Policy Dialogue

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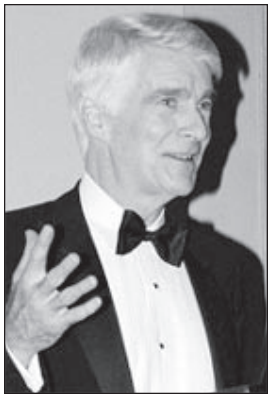
Preeminence in Peril

Bolstering Science and Math Education



The 2004 Lovett C. Peters Lecture in Public Policy focused on the disturbing gap in the number of science, technology, engineering, and mathematics graduates that the United States turns out compared to other nations. ***Robert J. (Bob) Herbold,*** *(pictured at right), a retired Microsoft official and chair of the President's Council of Advisors on Science and Technology's Workforce/Education Subcommittee, argued the situation threatens our nation's position as the world's industrial leader and requires immediate action to strengthen science and math education in our schools—including instituting merit and differential pay for teachers in such subjects. An edited transcript of his remarks follows.*

America's Innovation Ecosystem

This is a very important topic for the country. If you look back over the last 100 years in this country, it is obvious that we are the leader on a global basis with respect to entrepreneurship and innovation. And the important thing is that we want to keep it that way.

We have an innovation ecosystem in this country made up of several different entities that coalesce to form a very powerful force. A lot of innovation is spawned in our research universities. Government-funded research is also critical. Some of that money gets funneled through universities and is spent on smart things that lead us into new areas, creating new industries. Corporate research and development centers are also vitally important, as is the venture capital industry in this country.

One of the unique things about America is, from a business standpoint, it's actually okay to fail. You can convince a venture capitalist to give you a lot of money and then fail. You don't have to go jump off a building. You can have another bright idea and go back to the venture capitalists again and get yet more money. That's a good deal for this country because venture capitalists bet that, sooner or later, you are going to hit a few doubles and triples and home runs. And that's typically what happens.

Last but not least is this country's free enterprise system—that you have the ability to go out on your own and sink or swim. All these things put together make up the innovation ecosystem.

In terms of innovation, another thing that drives success in this country is the fact that we have two sources of incredible talent—one narrow and the other very broad.

Listen to the lecture—including questions and answers—and access a slide show accompanying the lecture online at **www.pioneerinstitute.org/herbold.cfm.**

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The narrow one is that in the area of physical science and engineering, at the Ph.D. level, we have typically been very talented. Why do I mention physical science and engineering? The major industries that have been generated in this country—the pharmaceutical, information technology, biotech, and going back further, automobile industries—are based on incredible innovation around physical science or engineering. That's why it's important for our country to worry about our strengths in these areas.

The major industries that have been generated in this country are based on incredible innovation around physical science or engineering. That's why it's important for our country to worry about our strengths in these areas.

The second core strength in America is a broad-based capability among the population in regard to science and math. That's because we've had relatively good schools. Of the top Fortune 100 companies, a little over 50 percent of these companies' leaders have technical backgrounds. This is a country where, basically, industries are built on technology and science and engineering.

What's the goal? Obvious—to protect this innovation ecosystem so that we can continue to be the innovation leader on a global basis.

How Are We Doing?

How we are doing is the crux of what I want to talk about. The panel I chaired came out with a number of findings. Finding number one is very obvious when you look at the data. We are significantly losing our share of the STEM (science, technology, engineering, and mathematics) expertise. Our share of bachelor's degrees and Ph.D.s in these areas is declining quite precipitously [see figure 1].

In 2001, about a million and a quarter bachelor's degrees were granted in the U.S.—59,500 were in engineering. In other words, about 5 percent of those degrees were in engineering. In China during that year, almost 570,000 degrees were granted, but 39 percent of them were in engineering. They generated about 220,000 engineers.

Figure 1. B.S./B.A. degrees - 2001

	B.S./B.A. degrees	B.S. engineering	% engineering
United States	1,253,100	59,500	5%
China	567,800	219,600	39%
South Korea	209,700	56,500	27%
Taiwan	117,400	26,600	23%
Japan	542,300	104,500	19%

Source: U.S. Department of Education, 2003

More recent figures are starting to come out and the trend continues in terms of this kind of massive discrepancy. But it's not just China; it's Asia. In South Korea, 27 percent of their graduates are engineers. They produce about the same number of graduate engineers at the bachelor's level as we do here in the United States. Taiwan, a small country that is less than half our size, is producing about 26,000 engineers per year—23 percent of their graduates.

On a global basis, we do not look like the giant. Compared to ten years ago, our numbers have fallen very significantly.

Looking at both engineering and science [figure 2], you see Singapore, China, Korea, and Taiwan with very high numbers of bachelor's degrees. Europe is generally in the 20 to 30 percent range. In the United States, only 17 percent of all graduates received a degree in engineering and science. Obviously, this a very worrisome trend.

Figure 2. Engineering and science degrees as % of all bachelor's degrees

Singapore	68%	Germany	31%	USA	17%
China	58%	U.K.	28%		
S. Korea	36%	Sweden	24%		
Taiwan	34%	Belgium	22%		

About the Speaker

As Executive Vice President and Chief Operating Officer at Microsoft Corporation from 1994 to 2001, Bob Herbold managed all operational aspects of the software giant during its rapid growth. He previously was Senior Vice President at Procter & Gamble, where he spent 26 years.

Now managing director of his own business, Mr. Herbold is the author of a newly published book, *The Fiefdom Syndrome: The Turf Battles That Undermine Careers and Companies – And How to Overcome Them*. He serves on the President's Council of Advisors on Science and Technology and chairs its Workforce/Education Subcommittee.

Now let's talk about the numbers of physical science and engineering Ph.D.s [figure 3]. Back in 1987, 4,700 U.S. citizens got these kinds of degrees. The number of Asian citizens who got these degrees, no matter where they got them, was 5,600. Going forward in time, the U.S. number remains relatively stable, while the number of Asian citizens grows. Today, they're producing well over five times the number of Ph.D.s in these very important areas that typically drive core innovation and have the capability of generating entire industries.

Figure 3. Physical science and engineering Ph.D.s

	U.S. citizens	Asian citizens
1987	4,700	5,600
1991	4,800	10,700
1995	4,900	15,600
1999	4,800	21,300
2001	4,400	24,900

Source: National Science Foundation, 2001

This is a very important trend and probably one of the most worrisome set of data in my presentation. A Nobel Prize winner at Rice University, R. E. Smalley, predicts that by 2010, 90 percent of all Ph.D. physical scientists and engineers in the world will be Asian, living in Asia. If his prediction turns out to be true, we are faced with some major league challenges in terms of keeping up on the innovation race.

The second finding is that the foreign countries that are producing all these students typically have low wages. Their standard of living is at a different stage of the development curve than ours. The differentials are huge, not only in India [see figure 4] but in Asia. Most importantly, though, some of these countries, particularly China, are beginning to receive investments from U.S. companies—global companies, really—which look at that environment and realize they can hire really good students and take advantage of the lower standard of living and lower wage scale in those countries. This is an important trend, with investment going from $7 million ten years ago to $3 billion today, and one that we need to pay attention to.

Figure 4. Comparative salaries

	U.S.	India
Software programmer	$66,100	$5,900
Mechanical engineer	$55,600	$5,900
IT manager	$55,000	$8,500
Accountant	$41,000	$5,000

Source: *Time* magazine, 8/4/2003

The third finding is that our K-12 science and math scores are really weak both in the absolute and versus other countries. The National Assessment of Education Progress tests students and rates them in four categories [see figure 5]. In science, only 2 percent of our twelfth graders achieved an advanced rating—the top category. Sixteen percent were categorized as proficient (solid academic performance for the grade that's being assessed), 34 percent achieved partial proficiency, and 47 percent were below partial proficiency. These numbers are not a surprise, but they are incredibly sobering in the absolute.

We are turning out students who by and large aren't qualified in science. And if you put in the 25 percent of students who have dropped out, these numbers are even worse.

Figure 5. National Assessment of Educational Progress, U.S. students, science and math, 2000

	4th grade		8th grade		12th grade	
	sci	math	sci	math	sci	math
Advanced	4%	3%	4%	5%	2%	2%
Proficient	26%	23%	28%	22%	16%	14%
Partial proficiency	37%	43%	29%	38%	34%	48%
Below partial proficiency	34%	31%	39%	34%	47%	35%

What's also important is how we are doing relative to other countries [see figure 6]. This is fascinating information. Our fourth graders rank in the 87th percentile in science compared to other nations—which means our scores are ahead of 87 percent of the countries that participated.

But that number drops off to 64 in the eighth grade, and is down to 23 in the twelfth grade. Comparing our advanced placement students to those in other countries, we are in the third percentile, which means 97 percent of other countries outperform us. It looks like the longer you are in the system, the further you fall behind. The math scores are even worse than the sci-

Figure 6. Student achievement by percentile (rank versus other countries)

	Math	Science
4th grade	53	87
8th grade	33	64
12th grade	9	23
12th grade advanced math & physics	7	3

Source: The International Math and Science Study

Middle school students have a 93 percent chance of being taught by an out-of-field teacher. A teacher who is basically trying to keep up day-by-day is certainly not going to stretch or inspire a student.

ence scores. Our scores are not only weak, they are far, far weaker than other countries.

The fourth finding is that America needs dramatic change in K-12 teaching. The quality of our teachers in terms of their backgrounds is really hurting. Fifty-six percent of high school students taking physical science are taught by an out-of-field teacher—a teacher who didn't even minor in the subject. At the middle school level—seventh, eighth, and ninth grades—students have a 93 percent chance of being taught by an out-of-field teacher. A teacher who is basically trying to keep up day-by-day is certainly not going to stretch or inspire a student.

Most teachers these days are not teaching curriculum that would even bring the student up to that grade level. It's obvious we have a core issue in terms of teaching quality at the K-12 level as it relates to math and science.

There have been efforts to go after a national curriculum. The National Commission on Excellence made a strong recommendation as to what the curriculum should look like in math and science, with a three-year program in math and two years in science. Unfortunately, in science, only 24 percent of schools are following it. One of the difficult issues in K-12 education is how fractionated it is; school systems, principals, and teachers all operate independently.

Recommendations

▶ *Execute "No Child Left Behind" with excellence.*

The number one recommendation the panel made was that the core principles behind the No Child Left Behind Act—accountability, measuring progress, and the quality of the teachers—need to be executed with real excellence. To some extent, this whole program has become a political football. School systems around the country are working hard to find ways to circumvent this program by modifying testing procedures and the like. It's very important that this law be implemented with excellence.

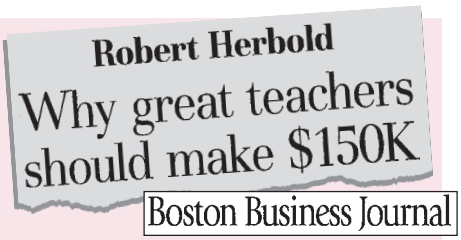
▶ *Require high school students to take three years of math and two years of science.*

The second recommendation that our group made was that we have to support the National Commission on Excellence in regard to curriculum for high school graduation; three years of math and two years of science ought to be required and the quality of the curriculum be adequately high.

▶ *Support school vouchers, charter schools, and new avenues for teacher certification.*

The third recommendation was to support all kinds of routes for teachers' certification as well as vouchers and charter schools. We need competition. Parents should have the ability to go elsewhere when they don't get the quality that they should be getting from the school in their local area.

While in Boston, Bob Herbold was interviewed by the *Boston Business Journal*. Read the Q&A online at **www.pioneerinstitute.org/news/BBJ12_7_04.html.**



▶ *Make teaching a more attractive profession by encouraging good management practices in K-12 public schools.*

The fourth recommendation was to make the K-12 teaching profession attractive again. It needs good management practices if it's going to become attractive to our best and brightest kids coming off college campuses. We need performance appraisals. We need salary differentiation. We need strict discipline guidelines.

Bob Herbold addressed invited guests at the sixth annual Lovett C. Peters Lecture in Public Policy December 1, 2004.

The teachers' unions fight performance appraisals. They do not believe it is right to evaluate teachers. They believe that all teachers are focused on the mission of training our children and that is a noble mission and that is enough to be said on the subject. This leaves them with no way to really differentiate salary because they have no performance evaluation. Consequently, most teachers make about the same amount of money as they progress, year after year. It's a system that rewards staying around as opposed to rewarding excellence.

There is no reason why the top 5 to 7 percent of K-12 teachers shouldn't be making $100, $125, $140,000. Similarly, there's absolutely no reason why every year, 5 percent of teachers shouldn't be put on probation and be told, "If it doesn't get any better than this, you're out of here."

There's no doubt that in this country a person getting out of college and thinking about teaching should be able to look at that profession and say, "I really will be appreciated. I will be able to pursue some change and do some innovative things. And I can make plenty of money." There is no reason why the top 5 to 7 percent of K-12 teachers shouldn't be making $100,000, $125,000, or $140,000. Similarly, there is absolutely no reason why every year, 5 percent of teachers shouldn't be put on probation and be told, "If it doesn't get any better than this, you're out of here." That does not happen and it needs to happen.

Strict discipline guidelines are needed because in some school systems teachers live in fear of being fired or sued for disciplining students. We can't have it that way. We need some solid thinking in terms of how we protect teachers so that they can run classrooms the way they should be in order to instill the discipline in students and get the rigor in the curriculum that we all know is needed.

▶ *Urge universities to reduce the time to get a Ph.D. in science and math.*

The fifth recommendation was that we need to drive down the time it takes to get a STEM Ph.D. Over the last 10 to 15 years, that time period has lengthened and now it averages 7.2 years from the time a student gets a bachelor's degree until he or she receives a Ph.D. What's worse is that it's an unpredictable amount of time for the student. In some cases it's as much as nine years. A good student will look at that and say, "Well, I can, with a fair amount of certainty, go to medical school and know that the program is four years. Or I can go to law school and be fairly assured that within three years I will be out of the program." Consequently, a really bright student who has a lot of options in regard to what to do in the future realizes that this is not an attractive system to dive into unless he or she is truly wedded to and excited by science.

We also had some recommendations dealing with funding from the government for universities to continue to support great research and the like. But in the interest of time, I'm going to conclude there.

From the Introduction by Charles Vest, then-President of MIT

Our nation has many enemies these days. In my view, the greatest of these is complacency—complacency about the very engine of science and technology-based innovation that drives our economy and the educational underpinnings and policies that surround the so-called innovation ecosystem.

This problem is so frightening that the Council on Competitiveness—a group of CEOs of corporations from many different sectors, university presidents, and labor leaders—together with a number of members of the Bush administration, will hold a summit in Washington to kick off the National Innovation Initiative. The theme for that kickoff will be "innovate or abdicate," which could very well be a subtitle for Bob Herbold's presentation.

Bob is definitely knowledgeable about this critical topic. He is chair of the workforce education subcommittee of PCAST, the President's Council of Advisors on Science and Technology. His remarks draw heavily on a comprehensive report on these issues, which was recently issued under his chairmanship.

I'm fortunate to serve with Bob on PCAST. As I've watched him explore these complex questions, I've been struck by his commitment to fact-based analysis and thoughtful concern for the large picture. I know that you all share or certainly should share Bob's concern for the future of innovation in America.