apparently was a member of the Boards of Proctor and Gamble, Riggs National Bank, and Conoco-Phillips. Other members (e.g., Robert Gates) also probably had 2005 corporate board memberships and/or stock holdings requiring legal disclosure. Thus, it appears that a voting majority had conflicts of interest that were undisclosed, but should have been ethically and legally disclosed. The National Academy of Sciences is legally required to provide "unbiased and impartial scientific advice, both in fact and in appearance."

[14] Nor did Ralph Cicerone (President of the National Academy of Sciences) and Charles Vest (President of the National Academy of Engineering), the senior officials with legal liability, disclose the annual donations and income to their National Research Council [now about $65 million/year from private and nonfederal sources in 2007] by the corporations and lobbying groups whose members served on the Augustine Commission and the working group that slipped-in the Gathering Storm tax give-away. It is unclear whether Norman Augustine and other members were required to file conflict of interest forms concerning stock owned in companies that would receive immediate and substantial benefits if Gathering Storm was believed. However, I believe that they should have informed readers of their Report, regardless of whether the National Academy has rules against telling the public of such conflicts.

[15] Transparency should include all emails, correspondence, records of telephone conversations, etc. that help to understand the behavior of individuals in their organizational set-

tings. We may need to instruct AAAS legal counsel to take steps to assure this full disclosure: Since the earlier Luce Commission scandal the senior officials of the National Academy have been unavailable for rational collegial discussions. (For example: there have been strong internal legal arguments that all Academy officials must defend the Academy's actions and reports in public.) However AAAS has a right to insist that the norms and values of the scientific community be honored, even if federal law and its own new rules do not compel the Academy to be transparent and accountable.

[16] I do not understand the NSF/National Science Board dysfunctions well enough to have an informed judgment. However, I suspect that any solution should include a separate and highly capable staff and legal counsel for the National Science Board. Permitting the Director of NSF to Chair the Executive Committee of the National Science Board and provide its staff prevents the National Science Board from doing its job to detect and correct problems in NSF programs and compensate for the limitations of the current NSF Director and several of his appointees.

from Fareed Zakaria, The Post-American World (NY: WW Norton, 2008)

America's Best Industry

"Ah yes," say those who are more worried, "but you're looking at a snapshot of today. America's advantages are rapidly eroding as the country loses its scientific and technological base." For some, the decline of science is symptomatic of a larger cultural decay. A country that once adhered to a Puritan ethic of delayed gratification has become one that revels in instant pleasures. We're losing interest in the basics—math, manufacturing, hard work, savings—and becoming a postindustrial society that specializes in consumption and leisure. "More people will graduate in the United States in 2006 with sports-exercise degrees than electrical-engineering degrees," says General Electric's CEO, Jeffrey Immelt. "So, if we want to be the massage capital of the world, we're well on our way."[15]

No statistic seems to capture this anxiety better than those showing the decline of engineering. In 2005, the National Academy of Sciences released a report warning that the United States could soon lose its privileged position as the world's science leader. In 2004, the report said, China graduated 600,000 engineers, India 350,000, and the United States 70,000. These numbers were repeated in hundreds of articles, books, and blogs, including a *Fortune* cover story, the *Congressional Record*, and speeches by technology titans like Bill Gates. And indeed, the figure does seem like cause for despair. What hope does the United States have if for every qualified American engineer there are 11 Chinese and Indian ones? For the cost of one chemist or engineer in the United States, the report pointed out, a company could

hire 5 well-trained and eager chemists in China or 11 engineers in India.

The only problem is that the numbers are wildly off the mark. A journalist, Carl Bialik of the *Wall Street Journal*, and several academics investigated the matter. They quickly realized that the Asian totals included graduates of two- and three-year programs—people getting diplomas in simple technical tasks. A group of professors at the Pratt School of Engineering at Duke University traveled to China and India to collect data from governmental and nongovernmental sources and interview businessmen and academics. They concluded that eliminating graduates of two- or three-year programs halves the Chinese figure, to around 350,000 graduates, and even this number is probably significantly inflated by differing definitions of "engineer" that often include auto mechanics and industrial repairmen. Bialik notes that the National Science Foundation, which tracks these statistics in the United States and other nations, puts the Chinese number at about 200,000 degrees per year. Ron Hira, a professor of public policy at the Rochester Institute of Technology, puts the number of Indian graduates at 120,000–130,000 a year. That means the United States actually trains more engineers per capita than either India or China does.[16]

And the numbers don't address the issue of quality. As someone who grew up in India, I have a healthy appreciation for the virtues of its famous engineering academies, the Indian Institutes of Technology (IIT). Their greatest strength is that they administer one of the world's most ruthlessly competitive entrance exams. Three hundred thousand people take it, five thousand are admitted—an acceptance rate of 1.7 percent (compared with 9 to 10 percent for Harvard, Yale, and Prince-

ton). The people who make the mark are the best and brightest out of one billion. Place them in any educational system, and they will do well. In fact, many of the IITs are decidedly second-rate, with mediocre equipment, indifferent teachers, and unimaginative classwork. Rajiv Sahney, who attended IIT and then went to Caltech, says, "The IITs' core advantage is the entrance exam, which is superbly designed to select extremely intelligent students. In terms of teaching and facilities, they really don't compare with any decent American technical institute." And once you get beyond the IITs and other such elite academies—which graduate under ten thousand students a year—the quality of higher education in China and India remains extremely poor, which is why so many students leave those countries to get trained abroad.

The data affirm these anecdotal impressions. In 2005, the McKinsey Global Institute did a study of "the emerging global labor market" and found that a sample of twenty-eight low-wage countries had approximately 33 million young professionals* at their disposal, compared with just 15 million in a sample of eight higher-wage nations (the United States, United Kingdom, Germany, Japan, Australia, Canada, Ireland, and South Korea).[17] But how many of these young professionals in low-wage countries had the skills necessary to compete in a global marketplace? "Only a fraction of potential job candidates could successfully work at a foreign company," the study reported, pointing to several explanations, chiefly poor educational quality. In both India and China, it noted,

* MGI's figure includes graduates trained in engineering, finance and accounting, life science research, and "professional generalists," such as call center operatives. Young professionals are defined as graduates with up to seven years of experience.

washingtonpost.com

Sputnik Scare, Updated

By Robert J. Samuelson
Post
Thursday, May 26, 2005; A27

Americans are having another Sputnik moment: one of those periodic alarms about some foreign technological and economic menace. It was the Soviets in the 1950s and early 1960s, the Germans and the Japanese in the 1970s and 1980s, and now it's the Chinese and the Indians. To anyone old enough, there's no forgetting Oct. 4, 1957, when the Soviets orbited the first space satellite. It terrified us. We'd taken our scientific superiority for granted. Foolish us. Soon there were warnings of a "missile gap" with the Soviets. One senator admonished that Americans should "be less concerned with . . . the height of the tail fin on the new car and . . . be more prepared to shed blood, sweat and tears if this country and the free world are to survive."

The missile gap turned out to be a myth, as did many later theories explaining why the Germans and the Japanese would inevitably surpass us. They were said to have better managers, better workers and better schools. They outsaved and outinvested us. It was just a matter of time. Let's see. In 2004, Americans' per capita incomes averaged $38,324, reports the Conference Board. The figures for Germany and Japan were $26,937 and $29,193.

One puzzle about the U.S. economy is why it *do*esn't do worse when there *are* so many reasons that it should. Our students do fare poorly on international comparisons. In a recent study of math skills of 15-year-olds in 29 countries, done by the Organization for Economic Cooperation and Development, Americans ranked 24th. We do depend heavily on immigrants to fill science and engineering jobs. In 2000, immigrants accounted for 17 percent of U.S. scientists and engineers with bachelor's degrees, 29 percent with master's degrees and 38 percent with doctorates. And our savings and investment rates are low. In 2001, the U.S. savings rate ranked 22nd out of 25 OECD countries.

The explanation is this: Every complex economy is more (or less) than the sum of its parts. What matters is not just how much we save -- but how well we invest. The Japanese have squandered much of their higher savings on unproductive investments. Similarly, many work skills are learned on the job. Perhaps 70 percent of the gap in average incomes between the United States and Western Europe reflects the fact that Europeans work less than Americans. The Europeans are entitled to their preferences (longer vacations, earlier retirement), but their higher unemployment and lower labor-force participation rates mean that fewer people acquire real job skills -- and that some people with skills don't use them.

The apparent American deficit in scientists and engineers is also exaggerated. Only about a third of our science and engineering graduates take science and engineering jobs. The rest often work as managers, salespeople, analysts or something else. If there were a shortage, the pay would go up, especially for doctorates. In 1999, the median salary of U.S. scientists and engineers was $60,000 -- solid but not spectacular pay. Someone with a PhD typically earned only 15 percent more than someone with a bachelor's degree, a modest premium. As for immigrants, they come for the opportunities.

The Sputnik syndrome is an illusion. It transforms a few selective economic happenings -- a satellite here, a Toyota there, poor test scores everywhere -- into a full-blown theory of economic inferiority or superiority. As often as not, the result is misleading. We are now going through this process with China and India. Their entry into the global economy is a big deal, with some obvious pluses and minuses for us. As they get richer, some of their talent that once came our way may stay home (especially if we make getting U.S. visas harder). On the other hand, good ideas that originate in Bangalore or Shanghai will soon benefit people everywhere -- just as good American or Japanese ideas have before.

Do China and India threaten us economically? Possibly, though not in the usually imagined way. Their low wages and rising skills will continue to cost us some jobs, especially in an easily interconnected world. But if global trade were reasonably balanced, we should roughly gain what we lose. Countries that export would spend their earnings on imports.

Unfortunately, trade isn't well balanced. China and many Asian countries (though not India) run huge surpluses; they sell more than they buy. That's why the Bush administration is rightly pressuring China to revalue its currency, which would make Chinese exports more expensive and its imports less expensive. The danger is that the China bloc destabilizes the world economy -- not that it soon overtakes us.

On being overtaken, history teaches another lesson. America's economic strengths lie in qualities that are hard to distill into simple statistics or trends. We've maintained beliefs and practices that compensate for our weaknesses, including ambitiousness; openness to change (even unpleasant change); competition; hard work; and a willingness to take and reward risks. If we lose this magic combination, it won't be China's fault.

A Phony Science Gap? [FINAL Edition]

The Washington Post - Washington, D.C. Author: Robert J. Samuelson Date: Feb 22, 2006 Start Page: A.15 Section: EDITORIAL Text Word Count: 922

It's true that in a "knowledge economy" -- one where new information and ideas increasingly form the basis of useful products and government programs -- nations need an adequate science and engineering (S&E) workforce. But it's emphatically not true, as much of the alarmist commentary on America's "competitiveness" implies, that the United States now faces crippling shortages in its technological elites.

Here are some facts:

In 2004 American colleges and universities awarded a record 233,492 undergraduate S&E degrees, reports the National Science Foundation (NSF). That was up 38 percent from 169,726 in 1990. Within that total, some fields have expanded rapidly. Computer science degrees have doubled since 1990, to 57,405. Other fields have stagnated. Engineering degrees, 64,675 in 2004, have been roughly the same since 1990. (Note: These figures exclude psychology and social sciences, such as economics, that are often counted in S&E totals.)

Graduate science and engineering enrollments hit 327,352 in 2003, another record. They've jumped 22 percent since their recent low in 1998. Computer science graduate students have increased 60 percent, to 56,678, since their low point in 1995, and engineering graduate students are up 27 percent, to 127,375, since their low in 1998. It's true that for these higher degrees, especially doctorates, foreign-born students have represented a growing share of the total. But that's also changing because -- after years of declines -- enrollment of native-born Americans and permanent residents for graduate work has increased 13 percent since 2000.

Judged realistically, China and India aren't yet out-producing the United States in engineers. Widely publicized figures have them graduating 600,000 and 350,000 engineers a year respectively, from six to 10 times the U.S. level. But researchers at Duke University found the Chinese and Indian figures misleading. They include graduates with two- or three-year degrees -- similar to "associate degrees" from U.S. community colleges. And the American figures excluded computer science graduates. Adjusted for these differences, the U.S. degrees jump to 222,335. Per million people, the United States graduates slightly more engineers with four-year degrees than China and three times as many as India. The U.S. leads are greater for lesser degrees.

Ever since Sputnik (1957) and the "missile gap" (1960), we've been warned that we're being overtaken technologically. Up to a point, that's inevitable. As countries modernize, they need more scientists and engineers. Technological competence expands. The United States now produces only about 11 percent of the world's S&E undergraduate degrees, reports the NSF's Mark Regets.

But a country's capacity for scientific and commercial innovation does not correlate directly with its number of scientists and engineers. Hard work, imagination and business practices also matter. Here the United States has some significant strengths: widespread ambition; an openness

to new ideas, especially from the young; an acceptance of skilled immigrants; strong connections between universities and businesses; and well-funded venture capitalists. Recall: Two Stanford University graduate students, one an immigrant, started Google.

In some ways the worldwide "knowledge economy" is unthreatening. Good ideas and products spread quickly. Knowledge is stateless. Two Americans invented the computer chip; now it's used everywhere. Still, we need to maintain a world-class science and engineering workforce. We want to keep high-value economic activity here, and we need to ensure superior military technology.

Only about 4 percent of the U.S. workforce consists of scientists and engineers. Having an adequate supply depends on what thousands - - not millions -- of smart college students decide every year to do with their lives. People choose a career partly because it suits their interests. This applies especially to science. "Physics is like sex," the physicist Richard Feynman famously quipped. "Sure, it may give some practical results, but that's not why we do it." But intellectual satisfaction goes only so far.

On average, American lawyers make 42 percent more than chemical engineers. At elite levels, huge pay gaps also exist. In 2005 the median starting salary for a new Harvard University MBA was $100,000. An MBA is a two-year degree. By contrast, a science or engineering PhD can take five to 10 years, with a few years of "post- doc" lab work. At a Business Roundtable press briefing, one CEO said his company might start this sort of scientist at $90,000. Does anyone wonder why some budding physicists switch to Wall Street?

Although we don't now have an S&E shortage, the retirement of baby boom scientists and engineers may cause one. There are some sensible ideas for avoiding this, including making it easier for foreign students who have earned advanced U.S. degrees to stay. But the main solution is obvious. "If we want more [scientists and engineers], we have to pay them better and give them better careers," argues Harvard economist Richard Freeman. The high-tech executives who wail about scarcities are part of the problem. They "would love to have more S&E workers at lower wages," he says.

The good news is that they may not have the last word. From 1993 to 2003, the median salary of engineers with bachelor's degrees and one to five years' experience rose 34 percent (after inflation), to $58,000, the NSF's Regets says. Among math and computer science graduates, the increase was 28 percent, to $50,000. By contrast, the average increase for non-S&E college graduates was only 7.7 percent, to $37,000. These are encouraging signs. Despite an eroding manufacturing base and the threat of "offshoring" of some technical services, there's a rising demand for science and engineering skills. That may explain higher enrollments and why this "crisis" - - like the missile gap -- may be phony.

SCIENTIFIC WORK FORCE

New Analysis Questions Push for More Degrees

Academics, business leaders, and politicians have warned repeatedly that the United States risks losing its economic edge unless it produces more scientists and engineers. They also say that the country's system of science and math education is not up to snuff. But a new study* questions two basic tenets of that argument, concluding that work force data do not support claims of a looming labor shortage and that test scores indicate U.S. students are doing at least as well in science and math as their international counterparts are.

The supposedly sorry state of STEM (science, technology, engineering, and mathematics) education was a driving force behind enactment this summer of the America COMPETES Act, which authorizes $44 billion for a cornucopia of research and education programs across several federal agencies (*Science*, 10 August, p. 736). The bill drew heavily on a 2005 U.S. National Academies' report, the title of which, *Rising Above the Gathering Storm*, refers to the impending economic crisis facing the United States unless it bolsters STEM education (*Science*, 21 October 2005, p. 423).

But sociologist Harold Salzman of the Urban Institute and demographer B. Lindsay Lowell of Georgetown University, both in Washington, D.C., say that the academies' report paints a misleading picture and that its assumptions are leading to flawed STEM education policies. They note that the annual U.S. production of bachelor's, master's, and doctoral degrees in STEM fields has averaged three times the annual growth of science and engineering jobs between 1985 and 2000. They also point out that fewer than one-third of the 15.7 million workers with at least one STEM degree at any level hold jobs that require such training. Given those numbers, says Salzman, "expanding our production of scientists and engineers just defies market reality." Last week, Salzman made his case twice on the same day, at a talk at the Urban Institute titled "Houston, Do We Really Have a Problem Here?" and in a hearing before the House Committee on Science and Technology on how globalization affects the U.S. science and engineering work force.

The authors also say that U.S. students are learning more than critics give them credit for. For example, they note, math scores on the National Assessment of Educational Progress (NAEP) for students in eighth grade rose 15 points from 1973 to 2004. And contrary to popular belief that they trail the pack, says Salzman, U.S. students rank in the middle tier of countries on an international assessment of 15-year-olds in math and science.

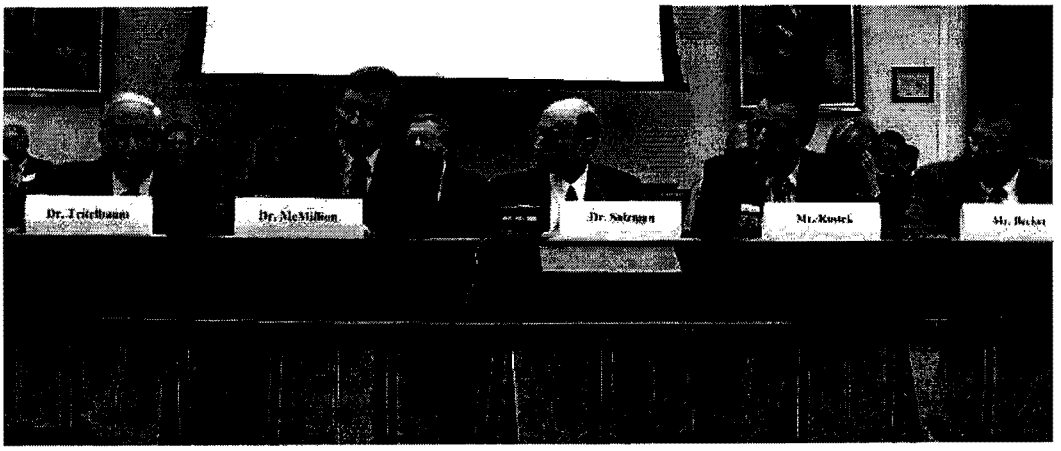
Norman Augustine, former CEO of Lockheed Martin and chair of the panel that produced the *Gathering Storm* report, does not buy their arguments. In an e-mail to other members of the panel, Augustine notes that "what the [new analysis] does not observe is that an undergraduate degree in [science or] engineering is a prized credential for those who wish to attend business school, law school, medical school or [go into] a number of other fields[.] ... If the *Gathering Storm* report is incorrect, we will end up having devoted additional dollars to improving our children's education and to the discovery of new knowledge. On the other hand, if Drs. Lowell and Salzman are wrong, America may well face a serious growth in unemployment and a commensurate decline in its standard of living."

Those who argue for strengthening U.S. science education say that NAEP is not the right yardstick for measuring what today's students need to know. "In a global economy with a global labor pool, it is insufficient to compare American students' past performance to American students' current performance," says Bill Bates of the Council on Competitiveness, one of several groups that lobbied heavily for the COMPETES Act. Salzman and Lowell say that they are not arguing for the status quo but rather that any new policies should address the real problems in STEM education. For elementary and secondary schools, they call for more resources for the lowest performing students, many of whom are minorities. And within higher education, they say that scholarships should be based on market demand for workers trained in individual disciplines rather than across-the-board support. Salzman also recommends that universities put greater emphasis on teaching communications and teamwork skills. "The iPod's success has had more to do with its creative design rather than its technical guts," he says.

Augustine says Salzman and Lowell have raised some important issues but that he is worried their criticism could undermine efforts to boost the research and training budgets of federal research agencies slated for growth in the COMPETES Act. However, David Goldston, the top staffer on the House Science Committee before he retired from the government last year, doesn't think their paper will weaken the case for greater investments in science and engineering. "It's worthwhile to debate what the nature of the investments should be, what part of the social scale they should be targeted toward, and what competitiveness really comes from," he says. If the new study sparks those discussions, Goldston adds, "that's all to the good."

–YUDHIJIT BHATTACHARJEE

* www.urban.org/UploadedPDF/411562_Salzman_Science.pdf



Against the grain. Harold Salzman (*center*) told Congress last week that the United States produces enough technical workers for the economy.

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