Summary of Arguments & Remedies re: Math and Science Education/Skills Crisis

Is there a crisis in math and science education in the US?

Firms, business organizations, some educators and policy makers warn of a crisis in math and science education in the US and have published a number of papers and reports intended to either articulate the problem or generate a response. [Key papers are summarized in Table 1.]

The argument: Math and science skills are critical to our ability to innovate. Innovation is the new competitive advantage in a global economy. US students are lagging in math and science, undermining the nation's ability to compete and threatening its future prosperity. Diminished US Government investment in R&D undermines the nation's capacity to conduct the kind of basic research that has lead to some of our most significant science and technology breakthroughs (e.g., the Internet) and created blue oceans of commercial applications.

The evidence cited includes:

- US youth score less well than youth in competitor nations math and science assessments.
- Fewer American students enrolling in higher education are majoring in math and science than in competitor nations.
- Too many students who do major in math and science change majors before they graduate (or don't graduate).
- Too few graduate students are majoring in math or science and 50% of them are foreign-born—and increasingly in-demand in their home countries.
- Too few PhDs are engaged in basic research.
- Federal R&D dollars have declined and are increasingly focused on security, rather than basic research.
- The percentage of knowledge capital (patents and papers) produced by US scientists as a percentage of the total is declining.
- The US has significant equity challenges—the performance of US-born minority students in math and science and their presence in professional circles is significantly lower than that of their white counterparts.

There are also contrarian views, denouncing the idea of a crisis.

- A 2004 Rand Corporation Report concluded: "Despite recurring concerns about potential shortages of STEM [scientific, technical, engineering, and mathematics] personnel in the U.S. work force, particularly in engineering and information technology, we did not find evidence that such shortages have existed at least since 1990, nor that they are on the horizon."
- Charles Kruthammer (Time, February 13, 2006) decries the doomsayers, pointing to the increasing productivity of US workers, a culture of entrepreneurship and our 3.5 economic growth rate (second only to Finland's in the developed world.

Another view holds that a science career is not economically rational:

- The education and training time relative to the economic payoff (a series of post-docs, followed by non-tenured positions in common) makes a PhD science career unattractive to many young professionals, particularly when their skills are valued in consulting and other high-wage professions.
- It's difficult to predict economic cycles—in the recent recession, people entering the labor market with computer science degrees, for example, tended not to fare well. Each recession has seen its share of unemployed PhDs.

And the possibly the most important links in the chain—parents and kids—don't think there's a problem at all. A 2006 Public Agenda survey found:

- Most parents think their children's schools will prepare them for college (69%) and for work (61%), and that schools today are better (61%) and harder (65%) than when they were growing up.
- When asked what their major concerns were, only 12% identified curricula and 73% identified social issues.
- The number of parents who worry about whether their children are learning enough math and science has declined since the late 1990s.
- 70% of high school parents report that their children's schools are teaching the right amount of math and science.
- Students are no very concerned about math and science either—24% report that kids are not taught enough math and science, compared to 64% who worry about discipline and 54% who worry about cheating.
- Half of all students say math and science skills are critical to their futures, but 4 in ten report they would be "really unhappy" in a math or science career.
- Interestingly, while these attitudes did not substantially differ between boys and girls, minority students (Blacks and Hispanics) were far more likely to thing math and science skills are important and were more worried they were not learning enough of them.

Adding some nuance…

1) Are we looking at the right data? Are PhDs awarded really the key indicator of math and science capacity or propensity for innovation?
    - Most labs also employ MS and BS degreed professionals
    - Most engineers are not PhDs
    - We're only partially counting science achievement that shows up in cross-disciplinary degrees that are increasing in number, appealing to today's students, and offer at least as much opportunity for innovation. Environmental Studies is a good example of this.

Environmental Studies—Science that's not called science.

In 1960, there were fewer than 20 Environmental Studies programs in US colleges and universities. By 2003, there were 1,061 such programs. A survey of these programs completed in 2003 claimed that it was student demand leading to their growth and development, but in the same year, the top 10 environmental job categories were predicted to grow an average of 18% over the next decade—far more than average expected job growth across the economy. Of these 1,061 programs, 86% are science-driven, but only 27% of graduates earn their degrees in science. The remainder earns law, economics, business, management, urban planning and BA degrees. But all of them are trained in science (and some in math as well). And their degrees range from 4-year to Masters and PhD level.

2) *Are we framing issues around skills and innovation in compelling (or accurate) ways?* If the point of increasing attention to math and science skills is the application of those skills in discovery, invention and innovation—then shouldn't we be we should be talking about the latter. There is evidence of rising interest in discovery and invention, but it's not necessarily connected to math and science discussions typically convened by practioners, teachers, business people or policymakers.

   For example, during the last few years there has been a dramatic rise on what many have called DIY ("do it yourself") movement, marked by renewed interest in everything from small business ownership to sewing circles. While this is not "science" in a policy sense, it has motivated skill development among the science and non-science educated across the board and spawned a variety of new products, services and communities of interest, including a fascinating little magazine called *Make: Technology on Your Time*. Now in its second year and growing faster than its editor and publisher predicted, *Make* sits squarely in the DIY movement, acting as a bridge between the artists and back-year inventors and top-notch Intel engineers regularly featured in its pages and at its annual *Maker Faire* comprising workshops and competitions on everything from Robotics to Green Technologies.

   All more inspiring than warnings about math and science skill shortages.

3) Are we competing on our strengths? Ingenuity, inventiveness and entrepreneurship among them? While we are lamenting our small number of engineering graduates compared to China's, the Chinese are also worried about a talent shortage of engineers. According to a recent McKinsey Quarterly (*China's Looming Talent Shortage*, #4, 2005), the Chinese educational pipeline for engineers emphasizes theory rather than practice, leaving few graduates having had experience working in teams, completing projects or designing solutions to real-world challenges. The resulting paradox is a shortage (of talent) among plenty (of jobs). This suggests that the quality of science and math education is at least as important and the quantity of graduates we produce.

More ingenuity…

In a recent NPR interview, Neil Gershenfeld, author *FAB: The Coming Revolution on Your Desktop*, told a story about piloting a class at MIT around Fab labs (or personal fabrication labs that allow the user to make almost anything). The class filled immediately and organizers were flooded with students begging to get in—and only a few of these students were science majors. Most were non-technical students inspired by the idea of designing and creating something of their own. Among the inventive things they developed? A web-browser for parrots, clothing with personal security sensors intact, and an alarm clock the use must wrestle with to turn off (and therefore prove they are awake). Gerhsenfeld noted, "These students answered a questions I hadn't asked—"what's it good for?" They pushed the envelope of what's possible and helped to democratize invention.

Where from here?

We can agree that math and science are increasingly important skills sets, and that we all have a role to play in creating access to more education and professional development opportunities for more and more diverse individuals all along the education and career continuum.

We can probably also agree that there is no one magic bullet—no one strategy—for making sure that the math and science education offered in our schools will help our students remain competitive in the 21st Century global economy. Rather, we all have a responsibility to do our part as students, parents, educators, community members, business people and policy makers.

Workforce Boards are in a unique position—they are good at developing partnerships—the one recommendation most of the math and science crisis reports agree upon. Many Boards have been active in building the math and science skills of their communities, either directly, or as part of broader sector-based or school-to-career initiatives.

- For the past three years, our own Board—The Chicago Workforce Board—has worked with Argonne National Labs and Chicago Public Schools to make possible an educational program comprising a series of "virtual visits" in which CPS students conduct experiments in conjunction with Argonne Scientists. In addition to the science and research content, a career component is built into the program that encourages students to ask the scientists about their own education and career paths.

- The San Diego Workforce Partnership has done much policy work on education in partnership with Biocom, the region's premier BioScience Industry Association—inventorying educational content and programs, characterizing skills shortages including those in math and science, advocating for specialized training programs (e.g. Lab-to-Leadership programs), and helped launch innovative programs like the Life Science Summer Institute, an eight-week internship and training program for high school, community college and four-year college students, and this year, for high school teachers as well.

- As part of the statewide Skills Shortage Initiative project, the Center of Workforce Innovations—the Workforce Board in Northwest Indiana—is putting together a summer boot camp in advanced manufacturing technology for middle school students (grades 6-8). While this component is one of a package of responses to skills shortages intended to work collectively, it brings new partners to the table including middle school teachers and principals and industry mentors.

- The Philadelphia Workforce Board, in collaboration with the Delaware Valley Healthcare Council, key healthcare and life sciences employers in the region, educational institutions and workforce partners including the Workforce Boards in Delaware, Bucks, Chester and Montgomery counties, launched the Life Sciences Career Alliance to focus on building the next generation of industry talent in greater Philadelphia.

Similar initiatives are occurring across the country. Workforce Boards occupy a unique position—they can assess their community's specific needs in relation to national and global trends, and develop programs and solutions that are both locally relevant and advance broader education and skill development needs nationally.

Table 1: Summary of Key Reports—Findings and Recommendations

Report	Argument	Recommendations
Losing the Competitive Advantage (AeA, 2005)	Once developing nations are quickly becoming US competitors by: ▪ Adopting market-friendly policies and participating in global commerce ▪ Adopting technologies created elsewhere and "leapfrogging" ahead [e.g, adopting cell phones as first phones—the US ranks 42nd in cell phone adoption (54% penetration) and Taiwan ranks 1st with 110 cell phone subscriptions for every 100 people. ▪ Investing in R&D ▪ Attracting US and European-trained talent back for jobs in their home-countries. The US faces serious challenges: ▪ Federal R&D funding has declined—funding for the National Science Foundation (investor in the internet, web-browser and mouse, together with Doppler radar, the MRI and nanotechnology) was cut for the first time in 15 years (in 2005). ▪ K-12 schools are not equipping students with the math and science skills they need to succeed in the 21st Century (while the math and science proficiency of 4th and 8th graders has improved, the figures plummet by the 12th grade, placing the US 19th in math and 16th in science out of 21 participating countries). Scores of minority students increasing—closing the gap with white students. But the poverty rate (measured by percentage of free or reduced-cost lunch) remains highly correlated with diminished performance. ▪ US Colleges and universities are not graduating enough science and engineering majors at any level and of math and engineering PhDs awarded in the US, 50% went to foreign nationals. ▪ The high (and increasing) cost of a college education is outpacing families' ability to pay and federal assistance is diminishing. ▪ Our aging population will leave major research labs and federal and state research and technology agency bereft of the talent they need in the coming decade. ▪ Post-9/11, the US has erected unreasonable barriers to	Report focuses on articulating the problem, not posing recommendations.

	immigration for learning or work, European, Canadian, Australian and Asian universities are reaping the rewards of talent no longer willing or able to work or study in the US.	
"Waiting for Sputnik" (Center for Strategic and International Studies, 2005)	This report argues that many recommendations for addresses the "innovation crisis" are good ones, but difficult to implement. One investment that would make a profound difference across a range of disciplines, defense among them is basic scientific research. The author argues that the government has faced similar pressures as the private sector facing demands for accountability, which drives short-term, quick turn product-cycle research but fails to prepare industries for the next generation.	The paper calls for: ▪ Restoring government funding for basic research across the sciences ▪ A larger percentage of DOD budget allocated to R&D ▪ Improved public-private partnerships and new models of collaboration on the innovation and talent agendas ▪ New incentives and funding vehicles to leverage private investment
Five Strategies to Improve Mathematics and Science Education (Education Commission of the States, 2005)	This paper offers the simplest logical argument of all of them: America's role as an economic leader and capacity to produce good jobs depends upon its ability to prepare its people to compete in the math- and science-based industries of the future. The paper summarizes the remarks of a conference that brought policymakers and math and science researchers together. Data cited includes the PISA (Program for International Student Assessment, comparison of US performance with other OECD countries' performance); the Trends in International Mathematics and Science Study; and the National Assessment of Educational Progress (NAEP). These are the same sources cited in all of the core reports. 80% of the fastest growing US jobs and 2/3 occupations with the largest numbers of new jobs in the US require math and science skills The US relies too much on foreign-born talent, which is now in higher demand all over the world as rapid development occurs	Five suggested strategies to address these trends include: ▪ Effectively assess student learning in math and science ▪ To strengthen teacher knowledge and skills in science and math ▪ To ensure high-quality math and science teachers are available to the most disadvantaged students ▪ To ensure srong leadership from the higher education community ▪ To promote public awareness of the importance of math and science education
Tapping America's Potential (The Education	Report is concerned with three sets of trends: ▪ Increasing international competition	▪ Build public support for making math, science, engineering and

for Innovation Initiative, 2005)	▪ Increasing reliance on and reduced availability of foreign-born talent in the US ▪ Negative trends in domestic math and science performance (student scores and graduation rates) The Initiative's stated objective is to increase the number of science, technology, engineering and mathematics graduates with bachelor's degrees by 2015.	technology education a national priority. ▪ Motivate US students and adults to study and enter science, technology, engineering and mathematics careers, with special effort geared to those in under-represented groups. ▪ Upgrade K-12 math and science teaching to foster higher student achievement ▪ Reform visa and immigration policies to enable the US to attract and retain the best and brightest science, technology, math and engineering students from around the world to study for advanced degrees and stay to work in the US ▪ Boost and sustain funding for basic research, especially in the physical sciences and engineering
The Knowledge Economy: Is the United States Losing its Competitive Edge? (The Innovation Taskforce, 2005)	This paper offers benchmarks in the areas of: ▪ Student performance ▪ Knowledge capital [Share of US science and engineering papers declining (to 31% in 2001 from 38% in 1988), ▪ Europe's and Asia's are increasing] ▪ Patent applications [Asia's numbers have increased 8 times faster than the US in ten years, through Asia started at much lower baseline] ▪ Investment in R&D [R&D investment in Taiwan, China and south Korea grew four times faster than US investment in R&D between 1995 and 2001, and more Asian R&D targeted basic research, while US R&D investments favored shorter-term product-focused research.] ▪ China has surpassed the US as the world's leading recipient of Foreign Direct Investment	Report focuses on benchmarks and does not offer solutions.

A Commitment to America's Future: Responding to the Crisis in Mathematics and Science Education (The Business Higher Education Forum, 2005)	This report departs from the others in its emphasis on interdisciplinary work—it recognizes that future innovation will come as much from connections between science and math disciplines as within them—and that typical higher education systems work against this kind of collaboration. Data sets cited are same as cited in previous reports (PISA, TIMMS, NAEL).	The most radical report of the collection, this report argues only significant structural change—in all 50 states—will make sustained improvements in the nation's stock of math and science talent. It calls for simultaneous revision of multiple components of the educational infrastructure—governance, standards, teacher training, curricula and policy, linked to four recommendations: ▪ Establish P-16 Education Councils in each states to provide guidance and oversight on K-12 and in the transition of students to higher education or work (or both). ▪ Simultaneously improve and align all five components of K-12 math and science education: content standards, curricula, assessments, teacher preparation and accountability. ▪ Engage business and higher education more effectively in school reform. ▪ Implement coordinated and state-specific public information programs (campaigns).
National Defense Education and Innovation Initiative: Meeting America's Economic and Security Challenges in the 21st Century (Association of American Universities, 2006)	This report makes an argument very similar to the AeA Report, using the same figures. It also notes the following (but offers no additional data): ▪ Emphasis on foreign language/experience as a 21st Century skill-set ▪ More emphasis on retaining students who enroll in college and university science programs in the pipeline ▪ More emphasis on creating opportunities for women and minorities in fields where they are under-represented	Solutions emphasize the equally important roles of government, universities and colleges, and business. Recommendations include: enhancing research and innovations; cultivating American talent; and attracting foreign talent, offering specific strategies for government, universities and colleges, and business in each area. Important

		themes in recommendations include: ▪ (More and more regular) blending of research and learning for students and teachers; Stronger school-industry partnerships at all levels; ▪ Accelerating degree and certification programs; increase public and private investments in research and talents; ▪ More effective use of the “bullypulpit” and of public workforce and education systems by business
Globalization is Forcing US Schools to Take a Broader View of Student Performance (Educational Vital Signs, 2006)	▪ 20 years ago, the US led the OECD in the number of 25-34 year-olds with high-school diplomas and college degrees; today the US ranks 9th and 7th on those measures respectively, and 16th on high school with 73% completing high school completion (73%--rivaling Greece and the Czech Republic. ▪ A 2004 OECD student ranked the US 21st in math and 23rd in problem-solving—with only 10% of Us students scoring high-level proficiency compared to an average of 13% and over 20% for the top eight scorers. ▪ But, SAT scores have risen steadily, even as the percentage of students taking them has increased and become more diverse—this is good news. ▪ Today’s 9 and 13-year olds score significantly better on math assessments than in 1975—with steady improvement despite increased language, ethnic and income diversity.	Report focuses on data, not recommendations.
Rising Above the Gathering Storm (National Academy of Sciences, National Academy of Engineering and Institute of Medicine, 2006)	Report documents trends across a wide range of issue aeas, focuses on recommendations.	▪ Increase America’s talent pool by vastly improving K-12 science and mathematics education ▪ Sustain and strengthen the nation’s traditional commitment to long-term basic research that has the potential to be transformational to maintain the flow of new ideas that fuel the

		economy, provide security, and enhance quality of life ▪ Make the US the most attractive setting in which to study and perform research so that we can develop, recruit and retain the best and brightest students, scientists, and engineers from within the US and throughout the world ▪ Ensure that the US is the premier place in the world to innovate; invest in downstream activities such as manufacturing and marketing; and create high- paying jobs based on innovation, and ensuring affordable broadband access