Education Commission of the States

Keeping America Competitive:

Five Strategies To Improve Mathematics and Science Education

Charles Coble and Michael Allen

July 2005

This report was made possible by a grant from the National Science Foundation (NSF # 0450138) and through support from the Johnson Foundation, which allowed use of its Wingspread Conference Center in Racine, Wisconsin.

The views expressed here do not necessarily reflect the views of NSF, the Johnson Foundation or of individual meeting participants.

Introduction

Improving mathematics and science education in the United States belongs near the top of the policymaking agenda. America's role as a leader in the world's economy and its capacity to produce wealth and quality jobs for its future citizens depend directly on the ability of our education system to produce students who can compete in the math- and science-dominated industries of the future.

Recognizing the seriousness of this issue, the Education Commission of the States (ECS), with the support of the National Science Foundation (NSF), brought together a nationally prominent group of experts at the Johnson Foundation's Wingspread Conference Center in Wisconsin. Participants included a carefully chosen mix of state policymakers and mathematics and science researchers – two key stakeholder groups who seldom have the opportunity to engage in the kind of extended dialogue the Wingspread conference made possible. The group was charged with listening to each other's thoughts and concerns, and then developing recommendations to help improve math and science education.

This paper, which is based on the experts' discussions, includes a brief overview of the importance of math and science education to U.S. global competitiveness and the performance of U.S. students on recent national and international tests. It culminates in five key strategies to policymakers, university leaders, education researchers, and math and science educators.

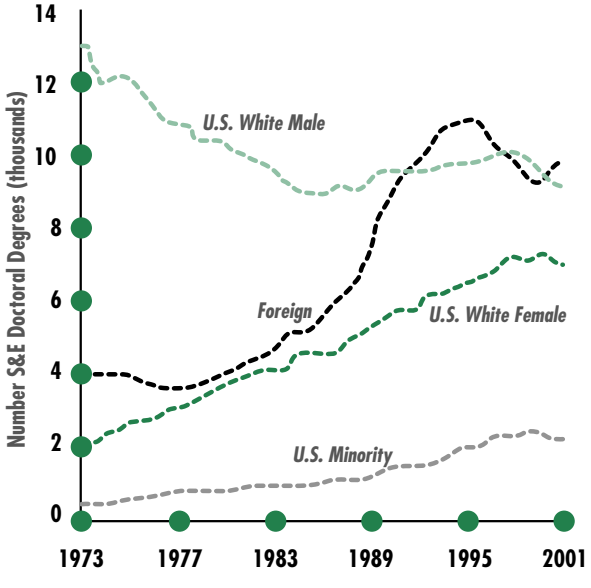
Wingspread Conference Participants
November 2004

Michael Allen, Education Commission of the States
Valerie Lewis, Connecticut Higher Education Commissioner
Deborah Loewenberg Ball, University of Michigan
Hazel Loucks, National Education Association
Rodger W. Bybee, Biological Sciences Curriculum Study
Carol Malloy, University of North Carolina at Chapel Hill
Charles Coble, Education Commission of the States
Peter McWalters, Rhode Island Education Commissioner
Dale DeCesare, Augenblick, Palaich & Associates
Barbara Olds, National Science Foundation
Anthony DeLegge, Wingspread Fellow
Michael Padilla, University of Georgia
Janice Earle, National Science Foundation
Suellen Reed, Indiana Superintendent of Public Instruction
Susan Fuhrman, University of Pennsylvania
Pat O'Connell Ross, U.S. Department of Education
Nicole M. Gillespie, Knowles Science Teaching Foundation
Jim Rubillo, National Council of Teachers of Mathematics
Janet Hansen, RAND Corporation
Alan Schoenfeld, University of California-Berkeley
Kaye Howe, University Corporation for Atmospheric Research
Iris R. Weiss, Horizon Research, Inc.
Carole M. Johnson, The Johnson Foundation
Gerald Wheeler, National Science Teachers Association
Paul Kimmelman, Learning Point Associates

The Rising Threat to American Competitiveness

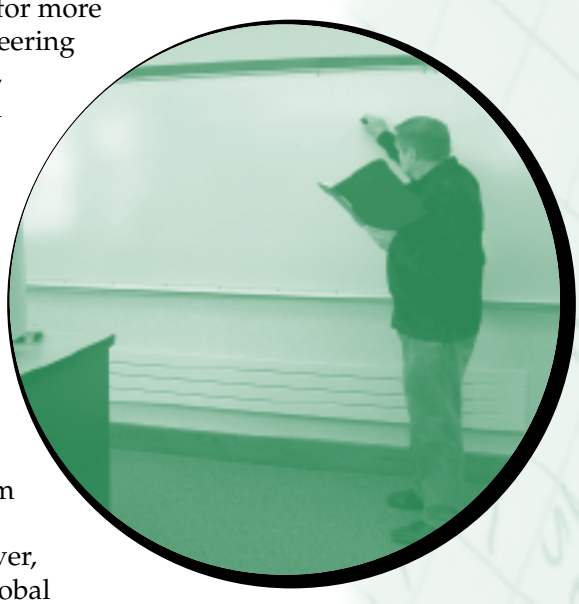
America's competitive edge in the global economy, the strength and versatility of its labor force, its capacity to nourish research and innovation – all are increasingly dependent on an education system capable of producing a steady supply of young people well prepared in science and math. It is widely recognized that many of the dominant industries of the future – and the highest-paying jobs that these industries produce – will be driven by advances in technology that require a strong math and science education.

In fact, over the past two decades alone the U.S. science, engineering and technology workforce has grown at more than four times the rate of total employment.[1] Occupational Employment Statistics projections for 2000-2010 reveal that over 80% of the fastest-growing occupations and two-thirds of the occupations with the largest job growth are dependent upon a knowledge base in science and mathematics. By contrast, less than 10% of the occupations with the largest-projected decline from 2000-2010 are science-math related.[2]



U.S. science and engineering doctoral degrees, by sex, race/ethnicity and citzenships status 1973-2001
(National Science Foundation, Science and Engineering Indicators 2004)

In large part, the United States has remained competitive in the science- and math-driven industries of the future by integrating large numbers of foreign-born scientists and engineers into the domestic workforce (see graph at right). In 2002, for instance, foreign nationals accounted for more than half of all engineering and math doctorates, and almost half of all computer science doctorates.



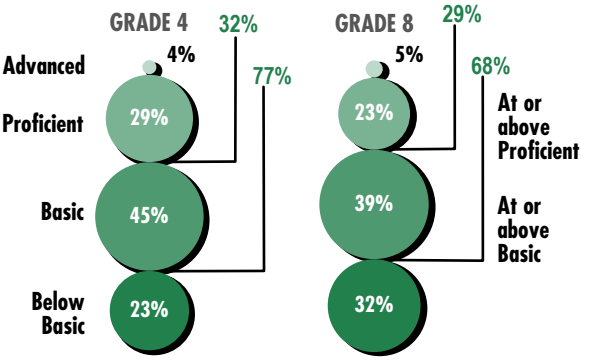
These foreign-born students have, in the past, provided a stop-gap for the consistent shortages of well-prepared math and science students the U.S. education system produces for itself. More recently, however, competition in the global marketplace for these workers has widened and intensified. In this environment, there are no guarantees that future foreign students with math and science talent will choose to remain in the United States after they receive their advanced degrees.

An over-reliance on the math and science talent of foreign students represents a major potential weakness in the future competitiveness and vitality of the U.S. economy and workforce. To help address this weakness, policymakers and education leaders must ensure the U.S. education system is successfully preparing its students for careers in science and math.

The State of U.S. Mathematics and Science Education

Unfortunately, the current U.S. education system does not have a strong record of producing students who are well prepared for math and science careers. On a number of key indicators – in particular, the National Assessment of Educational Progress (NAEP) – America's system of science and math education continues to perform below par.

2003 NAEP Math Results

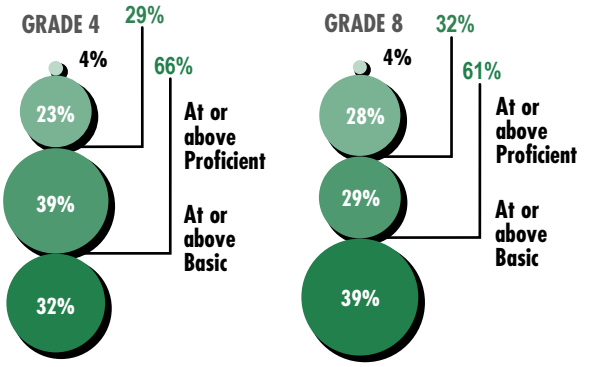


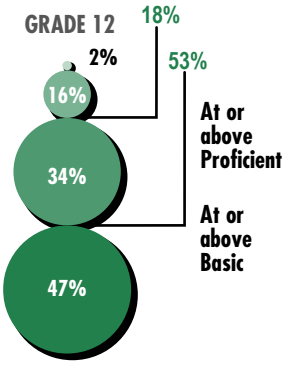
According to NAEP, students must score at the "proficient" level or higher to show they have mastered the fundamental knowledge and skills needed for appropriate grade-level understanding in a subject. On the most recent math and science NAEP tests, however, less than one-third of all students scored at the proficient level or higher. And only 2-5% in any grade level performed at an advanced level.[3]

As a result of this low performance, the proportion of U.S. citizens qualified to fill science and engineering jobs is stagnating. In 1975, the U.S. ranked third in the world in the percentage of students pursuing natural science and engineering degrees. Now it is 17th. And over the past 10 years, the number of high school seniors planning on careers in engineering has dropped more than 35%.[4]

This problem becomes even more pressing when one considers the large portion of the current workforce that is now rapidly approaching retirement age. Moreover, America's college-age population will increasingly be made up of Hispanics and blacks, whose participation rates in science, engineering and technology are half or less than those of white students and who consistently have lower NAEP scores than white students. In fact, in both math and science at all grade levels tested, significantly higher proportions of white and Asian students scored at or above the basic and proficient level compared with black and Hispanic students. In math, for instance, fewer than one in 10 Hispanic 8th graders scored proficient or advanced, compared with nearly half of white and Asian students.[5]

2000 NAEP Science Results





While student performance on nationwide tests provides reason for concern, international tests show equally troubling results. The most recent Trends in International Mathematics and Science Study (TIMSS) is instructive. When compared with the performance of students from countries around the world, the performance of U.S. 4th graders in both TIMSS math and science was

lower in 2003 than in 1995. For 8th graders, the TIMSS data found that U.S. math and science performance was higher in 2003 than in 1995 relative to the other countries. U.S. 8th graders, however, failed to place even in the top 10 in the 45 countries that participated in the study.[6]

The Program for International Student Assessment (PISA) also administers a system of international assessments that measures 15-year-olds' capabilities in math and science literacy. PISA was first implemented in 2000 and is carried out by the Organisation for Economic Cooperation and Development (OECD), an intergovernmental organization of industrialized countries. In 2003, U.S. performance in both science literacy and mathematics literacy and problem solving was lower than the average performance for most OECD countries.[7]

Five Strategies

The experts, which ECS and NSF gathered at this Wingspread meeting, identified a variety of areas that policymakers and education leaders should address to improve mathematics and science education. Of particular importance are the following essential needs:

- To 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 strong leadership from the higher education community, especially from university presidents
- To promote public awareness of the importance of math and science education to the country's future.

Below are five strategies that incorporate the pressing needs for improved research into a more comprehensive approach for improving mathematics and science education. As part of this comprehensive approach, the strategies are targeted toward a wide audience, including policymakers, education leaders, the higher education community and the public at large.

A recurring theme in the strategies is the need for better research. While high-quality research is central to any efforts to improve math and science education, there has long been a serious disconnection between education researchers and policymakers. Researchers too often conduct their work in relative isolation, and do not consider – or are not aware of – the types of problems that are most pressing to policymakers. Similarly, policymakers often are unaware of how current research findings can help guide and inform the development of better policies for math and science education.

This lack of connection between sound research and policy development has profound implications for the education system. Access to research, for instance, is required to properly institute reforms under the federal No Child Left Behind Act. It also is required to prevent policymakers and education leaders from repeating past mistakes and from instituting policies that may have popular appeal but little evidence of improving student achievement.

Equally important is the fact that research can help ensure teachers have the knowledge and skills needed to teach math and science effectively. For instance, nearly two decades of research already exists regarding what math teachers need to know to be effective. This research, while far from complete, shows that students need to develop a deep, conceptual understanding of why critical math processes work the way they do. Simple rote or procedural understanding of these processes is insufficient to build concrete mastery of complex mathematical principles. Importantly, the research also shows there are specific types of knowledge and skills math teachers must have to successfully convey such a conceptual understanding to their students.

1. Strengthen math and science assessments.

- The National Science and Mathematics Standards should be analyzed to find those core elements that student assessments might be linked around.
- The National Science and Mathematics Standards should be used to make appropriate changes to textbook and curriculum materials.
- Tests must be developed to measure both subject knowledge and overall student understanding of math and science concepts.

2. Ensure teachers have adequate knowledge and skills.

- Education leaders and schools of education must draw on the nearly two decades of research addressing the knowledge and skills needed to teach math effectively.
- Researchers and policymakers should work to develop more studies on the knowledge and skills needed to teach science effectively.
- Research findings should be used to revise and improve teacher education, training and professional development programs.

3. Give the neediest students the best teachers.

- Offer higher pay for math and science teachers who serve in hard-to-staff schools.
- Provide strong mentoring and induction programs for all new teachers.
- Develop cross-district programs that encourage experienced teachers to teach for several years in an urban district without risking loss of their seniority, pension or pay privileges if they return to their original district.
- Develop accommodations with teacher unions that promote incentives for math and science teachers to work in hard-to-staff schools.

4. Enlist the entire university in the effort to improve teacher education.

- Ensure that original research is connected to what policymakers need. Compensation, tenure and career-advancement incentives should be given to researchers whose work is most useful to policymakers.
- Identify promising ways of attracting talented students to become math and science teachers.
- Connect more math and science teachers with university researchers.
- Make it clear the responsibility for preparing teachers rests not just with the school of education, but with the institution as a whole – especially the arts and sciences faculty.
- Ensure graduates of education programs are supported, mentored and tracked over time.
- Review teacher education programs, focusing on:
  - The extent to which prospective teachers are grounded in the academic content area in which they will teach, proven practical teaching skills and using technology in the classroom.
  - The quality of students admitted to the program. Admission and performance standards for students in teacher education programs should match or exceed those of the student body as a whole.
  - The steps that teacher education programs are taking to attract and retain talented minority students.

5. Engage the greater public.

- Develop a series of clear messages that resonate with the public and with policymakers on the need to improve mathematics and science education.

- Engage communications specialists to translate research findings into materials that resonate with the public, policymakers, parents and young people who may choose to become tomorrow's math and science teachers.
- Engage the business community in sending an urgent message to policymakers and the public of the importance of math and science education to the U.S. economy.
- Engage university presidents and educators as visible, vocal advocates for improving science and math education at all levels.

Endnotes

[1] National Science Board. *Science and Engineering Indicators 2004*. Washington, DC: National Science Foundation, 2004.

[2] Herman, Roger E., Thomas G. Olivo and Joyce L. Gioia. *Impending Crisis: Too Many Jobs Too Few People*. Winchester, VA: Oakhill Press, 2003, pp 230-235.

[3] National Center for Education Statistics (NCES). *The Nation's Report Card: Mathematics Highlights 2003*. Washington, DC: NCES, 2004; *2000 NAEP Science Assessment*, available at Ed.gov, retrieved July 29, 2004, http://nces.ed.gov/nationsreportcard/science/results/natscalescore.asp.

[4] National Science Board. *Science and Engineering Indicators 2004*. Washington, DC: National Science Foundation, 2004. Retrieved July 29, 2004, at http://www.nsf.gov/sbe/srs/seind04/start.htm.

[5] Education Commission of the States (ECS). "Science and Mathematics Education." *Progress of Education Reform*, vol. 6, no. 1. Denver, CO: ECS, December 2004.

[6] NCES. *2003 Trends in International Mathematics and Science Study*. Washington, DC: NCES, December 14, 2004. Retrieved January 2005, at http://nces.ed.gov/commissioner/remarks2004/12_14_2004.asp.

[7] NCES. *International Outcomes of Learning in Mathematics Literacy and Problem Solving*. Washington, DC: NCES, December 6, 2004. Retrieved January 2005, at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2005003.

The Education Commission of the States is a nonprofit, nationwide organization that helps state leaders shape education policy.

Copies of this publication are available for $5.00 plus postage and handling from the Education Commission of the States Distribution Center, 700 Broadway, Suite 1200, Denver, CO 80203-3460; 303.299.3692. Ask for No. SI-05-05. ECS accepts prepaid orders, MasterCard, American Express and Visa. All sales are final.

ECS is pleased to have other organizations or individuals share its materials with their constitutents. To request permission to excerpt part of this publication, either in print or electronically, please write or fax the Communications Department at the address above, fax 303.296.8332 or e-mail ecs@ecs.org.

Please add postage and handling if your order totals: Up to $10.00, $3.00; $10.01-$25.00, $4.25; $25.01-$50.00, $5.75; $50.01-$75.00, $8.50; $75.01-$100.00, $10.00; over $100.01, $12.00.

Generous discounts are available for bulk orders of single publications. They are: 10-24 copies, 10% discount; 25-49 copies, 20%; 50-74 copies, 30%; 75-99 copies, 40%; 100+ copies, 50%.

Education Commission
of the States

Helping State Leaders Shape Education Policy

700 Broadway, Suite 1200
Denver, CO 80203
303.299.3600
www.ecs.org