LEARNING FOR THE FUTURE

Changing the Culture of Math and Science Education To Ensure a Competitive Workforce

A Statement by the Research and Policy Committee of the Committee for Economic Development

LEARNING FOR THE FUTURE

Changing the Culture of Math and Science Education to Ensure a Competitive Workforce

A Statement by the Research and Policy Committee of the Committee for Economic Development

CED

Library of Congress Cataloging-in-Publication Data

Learning for the future : changing the culture of math & science education to ensure
a competitive workforce : a statement on national policy / by the Research and Policy Committee
of the Committee for Economic Development.
p. cm.
Includes bibliographical references.
ISBN 0-87186-147-X
1. Mathematics—Study and teaching—United States. 2. Science—Study and
teaching—United States. I. Committee for Economic
Development. Research and Policy Committee.

QA13.L39 2003
510'.71'073—dc21

2003043432

First printing in bound-book form: 2003
Paperback: $15.00
Printed in the United States of America
Design: Rowe Design Group

COMMITTEE FOR ECONOMIC DEVELOPMENT
261 Madison Avenue, New York, N.Y. 10016
(212) 688-2063

2000 L Street, N.W., Suite 700, Washington, D.C. 20036
(202) 296-5860

www.ced.org

CONTENTS

RESPONSIBILITY FOR CED STATEMENTS ON NATIONAL POLICY

The Committee for Economic Development is an independent research and policy organization of some 250 business leaders and educators. CED is nonprofit, nonpartisan, and nonpolitical. Its purpose is to propose policies that bring about steady economic growth at high employment and reasonably stable prices, increased productivity and living standards, greater and more equal opportunity for every citizen, and an improved quality of life for all.

All CED policy recommendations must have the approval of trustees on the Research and Policy Committee. This committee is directed under the bylaws, which emphasize that "all research is to be thoroughly objective in character, and the approach in each instance is to be from the standpoint of the general welfare and not from that of any special political or economic group." The committee is aided by a Research Advisory Board of leading social scientists and by a small permanent professional staff.

The Research and Policy Committee does not attempt to pass judgment on any pending specific legislative proposals; its purpose is to urge careful consideration of the objectives set forth in this statement and of the best means of accomplishing those objectives.

Each statement is preceded by extensive discussions, meetings, and exchange of memoranda. The research is undertaken by a subcommittee, assisted by advisors chosen for their competence in the field under study.

The full Research and Policy Committee participates in the drafting of recommendations. Likewise, the trustees on the drafting subcommittee vote to approve or disapprove a policy statement, and they share with the Research and Policy Committee the privilege of submitting individual comments for publication.

The recommendations presented herein are those of the trustee members of the Research and Policy Committee and the responsible subcommittee. They are not necessarily endorsed by other trustees or by nontrustee subcommittee members, advisors, contributors, staff members, or others associated with CED.

RESEARCH AND POLICY COMMITTEE

Co-Chairmen

PATRICK W. GROSS
Founder and Senior Advisor
American Management Systems, Inc.

BRUCE K. MACLAURY
President Emeritus
The Brookings Institution

Vice Chairmen

IAN ARNOF
Retired Chairman
Bank One, Louisiana, N.A.

CLIFTON R. WHARTON, JR.
Former Chairman and Chief Executive Officer
TIAA-CREF

REX D. ADAMS
Professor of Business Administration
The Fuqua School of Business
Duke University

ALAN BELZER
Retired President and Chief Operating Officer
AlliedSignal Inc.

* PETER A. BENOLIEL
Chairman, Executive Committee
Quaker Chemical Corporation

ROY J. BOSTOCK
Chairman Emeritus, Executive Committee
Bcom^{3} Group, Inc.

FLETCHER L. BYROM
President and Chief Executive Officer
MICASU Corporation

DONALD R. CALDWELL
Chairman and Chief Executive Officer
Cross Atlantic Capital Partners

JOHN B. CAVE
Principal
Avenir Group, Inc.

CAROLYN CHIN
Chairman
Commtouch/C3 Partners

A. W. CLAUSEN
Retired Chairman and Chief Executive Officer
BankAmerica Corporation

JOHN L. CLENDENIN
Retired Chairman
BellSouth Corporation

GEORGE H. CONRADES
Chairman and Chief Executive Officer
Akamai Technologies, Inc.

RONALD R. DAVENPORT
Chairman of the Board
Sheridan Broadcasting Corporation

JOHN DIEBOLD
Chairman
John Diebold Incorporated

FRANK P. DOYLE
Retired Executive Vice President
General Electric

T.J. DERMOT DUNPHY
Chairman
Kildare Enterprises, LLC

CHRISTOPHER D. EARL
Managing Director
Perseus Capital, LLC

W. D. EBERLE
Chairman
Manchester Associates, Ltd.

EDMUND B. FITZGERALD
Managing Director
Woodmont Associates

HARRY L. FREEMAN
Chair
The Mark Twain Institute

BARBARA B. GROGAN
President
Western Industrial Contractors

RICHARD W. HANSELMAN
Chairman
Health Net Inc.

RODERICK M. HILLS
Chairman
Hills Enterprises, Ltd.

MATINA S. HORNER
Executive Vice President
TIAA-CREF

H.V. JONES
Managing Director
Korn/Ferry International

EDWARD A. KANGAS
Chairman and Chief Executive Officer, Retired
Deloitte Touche Tohmatsu

JOSEPH E. KASPUTYS
Chairman, President and Chief Executive Officer
Global Insight, Inc.

CHARLES E.M. KOLB
President
Committee for Economic Development

CHARLES R. LEE
Chairman
Verizon Communications

ALONZO L. MCDONALD
Chairman and Chief Executive Officer
Avenir Group, Inc.

NICHOLAS G. MOORE
Chairman Emeritus
PricewaterhouseCoopers

STEFFEN E. PALKO
Vice Chairman and President
XTO Energy Inc.

CAROL J. PARRY
President
Corporate Social Responsibility Associates

VICTOR A. PELSON
Senior Advisor
UBS Warburg LLC

PETER G. PETERSON
Chairman
The Blackstone Group

NED REGAN
President
Baruch College

JAMES Q. RIORDAN
Chairman
Quentin Partners Co.

LANDON H. ROWLAND
Chairman
Janus Capital Group

GEORGE RUPP
President
International Rescue Committee

ROCCO C. SICILIANO
Beverly Hills, California

MATTHEW J. STOVER
President
LKM Ventures

ARNOLD R. WEBER
President Emeritus
Northwestern University

JOSH S. WESTON
Honorary Chairman
Automatic Data Processing, Inc.

DOLORES D. WHARTON
Former Chairman and Chief Executive Officer
The Fund for Corporate Initiatives, Inc.

MARTIN B. ZIMMERMAN
Group Vice President, Corporate Affairs
Ford Motor Company

---

*Voted to approve the policy statement but submitted memorandum of comment, reservation, or dissent. See page 50.

SUBCOMMITTEE ON THE SUPPLY OF SCIENTISTS AND ENGINEERS

Co-Chairs

CHRISTOPHER D. EARL
Managing Director
Perseus Capital, LLC

SHIRLEY ANN JACKSON
President
Rensselaer Polytechnic Institute

Trustees

ROBERT B. CHESS
Chairman
Inhale Therapeutic Systems, Inc.

CAROLYN CHIN
Chairman
Commtouch/C3 Partners

DAVID M. COTE
President and Chief Executive Officer
Honeywell International, Inc.

THOMAS M. CULLIGAN
Executive Vice President
Raytheon Company
Chief Executive Officer
Raytheon International

JOHN DIEBOLD
Chairman
The Diebold Institute

LINDA M. DISTLERATH
Vice President
Merck & Co., Inc.

IRWIN DORROS
President
Dorros Associates

E. GORDON GEE
Chancellor
Vanderbilt University

JEROME GROSSMAN
Senior Fellow
John F. Kennedy School of Government
Harvard University

MATT NIMETZ
Partner
Cross Atlantic Partners, Inc.

STEFFEN PALKO
Vice Chairman and President
XTO Energy, Inc.

JERRY PARROTT
Vice President,
Corporate Communications
Human Genome Sciences, Inc.

GEORGE RUPP
President
International Rescue Committee

MICHAEL SEARS
Senior Vice President and
Chief Financial Officer
The Boeing Company

RUTH SIMMONS
President
Brown University

JAMES THOMSON
President and Chief Executive Officer
RAND

HERMINE WARREN
President
Hermine Warren Associates, Inc.

JOSH S. WESTON
Honorary Chairman
Automatic Data Processing

KURT YEAGER
President and Chief Executive Officer
Electric Power Research Institute

Ex-Officio Members

PATRICK W. GROSS
Founder and Chairman,
Executive Committee
American Management Systems, Inc.

CHARLES E.M. KOLB
President
Committee for Economic Development

BRUCE K. MACLAURY
President Emeritus
The Brookings Institution

Guest

CARLO PARRAVANO
Executive Director
Merck Institute for Science Education

Advisor

LINDA ROSEN
Education Policy Advisor

Project Directors

EVERETT EHRLICH
Senior Vice President and Director of
Research
Committee for Economic Development

JEFF LOESEL
Research Associate
Committee for Economic Development

PURPOSE OF THIS STATEMENT

Continued innovation and growth in our economy depend substantially on the quality and size of the professional technical labor force. The increasing complexity of daily life also requires a citizenry that is scientifically literate. Improving the quality of math and science education in America is a critical first step toward both of those goals. Inspiring widespread student interest in math and science can also be a way to address the need for diversity in the technical labor force. In this report, we document the importance of quality math and science education to the economy, society, and to individual entrants into the labor force.

Learning for the Future: Changing the Culture of Math and Science Education to Ensure a Competitive Workforce builds on a long history of CED reports on education and labor market issues. CED last examined math and science education directly in *Connecting Students to a Changing World: A Technology Strategy for Improving Mathematics and Science Education* (1995). More recent reports on education policy include *Measuring What Matters: Using Assessment and Accountability to Improve Student Learning* (2001) and *Preschool for All: Investing in a Productive and Just Society* (2002). Other recent reports on the requirement for a well-qualified technical labor force include *America's Basic Research: Prosperity Through Discovery* (1998) and *Reforming Immigration: Helping Meet America's Need for a Skilled Workforce* (2001).

ACKNOWLEDGMENTS

We would like to thank the dedicated group of CED Trustees, special guests, and advisors who comprised CED's Subcommittee on the Supply of Scientists and Engineers (see page vii). Special thanks go to the subcommittee's co-chairs Christopher D. Earl, Managing Director of Perseus Capital, LLC, and Dr. Shirley Ann Jackson, President of Rensselaer Polytechnic Institute, for their leadership and guidance. We are also indebted to Jeff Loesel, CED Research Associate and Project Director. Thanks are also due to Everett Ehrlich, CED's Senior Vice President and Director of Research, and Linda Rosen, education policy advisor, for their substantial contributions to the project.

Patrick W. Gross, *Co-Chair*
Research and Policy Committee
Founder and Senior Advisor
American Management Systems, Inc.

Bruce K. MacLaury, *Co-Chair*
Research and Policy Committee
President Emeritus
The Brookings Institution

EXECUTIVE SUMMARY

Improving the math and science skills of our young people is an important step towards maintaining innovation-led economic growth in the coming decades. While producing a more scientifically proficient citizenry, widespread math and science achievement will also widen the pipeline of scientists and engineers who drive innovation.

This report investigates the challenges confronting math and science education from the perspective of culture change. The culture surrounding math and science achievement is often negative: students who succeed in these fields are often dismissed by their peers, while a culture of low expectations burdens other groups, perpetuating their underrepresentation in the professional technical labor force. To address these issues, CED calls for the implementation of a strategic plan that will increase student "demand" for and achievement in mathematics and science. CED believes that all stakeholders in math and science education policy, including state and local governments, school districts, and business, must be proactive in addressing the problems of math and science education.

FINDINGS

K-12 Math and Science Education

1. Most national measures of K-12 student achievement in math and science yield generally disappointing results, despite some small positive signs.

2. States that have adopted standards-based assessment for promotion or graduation have seen scores and proficiency levels climb. These examples show that reform is possible.

3. The international performance of America's youngsters remains consistently mediocre. Though fourth graders perform well in both math and science in international comparisons, American twelfth graders finish towards, or at, the bottom of these surveys.

4. Student interest in math and science topics has declined. Fewer children respond positively on surveys to such basic statements as "I like math." This trend is especially prevalent among high school seniors.

5. Challenging courses are not readily available for some students, while others may be discouraged from taking them. Minority students also face differential expectations, and often lack the support and encouragement to succeed in higher-level courses.

6. Teachers in math and science courses are often teaching out-of-field. Almost a third of high school math classes are taught by teachers who do not have a major or minor in mathematics. In biology, it is 45 percent and in the life sciences the number reaches 60 percent. For middle school students, especially those in underprivileged areas, the problem is yet worse.

7. Teacher retention is a serious problem, especially among math and science teachers; this problem will become more critical as baby boomer teachers near retirement age. Of new math and science teachers, about a third will leave the field within their first three years. This turnover is expensive and leads to other staffing problems.

Undergraduate and Labor Market Issues

1. The percentage of college students seeking degrees in science and engineering continues to fall. Aside from a gain in the biological sciences, all other science and engineering disciplines have seen an absolute decline in the number of degrees conferred annually since 1985.

2. While women and minorities have increased their participation in science and engineering, they are still proportionally underrepresented. Women and minorities do not participate in science and engineering at the postsecondary level at a rate equal to that of white men, and many high achieving women and minorities have intentionally directed themselves away from these fields. Accordingly, their participation in the professional technical labor force is disproportionately low.

3. The expansion of the economy and the retirement of the baby boomers will leave a gap in professional technical labor market. Projections suggest that a strong economic expansion will create approximately 2.1 million jobs in these fields over the next decade, with a total of 2.7 million job openings, including retirements.

4. Both the private and public sector will face problems if the pipeline for scientists and engineers is not widened. The private sector employs three-quarters of the professional technical workforce and will drive the expansion of the economy. The public sector, which often struggles to compete for talent with the private sector, will need to replace retiring scientists and engineers, while being constrained by the fact that many public sector jobs must be held by American citizens.

5. There will also be a continuing need for math and science teachers. Many districts already face shortages (leading to the problem of out-of-field teachers), while enrollment is expected to continue to expand. Two hundred thousand additional secondary math and science teachers will be needed in the next decade.

6. Foreign workers are not a long-term solution to labor market shortages. National security concerns will likely limit the number of H1-B visas allowed, and previous increases in the visa limits are unlikely to be renewed. As other economies continue to develop, they will be better able to retain talented young people who have studied in the United States.

RECOMMENDATIONS

Improving the culture of math and science, in CED's view, requires addressing three challenges aimed at changing the culture of math and science education.

CHALLENGE ONE:
Increasing Student Interest in Math and Science to Sustain the Pipeline

1. Local school districts should review their adopted curricula to ensure that they adequately engage students, promote active learning, and align to state and local standards of student performance and knowledge.

2. Businesses should collaborate with school districts to develop enhancements to the district-adopted math and science curricula that integrate state-of-the-art applications of mathematical and scientific principles into the classroom setting and provide an insight into the work scientists and engineers perform every day.

3. Business should provide financial and logistical support to extracurricular math and science activities, as well as the time and talents of their employees, to enrich the learning experiences of students. Educators should organize student groups to participate in such activities, if they do not already exist, and work to integrate business support into these programs.

4. Colleges and universities should pay close attention to the number of graduates they yield each year when evaluating the effectiveness of their science and engineering programs. Experienced professors should be assigned to introductory classes, among their teaching responsibilities. Grading policies should be monitored in STEM (science, technology, engineering, and mathematics) classes for accuracy and fairness, to ensure alignment with other department courses in the institution.* Additionally, articulation between higher education and K-12 should be increased to better prepare students for the rigors of higher education.

5. Scientifically-based businesses should collaborate with institutions of higher education to highlight the professional opportunities that are available to those with a background in STEM fields.

6. Programs with proven effectiveness to support high achievement among traditionally underrepresented groups of students in K-12 STEM courses should be replicated; businesses must redouble their efforts to provide support to traditionally underrepresented groups of undergraduate students in the STEM pipeline.

CHALLENGE TWO:
Demonstrating the Wonder of Discovery While Helping Students to Master Rigorous Content

1. Colleges and universities that educate future and current teachers must ensure that their courses of study emphasize acquisition of content knowledge, an understanding of the place of that knowledge in society, as well as the pedagogical training to deliver that knowledge to students of all backgrounds and abilities.

2. Businesses should partner with local school districts to establish programs that provide scientists and engineers as resources for schools. These forums should facilitate direct contact between teachers and scientists and engineers, and as appropriate, direct contact between scientists and students.

*See memorandum by PETER A. BENOLIEL (page 50).

3. Businesses, colleges and universities, and school districts should jointly develop effective programs to provide summer experiences for teachers. Businesses should create mechanisms within their firms that allow the fruitful participation of teacher/interns in their work.

4. Business, higher education, and K-12 school districts should collaborate to provide staff development to enrich and expand teacher knowledge and talent.

5. Local school districts should be encouraged to seek innovative and promising solutions to improve math and science teaching and learning.

6. The scientifically-based business community should expand efforts to work with state governments and boards of education in the ongoing process of reviewing and revising state standards for science education.

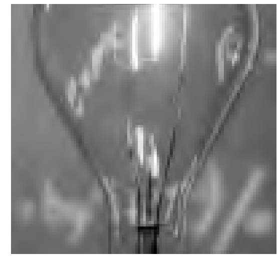
CHALLENGE THREE: Acknowledging the Professionalism of Teachers

1. State governments should work with local school districts to increase starting teacher salaries to better reflect local labor market conditions. The salary structure should take note of the many highly remunerative opportunities open to skilled math and science graduates apart from teaching.

2. State governments and boards of education should implement high quality programs for teacher certification of professional scientists, mathematicians, or engineers who seek to enter teaching.

3. State governments should partner together to develop systems of license and pension reciprocity.

Chapter 1



THE NEED TO IMPROVE MATH AND SCIENCE EDUCATION

A skilled workforce is crucial to a growing economy. America's rising standard of living depends upon invention and innovation, driven by fresh ideas created by enterprising scientists and engineers. But American colleges and universities are not now graduating enough scientists and engineers to meet the expected needs of our future economic growth.

The issue is not solely one of producing the next generation of Nobel Prize winners. The increasing complexity of civil discourse in the 21st century — issues from cloning to homeland security — requires that all citizens attain scientific proficiency. Moreover, the nation's level of scientific proficiency will become more important as women and people of color, who generally score lower than their white counterparts on math and science assessments, form a growing percentage of the labor force.

CED has often stressed the importance of these labor market factors. Our recent report, *Basic Research: Prosperity Through Discovery*, discussed the roles of both the public and private sectors in the innovation process.[1] In that Policy Statement, we noted the pivotal role of technological workers and expressed concerns as to whether the economy was supplying scientists and engineers in sufficient numbers. Specifically, CED recommended that the nation embrace "high achievement standards at the national level in all core academic subjects, with particular emphasis on mathematics and science," and that the nation's schools, particularly its middle and high schools, "attract and continuously support better-qualified math and science teachers."[2] CED also cited the need for "substantial investment in infrastructure improvements" and recommended that "businesses, universities, and schools work together to place more professional scientists and engineers in the classroom..."[3]

CED's report, *Reforming Immigration: Helping to Meet America's Need for a Skilled Workforce*, noted that the shortage of these skilled workers was so pronounced that immigration policy would have to be managed to take this shortage into account. That report's first and most pressing finding was that "the markets for skilled workers have been very tight in recent years, and the demand for skilled workers will grow rapidly."[4] Although there has been a temporary abatement of this problem due to the slowing economy, the problem is sure to reemerge when strong economic growth resumes.

But immigration is not a solution to the problem of long-term shortages of skilled workers in the American economy; there is no substitute for an indigenous supply of scientists and engineers in a competitive economy.

THE IMPORTANCE OF SCIENCE AND ENGINEERING: GROWTH, CITIZENSHIP, AND MOBILITY

While science and technology have always played a central role in our nation's development, the public attention given to them has come in cycles. The launch of Sputnik five decades ago led the United States to give science and engineering a greater emphasis, culminating in the success of the Apollo Program. Part of that emphasis was increased funding for efforts in math and science at all levels.

The explosion in the fields of science and engineering helped to fuel America's post-war growth. The greater supply of scientists and engineers allowed technology to move forward dramatically, and was a major contributor to advances in computer engineering, microelectronics, health research, materials science, and other disciplines. But more recently, that attention has waned. Paradoxically, much of the decreased popular enthusiasm for science and engineering occurred just as the Internet was entering popular use. Perhaps this was due to the remarkably sophisticated technology that made the Internet appear effortless; perhaps it was due to the fortunes that apparently could be made through financial engineering and business prowess during the technology bubble. But as we will argue in later chapters, some of this decrease in interest reflects a larger deterioration in the culture of math and science education, at both the K-12 and postsecondary level.

An understanding of science and mathematics remains at the core of our economy and society. The driving force behind economic growth is technological innovation. Absent a long history of technological change, our country would be a nation of artisans and mule drivers, with a commensurate standard of living. Technological innovation allows workers to become more productive by giving them improved tools and skills, which in turn increases our income and well-being. The nation's science and engineering workers play important roles in this process. First, they are a source of *new ideas*, the driving force behind invention. Second, they are a means of *disseminating* those ideas, either as they learn about new innovations and adapt them to their organizations, or as they move from firm to firm, taking their knowledge and experience with them.

When we think about the prospects for growth in the years ahead, we think of them in technological terms — new wonders from microprocessors and information technology, advances in biotechnology and their application not only to health but to industrial processes, materials science, energy production and environmental management, and many others. Indeed, as other nations in the world economy gain advantage as low-cost manufacturers, America's global economic position will evermore depend on our command of science and technology as a means to add value to production and to develop original goods and services. Thus, the economy fundamentally depends on a scientifically skilled workforce.

But beyond the economy's needs, scientific awareness is an important aspect of modern citizenship and an increasingly significant part of daily life. Doctrines of "creationism" crowd current scientific teaching out of classrooms; biological advances, from genetic engineering in agriculture to medical breakthroughs, require a public discussion of safety, risk, and ethics; concerns about privacy and security accompany the information revolution; man-made global climate change threatens the way of life of many on the planet over the long-term. All of these issues require a thorough public discussion, but such a discussion can only take place among an informed citizenry. (And this "scientific proficiency" should not be confused with "computer literacy." An accompanying box describes the difference.)

Science and technology employments are important for a third reason — they provide an important avenue for social mobility. Diverse ethnic and immigrant groups have embraced scientific education as a means to contribute to American culture and to

"COMPUTER LITERACY" IS NOT A SUBSTITUTE FOR MATH AND SCIENCE PROFICIENCY

The increased use of computers in the classroom is an important step in improving the math and science skills of young students. This knowledge is essential, as most jobs in the current (and future) economy (will) require the use of a computer at some level, and numerous studies show that students who use computers regularly in the classroom score better on proficiency tests. However, a students' proficiency with a computer should not be mistaken for a basic understanding of the scientific principles behind the computation or the computer. CED warned of this problem in our 1995 report, *Connecting Students to a Changing World: A Technology Strategy for Improving Mathematics and Science Education*, reminding people that "our support for technology should not be equated with adulation. Technology has meaning and purpose only in the way it is used by people." The ability to use a computer is not a substitute for a knowledge base in math and science that will ultimately help the student to understand weather patterns, instructions from a doctor, or to determine which long distance calling plan will save the most money.

improve the social and economic standing of their families. Technical workers trained in the post-Sputnik rush were often the first people in their families to go to college — scientific training was an important route to their economic betterment. Math and science education have historically contributed to the meritocratic society America aspires to. Moreover, as the majority population grows more slowly than people of color, the nation's corps of scientists and engineers will progressively need to be drawn from this latter, more diverse, group. This is all the more important when the aging of the math and science workforce is observed. Many government agencies rely on technical workforces that are close to retirement age. The same may be said of the nation's schoolteachers. The cohort that entered teaching as the Baby Boom graduated from college in the 1970s is now reaching the age and level of service that will allow them to retire. It is not clear how the hundreds of thousands of teachers who are somehow involved in math and science education throughout the K-12 system will be replaced, particularly with the high turnover rates already experienced in this field.

A FOCUS ON MATH AND SCIENCE EDUCATION

A variety of factors determine our society's scientific proficiency. In recent years, many young people, the "best and brightest," have been attracted to careers in finance or other business activities, eschewing options in math and science that failed to capture their interest. For this reason, CED has chosen to focus on the factor it views most important in the long term — the quality of math and science education in both K-12 and postsecondary education. All of the functions of science in society — the availability of skilled workers, the competence of scientific "citizenship," and the availability of science and math as a tool for mobility — are drawn from this common well.

The K-12 system is entrusted with building science and mathematics competence in our young people. It must capture and maintain their interest in these subjects, and teach them not only the "facts" of science, but the underlying concepts of scientific inquiry, experimentation, and empiricism. Moreover, the K-12 system is responsible for producing a group of young people who will be interested in pursuing math, science, and engineering coursework in their undergraduate careers.

The postsecondary system is charged with producing these highly skilled workers, but also has great bearing on the K-12 system. It produces the teachers who will staff the K-12 system. It sets expectations for math and science education that compel a response by the K-12 system. And it offers students a path to careers in science and engineering, which in turn creates interest among young people. Thus, neither the K-12 nor the postsecondary segments can be seen in isolation; together, they comprise a continuous "system" that determines the long-term supply of our nation's scientifically skilled workforce.

Many organizations have examined this system and recommended ways to improve it. An accompanying box summarizes a few of these efforts. Their common theme has been the shortage of resources going to math and science education, or, the "supply side" of the equation.

CED supports these efforts and their point of view. Improving the nation's math and science education *will* take more resources, and more well-spent resources. We should be concerned about the costs and quality of the math and science education infrastructure, about the costs and quality of professional development for math and science teachers, and about the overall level of compensation for teachers. Moreover, the manner in which these resources are brought to bear could often be improved as well.

But these are all about the *supply* of math and science education. CED also believes that improving the nation's math and science education will require change on the *demand* side as well, that is, the way our nation's young people regard these disciplines. Too often, they are dismissed as too hard, too inaccessible, too elitist, too boring, or too unfashionable. In turn, the young people who *do* express interest in these subjects are, in many schools, disdained by their peers. Stereotypes in popular culture persist in portraying scientists as unfashionable, absent-minded, obsessed, or socially backward. Despite best intentions, the education system can reinforce these views, by presenting math and science as "hard" compared to other subjects and rationing good grades in those topics.

This Policy Statement will emphasize ways to link both "supply" and "demand" side policies together to change the *culture* of math and science in the education system and in society. By culture change, we mean the way students, teachers at all levels, educators at all levels, and the business community think about math and science education.

Culture change cannot be mandated or decreed. Instead, it is the product of a broad range of actions by a diverse set of actors. As a result, CED's report is aimed at several audiences. *Business leaders* have the ability to work with school systems to provide resources and expertise otherwise unavailable; many businesses, as discussed throughout our recommendations, do so already. *State governments*, now charged with directing efforts to measure school performance and hold individual systems accountable, have an obvious role. So do *local governments*, which define the roles and expectations of the teachers they employ.

Our recommendations also affect *teachers* themselves. The recommendations sometimes call for changes in the way teaching is structured or what occurs in classrooms. These recommendations, however, are not intended to be critical of the teaching profession. America's teachers are undervalued; few if any people enter teaching for reasons other than a commitment to the job. Our recommendations, ultimately, are designed to give teachers the tools and environment that will let them do their jobs as they prepare the next generation of our nation's young people for the challenges of a complex technological society.

CED's effort and perspective are meant as a complement to the efforts that have pre-

A REVIEW OF OTHER REPORTS ON MATH AND SCIENCE EDUCATION AND THE TECHNICAL LABOR FORCE

A number of reports have been written over the years that highlight certain aspects of the problems facing math and science education and its workforce implications. Here are the conclusions of a few prominent reports.

Building Engineering & Science Talent (BEST), *The Quiet Crisis* (2002)

Following up on the report *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology* (2000), this report investigates the problem of the underrepresentation of minority groups in the technical labor force. *The Quiet Crisis* calls for increased recruitment of teachers, an increase in federal investment in education and other strategies to promote inclusiveness in the professional technical labor force.

Educational Testing Service, *Meeting the Need* (2002)

Meeting the Need outlines the problems facing the technical labor force, finding part of the solution in the preK-12 math and science education spectrum. A special emphasis is also placed on the achievement levels of underrepresented minorities and efforts to recruit them into the technical labor force.

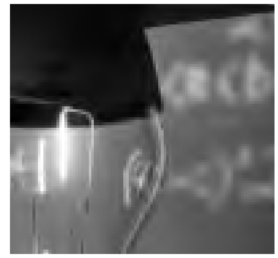
National Commission on Mathematics and Science Teaching for the 21st Century, the "Glenn Commission," *Before It's Too Late* (2000)

Improving the quality of the math and science teaching force is the focus of this report. Emphasizing better preparation and professional development for teachers and a more competitive wage structure, the report sought to attract more teachers into the field, as well as retain them, while providing mechanisms to provide for continued growth and development.

ceded it, and are in no way meant to detract from those previous efforts' importance. In this report, we examine issues such as teacher compensation and accreditation that have been examined before, but with an eye to how they might make mathematics and science more appealing to young people. We identify emerging issues that might directly affect the way both young people and society at large perceive math and science. In either event, our focus is on improving the nation's math and science education, as measured by the overall level of math and science competence in society as well as the number of skilled workers the school system produces.

Moreover, we offer our recommendations while being aware that in classrooms, school districts, and institutions of higher learning around the country, people are now struggling to address these issues. Businesses already have undertaken innovative programs to bring their unique abilities and resources to local school districts; school districts and systems are already experimenting with fresh ways to train teachers of math and science; all of these groups have come together to offer exciting programs that complement school, or that redefine school itself. Our mission, in large part, is to support these experiments, help to scale them up, and to encourage the business community to be a fully-fledged partner in these efforts.

Chapter 2



CHALLENGES IN K-12 MATH AND SCIENCE EDUCATION

There is continuing concern about the need to improve student achievement in math and science. Indeed, the very title of the 2002 federal legislation for K-12 education — No Child Left Behind — captures the urgency felt by policymakers and the public to place a new emphasis on quality public education. But the title also suggests a fundamental truth: averages and generalities, while illuminating, can obscure important facts that may point to solutions.

The data presented in this chapter should be familiar to those who work in the field of math and science education.† While the picture of K-12 math and science education in America is bleak in many ways, there are areas in which we are beginning to see some encouraging signs. Accordingly, this chapter will present both a general and specific look at math and science education. It will provide data about student achievement and other measures and offer some possible explanations for disappointing levels of student performance.

K-12 STUDENT ACHIEVEMENT IN MATH AND SCIENCE: A NATIONAL PERSPECTIVE

The National Assessment of Educational Progress (NAEP) — known as the "Nation's Report Card" — measures student proficiency in mathematics and science. NAEP has two components. The first, developed in the early 1970s and called "long-term trend NAEP," is designed to measure progress over time. The second, developed in the early 1990s and called "main NAEP," measures current curricula and reflects the latest assessment methodology. While results from the two components can not be directly compared, together they provide a rich database of information on student achievement nationwide.

The U.S. Department of Education administers NAEP to a representative sample of American students at ages 9, 13, and 17 — corresponding to fourth, eighth, and twelfth grade — about every four years. Long-term NAEP (measuring long-term progress) is reported by age whereas main NAEP (measuring proficiency) is reported by grade level. The two components generally are not given in the same year.

Long-Term Trend NAEP Results

The long-term math assessment measures students' knowledge of basic facts and basic measurement formulas, ability to carry out numerical procedures, and ability to apply mathematics to skills of daily life.[5] The science assessment focuses on students' ability to conduct inquiries and solve problems and their knowledge of science content.[6]

The most recent long-term mathematics and science NAEP assessment was administered in 1999. Results show that math and science scores have followed similar trajectories: declines in the 1970s, increases in the 1980s and early 1990s, followed by a leveling off for the remainder of the 1990s. Students

† References to "math and science education" throughout this report reflect ideas that are applicable to science, technology, engineering, and mathematics, or STEM, courses at large.

in all age groups showed improvement in mathematics, with the 9-year-old cohort making the greatest strides. Results for science varied with age; 9-year-old students showed improvement in science scores, yet the scores of their 13-year-old 'siblings' were unchanged over time and the scores of their 17-year-old 'siblings' decreased. (See Figures 1 and 2 for the results.)

Analysis of long-term NAEP also yields information about a persistent achievement gap between minority and white students. Black students continue to achieve at lower levels in mathematics than their white counterparts, although the gap is narrowing. The gap between Hispanic and white, non-Hispanic students narrowed for 13- and 17-year-olds, but not for 9-year-olds. In science, the 9- and 13-year-old black students narrowed the gap with their white peers, whereas the gap between Hispanic and white, non-Hispanic students was unchanged.

Analysis by gender yielded some promising results: in 1999, males and females performed at comparable levels in math for the first time since the long-term testing began. Although 13- and 17-year-old males outperformed females in science, the gap among the older students also narrowed for the first time. Male and female 9-year-old scores in science were statistically comparable.[7]

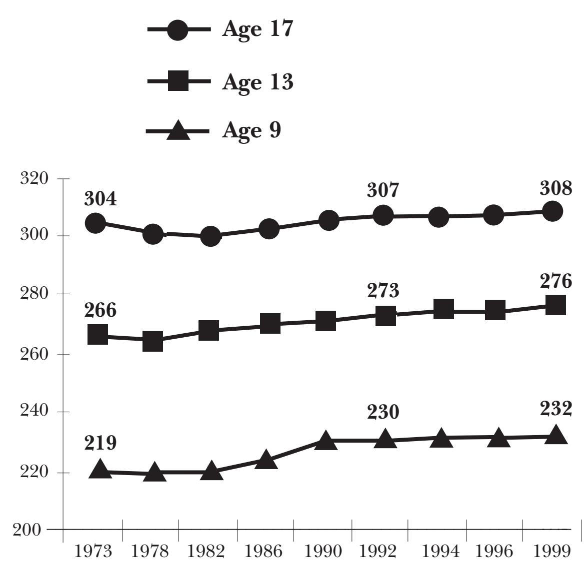
Thus, while there are important general concerns about student performance in math and science, long-term NAEP results contain some positive news as well.

Main NAEP Proficiency Levels

To establish what students should know, main NAEP defined proficiency levels and then tested to see whether they were being

Figure 1

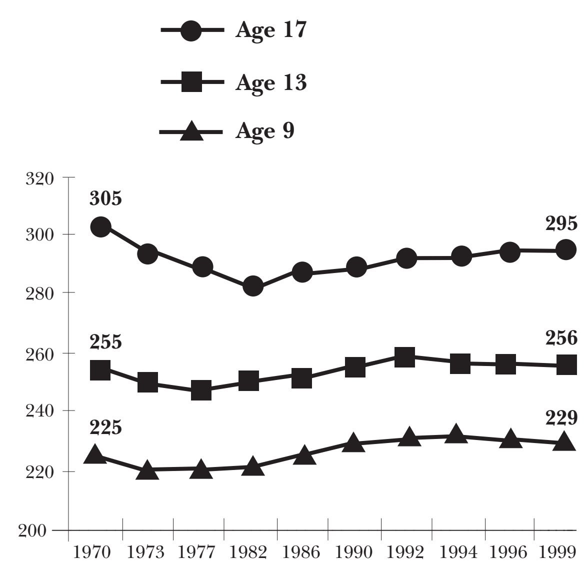
Long-Term NAEP Scores for Mathematics, 1973-1999



SOURCE: National Center for Education Statistics, *NAEP 1999 Trends in Academic Progress: Three Decades of Academic Performance*, NCES 2000-469 (Washington, D.C.: U.S. Department of Education, August 2000), Figure 1.1.

Figure 2

Long-Term NAEP Scores for Science, 1970-1999



SOURCE: National Center for Education Statistics, *NAEP 1999 Trends in Academic Progress: Three Decades of Academic Performance*, NCES 2000-469 (Washington, D.C.: U.S. Department of Education, August 2000), Figure 1.1.

achieved. The most recent administration of main NAEP, in 2000, found that 74 percent of fourth graders, 72 percent of eighth graders, and 83 percent of twelfth graders scored at 'basic' (the minimum standard of achievement) or 'below basic' in math. In science, 71 percent of fourth graders, 68 percent of eighth graders and 81 percent of twelfth graders scored 'basic' or 'below basic.' (See Figures 3 and 4.) Such levels of understanding, as defined in Table 1, will certainly not support success for these students in their next higher math or science course, or for using math and science skills in their future work lives.

Equally disappointing, the science assessment in 2000 showed that substantial gaps between the performance of white and black students, as well as between white and Hispanic students, remain at all three grade levels. Fourth and eighth grade males continue to outperform their female peers in science. (It should be noted that the fourth grade data regarding gender disparities are inconsistent, as the main NAEP assessment demonstrates an increase in the gap from the last assessment, while the long-term NAEP scores show a decrease.)

Table 1

Achievement Level Policy Definitions

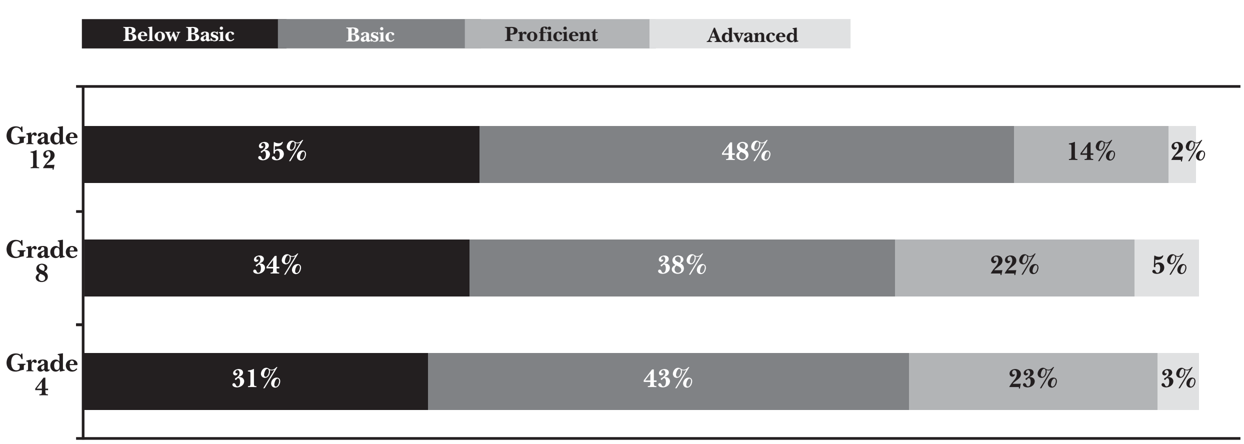
Advanced:	**Superior performance.**
Proficient:	**Solid academic performance** for each grade assessed. Students reaching this level have demonstrated competency over challenging subject matter, including subject-matter knowledge, application of such knowledge to real-world situations, and analytical skills appropriate to the subject matter.
Basic:	**Partial mastery** of prerequisite knowledge and skills that are fundamental for proficient work at each grade.

SOURCE: National Center for Education Statistics, *The NAEP Mathematics Achievement Levels*, (August 2002), available at <http: //nces.ed.gov/nationsreportcard/mathematics/achieve.asp>. Accessed April 2, 2003.

But there is some reason for optimism from the 2000 results on main NAEP. Math students in fourth, eighth and twelfth grade had higher average scores in 2000 than in 1990. Indeed, fourth and eighth grade stu-

Figure 3

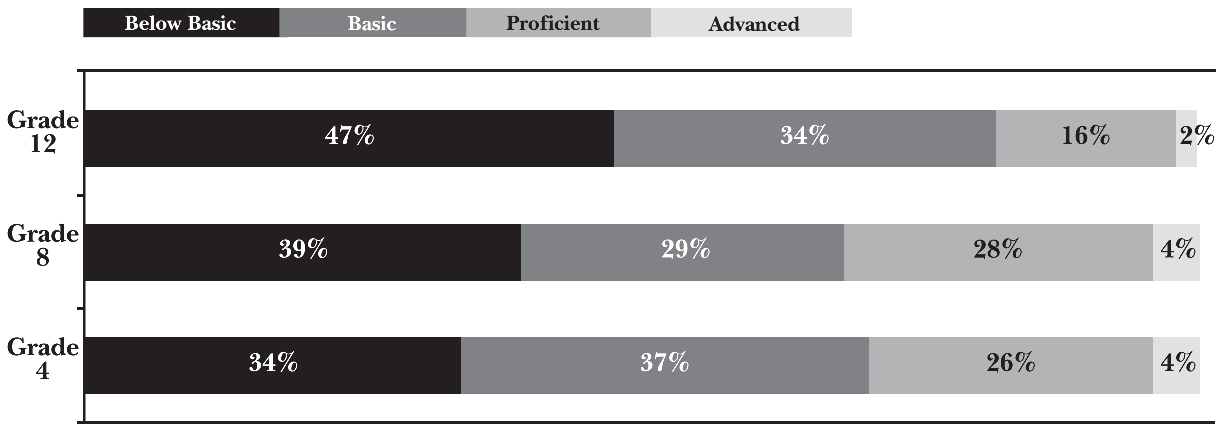
NAEP Mathematics Achievement Levels by Grade – 2000



SOURCE: National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000,* NCES 2001-517 (Washington, D.C.: U.S. Department of Education, August 2001), Figure 2.2. Numbers do not sum to 100 due to rounding.

Figure 4

NAEP Science Achievement Levels by Grade – 2000



SOURCE: National Center for Education Statistics, *The Nation's Report Card: Science Highlights 2000*, NCES 2002-452 (Washington, D.C.: U.S. Department of Education, 2002), p. 2. Numbers do not sum to 100 due to rounding.

dents demonstrated consistent progress in math through the decade whereas twelfth grade students improved between 1990 and 1996, but lost ground between 1996 and 2000. Science results are less promising, although between 1996 and 2000, the percentage of eighth graders performing at the 'basic' level decreased with a corresponding increase in the percentage performing at proficient or advanced.

K-12 STUDENT ACHIEVEMENT IN MATH AND SCIENCE: A STATE PERSPECTIVE

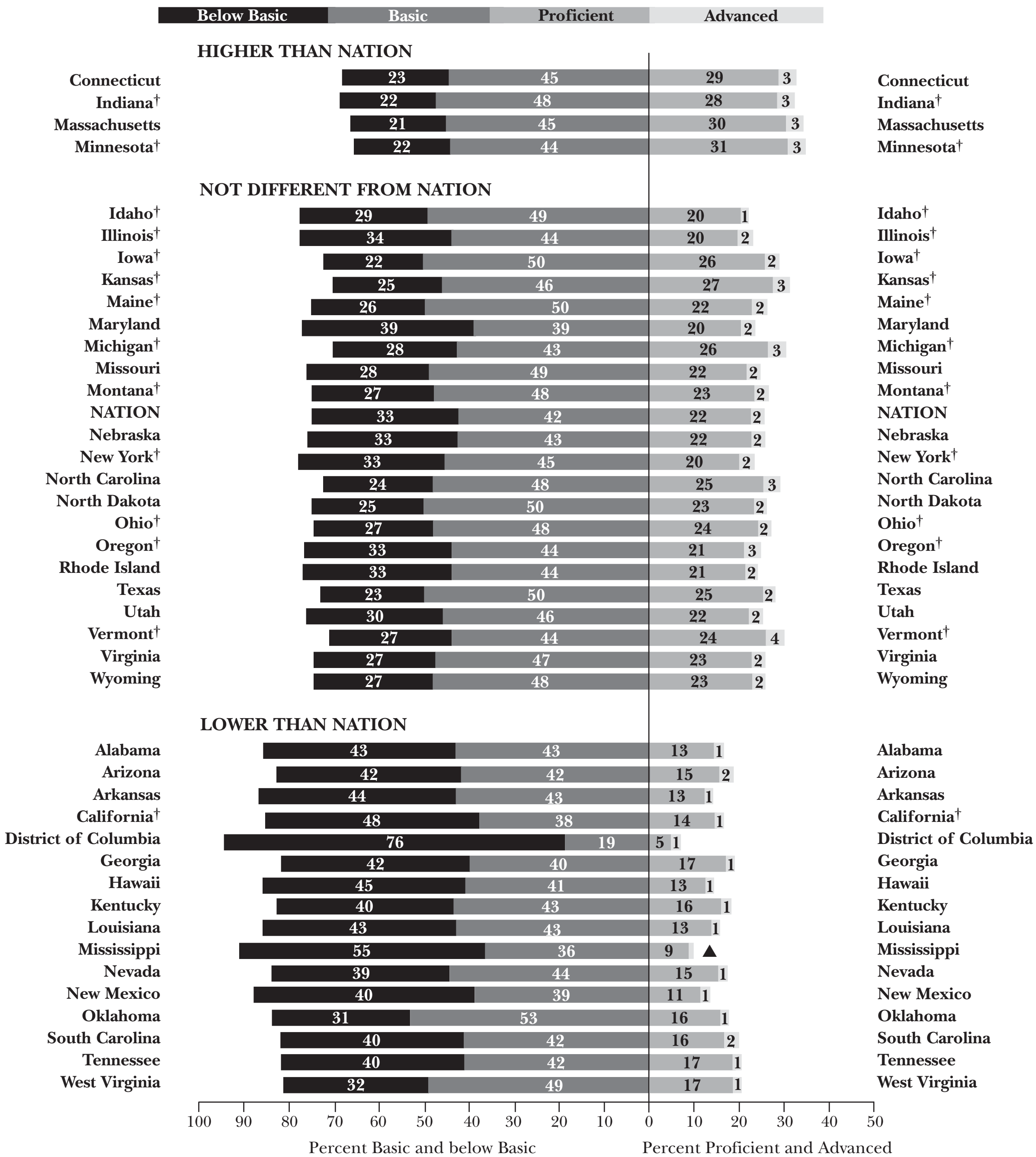
For states that choose to participate, representative samples of students take the main NAEP test, so that an analysis is available on a state-by-state basis. In the two tables of math results that follow, the proficiency levels of students in fourth and eighth grade are presented in bands for each state and compared to national scores. Put together in this manner, one can clearly see the uneven performance across states. (See Figures 5 and 6.)

Since education remains the responsibility of the state, results on state-administered assessments are illuminating. Indeed, in our 2000 report, *Measuring What Matters*, CED argued for a system of assessment and accountability as part of a larger program for improving education in America.[8] Relevant results from California, Massachusetts, and Virginia are briefly described below.

- The Class of 2004 must pass the California High School Exit Exam to receive diplomas. After taking the test in their sophomore year, 52 percent passed the mathematics portion.[9] (Students have six additional opportunities to pass the assessment.) Analyzing the data for racial/ethnic groups show that "black and Hispanic students had the highest rate of failure this year [for math, reading, and writing], with only 28 percent of black students and 30 percent of Hispanic students passing. On the other hand, 70 percent of Asian students and 65 percent of white students passed the test."[10]

Figure 5

Mathematics Achievement Level Results by State at Grade 4 Public Schools: 2000



SOURCE: National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000*, NCES 2001-517 (Washington, D.C.: U.S. Department of Education, August 2001), Figure 2.10.

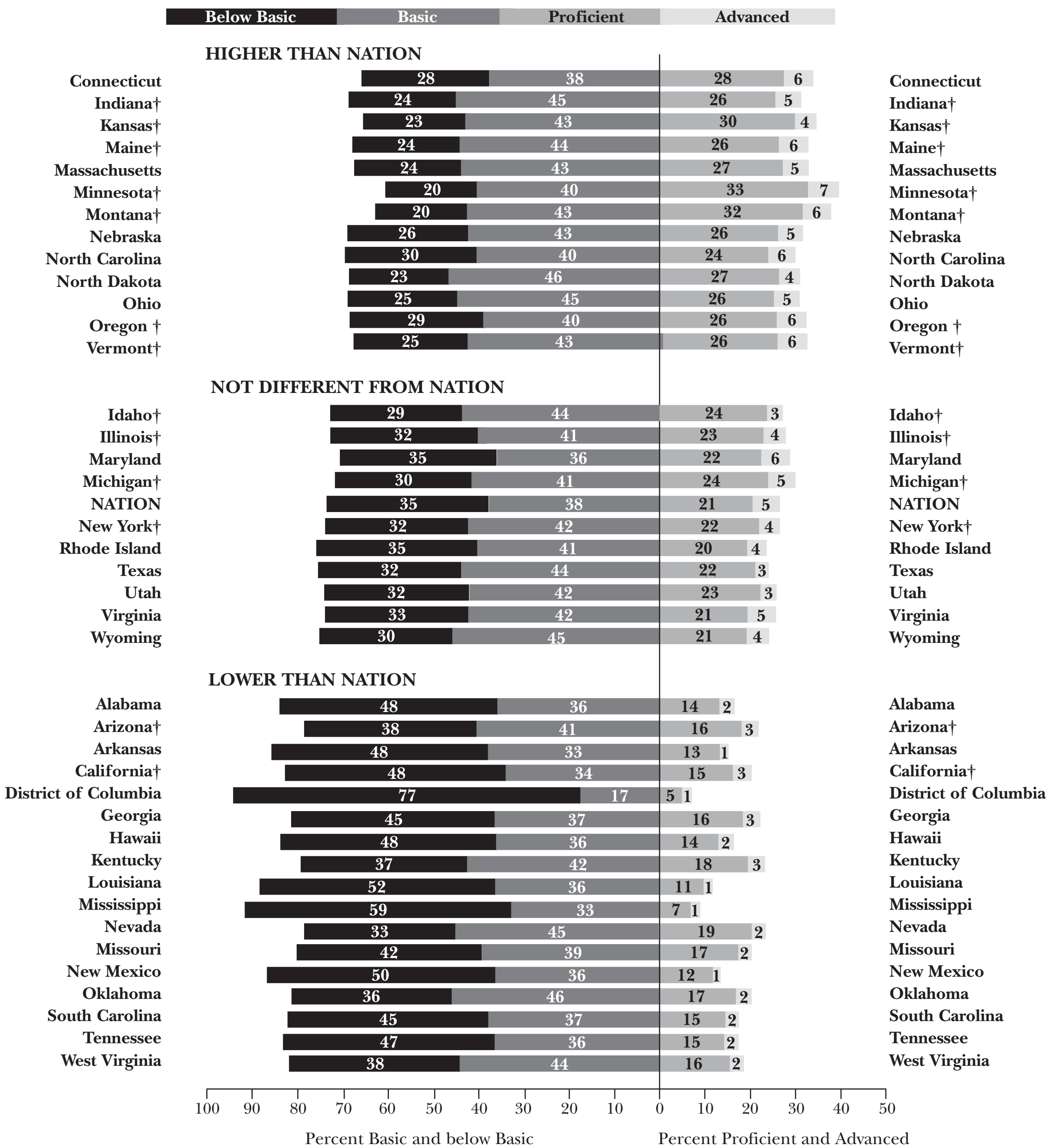
† Indicates that the jurisdiction did not meet one or more of the guidelines for school participation.

▲ Percentage is between 0.0 and 0.5.

NOTE: Numbers may not add to 100 due to rounding.

Figure 6

Mathematics Achievement Level Results by State at Grade 8 Public Schools: 2000



SOURCE: National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000*, NCES 2001-517 (Washington, D.C.: U.S. Department of Education, August 2001), Figure 2.11.

† Indicates that the jurisdiction did not meet one or more of the guidelines for school participation.

NOTE: Numbers may not add to 100 due to rounding.

- Public school students in grades 3, 4, 5, 6, 7, 8, and 10 took the Massachusetts Comprehensive Assessment System (MCAS) in the spring of 2002. MCAS results have risen steadily over the five years that the system has been in place. This year, in grade 10, the percentage of students reaching the 'proficient' and 'advanced' level in mathematics (as defined by the state) increased 20 points, while 25 percent 'failed' the test. Students in grades 4 and 6 improved slightly, but eighth graders worsened a bit over previous administrations of the assessment. Racial/ethnic analysis of 2002 mathematics results, when compared to 2001 results, yielded improved performance for "[black] students in grades 6 and 8, Asian students in grades 4, 6, and 10, Hispanic students in grade 6, Native American students in grade 4, and for white students in grades 4 and 6."[11]

- Before graduation, Virginia requires students to pass a series of assessments, called the Standards of Learning (SOL). In the 2002 administration of end-of-course assessments:
  - The percentage of students passing the Algebra I test rose to 78 percent, compared with pass rates of 74 percent in 2001 and 40 percent in 1998.
  - Achievement on the Algebra II test also increased in 2002. Seventy-seven percent of the students who took the Algebra II test passed, compared with 74 percent in 2001 and 31 percent in 1998.
  - The percentage of students passing the geometry test rose to 76 percent in 2002, compared with pass rates of 73 percent in 2001 and 52 percent in 1998.
  - Students achieved pass rates of 83 percent on the biology test, 70 percent in earth science, and 78 percent in chemistry in contrast to 2001 pass rates of 81 percent in biology, 73 percent in earth science, and 74 percent in chemistry.[12]

The data presented for California, Massachusetts and Virginia demonstrate the success of a focused response to the problem of poor student achievement and can provide a model for other states. It is critical, however, that state assessments are of high quality, especially with the requirements of No Child Left Behind. In fact, Massachusetts is one of a handful of states to improve student performance on their own assessments, while simultaneously improving on NAEP.

K-12 STUDENT ACHIEVEMENT IN MATH AND SCIENCE: AN INTERNATIONAL PERSPECTIVE

International comparisons of student success in math and science are intended to reflect how successfully a nation educates its youth. But they also reveal the prospects for the skilled labor force 20 or 30 years hence.

Limits of International Comparisons

Although international comparisons help shed light on the relative strengths of education systems worldwide, their results must be interpreted in light of their inevitable shortcomings. These studies have made great strides over the years to standardize the tests and procedures across all nations, but perfect standardization is impossible. There may be problems with the cohort selected, especially among older students. While a significant majority of U.S. students attend school through twelfth grade, in a number of other countries, students have chosen a path to technical schools or apprenticeships by that age and therefore, are not included in the pool of students being assessed.

Nonetheless, the results of these comparisons are valuable. A better understanding of the characteristics of the educational systems in those nations that consistently score well can and should inform U.S. policy.

TIMSS

The first comparative study of student achievement in math worldwide — known as the First International Math Study (FIMS) — occurred in the 1960s; the second occurred in the 1980s (SIMS). The most comprehensive study of international student performance in math *and* science — the Third International Mathematics and Science Study — was administered in 1995 (TIMSS) and 1999 (TIMSS-Repeat). U.S. students have consistently performed disappointingly, scoring only at the average level or less in these international comparisons. Certainly, the U.S. has led and helped usher in a global revolution in scientific learning and discovery. Thus, our education system has produced sufficient mathematical and scientific talent to fuel this revolution. But, other nations, recognizing math and science education as the key to economic health and improvement in the way of life, have been putting more emphasis on math and science education than the U.S.

TIMSS assessed students essentially at three grade levels — fourth, eighth and twelfth — and involved 41 countries. (Not all countries participated at all three levels.) U.S. fourth graders scored only slightly above the international average in math and near the top in science. Eighth graders were only slightly above the international average in science and below the average in math. But American twelfth graders scored at the *very bottom* of the international ratings. More troubling, the twelfth grade sample did not include the nations of southeast Asia, which are often pointed to as countries that have made great strides in increasing the scientific literacy of their populations and the capabilities of their labor forces.

In other words, the longer American students stayed in school and studied these disciplines, the less favorably they compared with students in other countries. From TIMSS, we also learned that "…mathematics and science curricula in U.S. high schools lack coherence, depth, and continuity; they cover too many topics in a superficial way."[13] U.S. researchers involved in the TIMSS study assessed our math curriculum, in comparison to other countries, as "a mile wide and an inch deep." The rigor and pace of U.S. courses is similarly suspect. And, "topics on the general knowledge (TIMSS) twelfth grade mathematics assessment were covered by the ninth grade in the U.S., but by seventh grade in most other countries. In the general (TIMSS) science assessment, topics in the U.S. were covered by the eleventh grade, but by ninth grade in other countries."[14]

TIMSS-R

Thirty-eight nations participated in TIMSS-R in 1999, which focused only on eighth grade math and science.[†] The study contains a significant amount of data, only some of which has been made public to date. Among its findings were:

- U.S. eighth graders exceeded the international average in math and science, echoing the earlier TIMSS results at this grade level.
- Eighth grade performance in 1995 and 1999 showed no change. This was true in nearly all of the 23 nations that participated in both studies.
- The performance of U.S. eighth graders in 1999 was lower relative to other nations than the performance had been of the same cohort of students four years earlier in TIMSS. That is, students in other nations learned more mathematics and science in the intervening years between 1995 and 1999 than did U.S. students.
- U.S. students were less likely than their international peers to be taught by a teacher who had earned a bachelor's or

† There were important differences between the TIMSS and TIMSS-R participants. Several European countries did not join TIMSS-R, while many developing countries did. The highest scoring TIMSS nations did, however, participate in TIMSS-R.

master's degree in math. But U.S. students were as likely as their international peers to be taught by a teacher with a major in biology, chemistry, or science education.

- There was no gender difference in the math achievement scores of U.S. male and female students, whereas eighth grade males outperformed eighth grade girls in science.[15]
- Preliminary analysis of videotapes of eighth grade math classrooms in seven countries, including the U.S., shows important differences in the way that lessons were structured and how content was presented to and worked on by students. The other six nations surveyed outperformed the U.S. on TIMSS.[16]

Another portion of TIMSS-R, known as the benchmarking study, had 27 states, districts and consortia of districts in the U.S. voluntarily participate in the TIMSS-R assessment. Once again, greater detail yielded important results. Some localities, such as Naperville School District #203 and the First in the World Consortium, both in Illinois, kept pace with the top-performing nations, despite the lackluster national performance. And other U.S. districts, recognizing the high probability of poor results, still chose to participate so that they would be armed with data to guide their improvement efforts.[17]

PISA

Another study, the Program for International Student Assessment (PISA), organized by the Organization for Economic Cooperation and Development (OECD) and conducted in 2000, examines the test results of 15-year-olds (approximately 10th grade) in OECD countries. This survey found that U.S. students perform at a level equivalent to the international mean in math and science literacy. The study, which included reading proficiency, also found that more nations outpace U.S. students in math and science proficiency than do so in reading.[18]

WHAT MIGHT ACCOUNT FOR UNEVEN PERFORMANCE IN K-12 MATH AND SCIENCE?

In a nation that produced a Barbie doll who complained about the difficulty of learning mathematics and ridicules math and science in the comic pages, it is small wonder that there is a culture of acceptance and even expectation about low performance in these fields. There are many possible explanations for this perspective.

Disinterested Students

Students who are not interested in a topic will not seek to excel in it. According to a student survey accompanying the main NAEP assessment, 70 percent of fourth graders responded positively to the statement "I like math," but only 47 percent of twelfth graders replied in the affirmative. Students who enjoy math performed better on the assessment, at all levels.[19]

There has also been a decrease in interest over time among twelfth graders, or those who will most immediately choose to pursue science or engineering degrees in college. In 1990, a majority of twelfth graders had a favorable opinion of math. This number declined in each of the next three assessments, with the fall between 1996 and 2000 coming at a statistically significant level. Similarly unsettling is the trend in student attitudes with regards to the usefulness of mathematics. Only 61 percent of twelfth graders in 2000 agreed with the statement that "math is useful for solving problems," down from 73 percent in 1990.[20] The ramifications of this change are not entirely clear, but greater numbers of students may be less inclined to consider science or engineering degrees in college as a result.

Media perceptions of scientists and engineers may be partly to blame. A report published by the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technological Development argued that media images of scientists, even in the context of the technology boom, played a significant negative role in forming children's attitudes towards math and science.[21]

The disinterest of American students contrasts sharply with that of their peers worldwide. The Brown Center on Education Policy surveyed American high school students studying abroad and their international counterparts studying in America, to identify any attitudinal differences towards math. Survey results from both groups showed students abroad value math more than American students. While 37 percent of American students studying abroad responded that students in their host country valued math more (against 25 percent saying that it was valued more in America), 45 percent of international students agreed with the proposition that math was valued more in their home country. Only 14 percent of international students studying in the U.S. felt that math was valued more by American students.[22]

The cultural context of this data is also a consideration. In an international survey of students in 37 countries, Japanese students ranked 36th in regard to "students' interest in and enjoyment of math," a trend demonstrated by other high achieving countries as well.[23] But even though they do not "enjoy" math, Japanese students still rank at the top in international assessments. A possible explanation is that Japanese students have been imbued with a sense of the importance of mathematics to their daily lives, as suggested by the Brown Center study mentioned above. Current reform efforts in Japan are attempting to increase the lackluster student interest in math and science by making the curriculum more interactive, in a manner similar to that prescribed for American schools in this report.[24]

Low Expectations

A national sample of fourth and eighth grade teachers was recently polled about the mathematics and science topics their students were expected to master, among other things.[25] The results suggest that expectations are low. Fourth grade teachers, for example, expect their students to master basic operations with two- and three-digit numbers. But a third of these teachers expect that less than half of their students would be able to compare fractions with like and unlike denominators. This attitude is mirrored among eighth grade math teachers. High percentages of teachers expect students to master the "basics of middle school," such as solutions of one-step linear equations or calculation of means and medians, but the percentages fall significantly with more complex middle school content such as converting from one unit of measure to another. Science fared no better. Among the eighth grade science teachers queried, for example, one in five thought that none of their students would know the general form, function, and location of the major organ systems of humans.

Differential expectations take many forms. Research has shown that teachers pose more routine math questions to their female students than their male students.[26] Similarly, teachers give less time for low achievers to respond to questions than to high achievers. They criticize low achievers more often for failure and dole out praise for success with less frequency.

A corollary to low expectations is the belief that some classes are only for a talented few. The Council of Great City Schools,† in collab-

† The Council of Great City Schools is comprised of one hundred urban districts, of more than 16,800 districts nationwide, serves 23 percent of the nation's students, including 40 percent of American minority students and 30 percent of those who are disadvantaged economically.

oration with the Manpower Demonstration Research Center, recently released case studies of three urban districts. Faculty in these districts acknowledged a tendency to reduce their achievement expectations of minority and low-income students in the lower grades. At the high school level, these same students were underrepresented in college preparatory and/or Advanced Placement (AP) courses. Indeed, schools with very high minority enrollment offered such courses infrequently.[27] This lack of availability presents a significant obstacle for continued advancement in math and science courses.[28]

Teaching Knowledge and Methods

There is a growing body of research supporting the relationship between teaching quality and higher student achievement.[29] Not surprisingly, students of highly qualified teachers have significant learning advantages. In this case, 'highly qualified' is defined as teachers having an undergraduate major or minor in the field in which they are assigned to teach.

A study by the Center for the Study of Teaching found that two factors were most consistently and powerfully linked with student success — teaching certification and a college major in the field being taught.[30] Main NAEP, administered in 2000 in mathematics, found that a teacher with an undergraduate degree in mathematics education led to an increase of 6 points for both fourth and eighth graders.[31] Results for the 2000 main NAEP in science were similar; there is a statistically significant difference in the science achievement of eighth graders between those taught by instructors with undergraduate degrees in science and those who were not.[32]

These differences are of greater concern when considered in the light of a recent study — *Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching in 1987-88 to 1999-2000* — that reports that 69 percent of middle school students enrolled in math are taught by teachers who neither majored in math in college nor are certified to teach math at that level.[33] About 60 percent of middle school students enrolled in biology or life sciences find themselves taught by teachers who are similarly 'out-of-field.' The same report noted that 93 percent of middle school students enrolled in physical science are taught by 'out-of-field' teachers.

The situation in high school is only a little better. At least 60 percent of high school students enrolled in physical science — including chemistry, geology/earth/space science, and physics — have teachers without a major or certification in the subject taught. Forty-five percent of high school students enrolled in biology or life science and about 30 percent of those enrolled in math have 'out-of-field' teachers.[34]

This problem is even worse for predominantly minority and poor schools: more than 70 percent of middle-grade math classes are taught by teachers who lack even a college minor in the field.[35] In fact, a 2000 survey reported that more than 90 percent of 40 large urban schools that responded to the survey had an immediate need for a certified math or science teacher.[36]

Elementary school teachers are drawn to teaching careers for many reasons, but an affinity for math and science is not often one of them. Despite good intentions, the quality of instruction in these two disciplines is often lacking. Many middle school teachers have K-8 certification; that is, they earned only three or six undergraduate credits in math and/or science, which is an inadequate knowledge base for the content slated for middle school math and science courses.

Problems with the Curriculum

Three recent reports have acknowledged the poor quality of curricular materials as one of the problems confronting math and science education. Project 2061, organized by the American Association for the Advancement of Science, reviewed middle grade math and science textbooks against their own benchmarks for quality textbooks. The results were dismal: only a few math textbooks scored at an acceptable level, while no science textbooks gained Project 2061's imprimatur.[37]

The National Research Council's report on math education, *Adding It Up: Helping Children Learn Mathematics*, (a companion report on science is forthcoming) points to the need for an interactive curriculum, instead of the current "shallow" curriculum that emphasizes "the execution of pencil-and-paper skills…through demonstrations…followed by repeated practice."[38]

Research conducted by William Schmidt, the U.S. National Coordinator for TIMSS, demonstrated that the top achieving countries have coherent, focused and demanding curricula, whereas the U.S. curriculum is disorganized and focused too long on basic skills.[39]

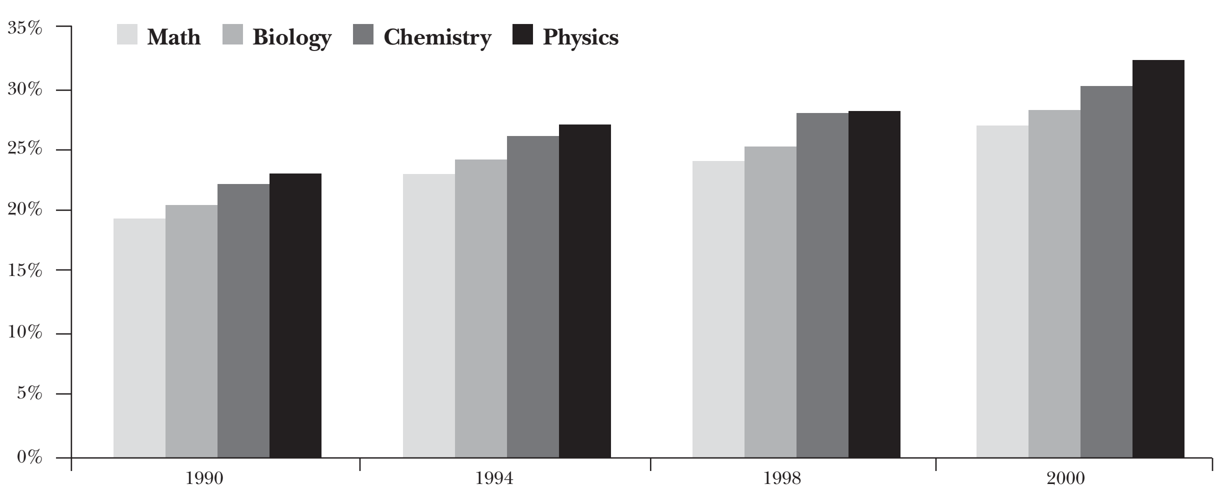
Aging of the Teaching Force

Like many sectors of the labor force, significant numbers of teachers are nearing retirement. Recent estimates suggest that two-thirds of the K-12 teaching force will retire or otherwise leave the profession in the next ten years.[40] Yet, 53 million young people are enrolled in elementary and secondary schools in this country, the most ever. This population growth trend will not abate soon. Experts predict that by 2020, there will be 55 million young people (aged 5-17) in America, with the growth rate continuing throughout this century.[41]

Among math and science teachers, the number of those nationwide over the age of 50 continued to rise through the 1990s. (See Figure 7.) Connecticut had the largest percentage, with 44 percent of math and science teachers over age 50 in 2000. Only New Jersey, among the 27 states reporting data, showed a decrease in this measure.[42] Hence, even as more teachers will be needed to match the population growth, more teachers will be eligible for retirement. The challenge has greater impact than 'just a shortage,' since fewer experienced teachers will be available to mentor newcomers to the profession.

Figure 7

Percentage of Math and Science Teachers over the Age of 50, 1990-2000



SOURCE: Council of Chief State School Officers, *State Indicators of Science and Mathematics Education: 2001* (Washington, D.C.: Council of Chief State School Officers, 2001), p. 83.

Retention of Qualified Teachers

At the same time, 18 of the 27 states reported an increase in the percentage of teachers under the age of 30. While young people entering the teaching profession is heartening, other data demonstrates that their professional tenure may be limited.

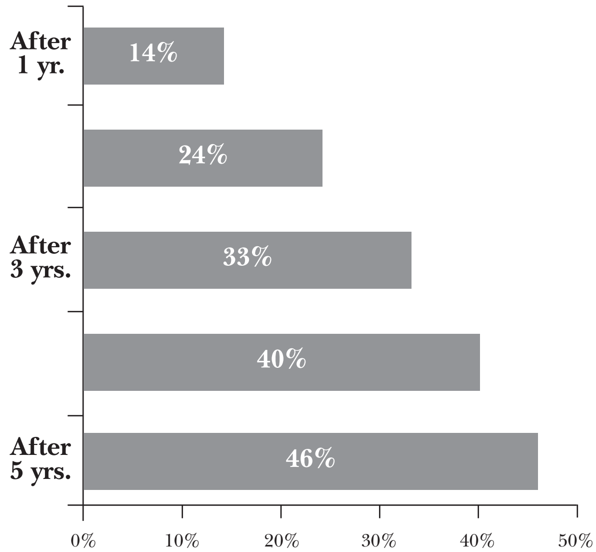
By the time new math and science teachers have been in the profession for three years, a third of them have left the field. Two years later, another 13 percent of the initial group has left the profession.[43] (See Figure 8.) Although this revolving door may slow somewhat with the current downturn in the economy, there is no reason to believe that the change will be permanent. Thus, the annual influx of new teachers replaces those retiring, but makes little impact on the shortage of qualified teachers. Much of the teaching burden is then left to inexperienced teachers.

Moreover, such turnover is expensive. Estimates for the losses absorbed by Texas due to teacher turnover (where the 15.5 percent rate of annual turnover is slightly higher than the national average) are conservatively estimated at $329 million annually for teachers in all fields. More complex models that include factors such as the additional training and learning curve setback yield losses as high as $2.1 billion a year.[44]

The challenge of retention is not limited to new and nearly retired teachers, however. Research suggests that the turnover rate among teachers is higher than among many other professions. Teachers cite "job dissatisfaction" in significant numbers as a main reason for leaving the field. Two-thirds identify low salaries as the source of the dissatisfaction; other factors included a lack of administrative support, student discipline problems and a lack of student motivation. For math and science teachers, salary and student motivation are the key factors in dissatisfaction, with twice as many citing student motivation as a problem, as compared to the general population of teachers.[45]

Figure 8

Cumulative Attrition for Beginning Teachers



SOURCE: Richard M. Ingersoll, "The Teacher Shortage: A Case of Wrong Diagnosis and Wrong Prescription," *NASSP Bulletin*, vol. 86, no. 631 (2002), pp. 16-31.

New levels of student interest cannot be mandated, nor an end to the flow of teachers from the classroom decreed. We believe, however, that a well-conceived and implemented plan of action, taking into account these data, has great potential for positive impact.

Chapter 3

UNDERGRADUATE AND LABOR MARKET ISSUES

The important role of K-12 education in creating a scientifically literate society cannot be overstated. Equally important in maintaining the pipeline for scientists and engineers is education at the undergraduate level. The economy's continued expansion requires an infusion of science and engineering talent, including that of trained scientists and engineers as well as the improvement of technical skills throughout the workforce, and that infusion will have to come from America's colleges and universities.

While the total number of bachelor's degrees conferred in the United States increased over the past 20 years, most areas of science and engineering saw a decline. The proportional decline in the United States far outpaced that of our international competitors, who continue to emphasize math and science skills as an integral part of education.

Currently, American firms are scrambling abroad to find talent, and will soon be faced with a new wave of retirements as the baby boomers, educated during the post-Sputnik rise in interest in science and engineering, exit the labor force. The most desirable technical jobs that are being created are good jobs, with relatively high salaries. Without the proper science and engineering training, a large percentage of young people, especially women and underrepresented minorities, will miss out on a major component of the opportunity America offers. Though undergraduate and labor market issues could easily fill chapters of their own, we address them here together to demonstrate our belief these areas are interrelated and that signals in one market can have an important impact on the other.

REDUCTIONS IN THE NUMBER OF UNDERGRADUATES IN SCIENCE AND ENGINEERING

After the launch of Sputnik and within the context of the Cold War, the federal government instituted an array of programs to increase the number of graduates with degrees in science and engineering fields. This influx of talent helped fuel the economic growth that the United States experienced during the latter half of the 20th century. However, that cohort of scientists and engineers will be retiring soon. Our colleges and universities are not producing enough scientists and engineers to meet the additional labor needs of an increasingly technological society.

During the period 1985-2000, the number of bachelor's degrees conferred in most science and engineering fields stagnated or fell, despite the general growth in the number of bachelor's degrees awarded annually. The lone exception has been strong increases in the biological sciences, particularly in biomedical fields. Yet despite the dramatic growth in biology degrees over the past fifteen years, it still comprises a smaller share of all degrees granted than it did in 1975 (7.1 percent).[46] Otherwise, all other fields of science and engineering have failed to keep up

Table 2

Earned Bachelor's Degrees by Field, 1985-2000

	1985	2000	% Change	% of all Degrees 1985	% of all Degrees 2000
All Bachelor's Degrees, All Fields	990,877	1,253,121	26%	100%	100%
Total Science & Engineering*	207,240	210,434	2%	20.9%	16.8%
Natural Sciences	75,158	101,775	35%	7.6%	8.1%
Biological and Agricultural	51,312	83,148	62%	5.2%	6.6%
Earth/atmospheric/ocean Sciences	7,576	4,047	-47%	0.8%	0.3%
Physical Sciences	16,270	14,580	-10%	1.6%	1.2%
Chemistry	10,701	10,390	-3%	1.1%	0.8%
Physics	4,111	3,362	-18%	0.4%	0.3%
Mathematics and Computer Sciences	54,510	49,123	-10%	5.5%	3.9%
Mathematics	15,389	11,735	-24%	1.6%	0.9%
Computer Science	39,121	37,388	-4%	3.9%	3.0%
Engineering, All	77,572	59,536	-23%	7.8%	4.8%
Chemical	8,941	6,219	-30%	0.9%	0.5%
Civil	9,730	9,596	-1%	1.0%	0.8%
Electrical	23,668	17,672	-25%	2.4%	1.4%
Industrial	4,009	3,937	-2%	0.4%	0.3%
Mechanical	17,200	13,109	-24%	1.7%	1.0%
Engineering Technologies	20,476	14,825**	-28%	2.1%	1.2%

* = Does not include social and behavioral sciences.
**=1998
SOURCE: National Science Foundation, *Science and Engineering Degrees: 1966-2000* (Arlington, VA: National Science Foundation, 2002); data for "Engineering technologies" from National Science Foundation, *Science and Engineering Indicators: 2002,* NSB 02-01 (Arlington, VA: National Science Foundation, 2002), Appendix Table 2-16.

with the general growth in the number of bachelor's degrees awarded each year. For the fields of engineering and mathematics, these losses are significant. (See Table 2.)

Newly released data show that the field of computer science, however, may be making a comeback. After peaking with over 42,000 bachelor's degrees conferred in 1986, computer science suffered a steady decline. By 1992, that number fell to 24,958, a range it maintained until the late 1990s; then, after smaller increases in 1997 and 1998, the number of bachelor's degrees conferred in computer science increased almost 35 percent between 1998 and 2000. It is too early to call this increase a "trend," nor is similar growth reflected in any of the other sciences. However, this could be an example of signaling between the labor market and undergraduate students who are choosing a field of study, as well as the costly lag that accompanies such a *reaction* to employment trends. Providing students with a better sense of future trends, such as those discussed below, would allow for improved synchronization between the two markets. It should also be noted that men outnumbered women in the 2000 undergraduate cohort by more than two-to-one, a ratio that has increased since 1986.

Minorities and Women in Science and Engineering

The total number of bachelor's degrees granted to minority students has been increasing throughout the past 25 years.[47]

Many of these students are the first in their family to attend college. This matriculation is a success that should be built upon with encouragement to pursue careers in science and engineering.

Currently, high achieving minority and female students tend to move away from opportunities in science and engineering. Citing poor teaching in previous math and science courses, a lack of support and a lack of confidence in their ability to succeed in science and engineering, black and Hispanic students with high grade point averages and SAT scores typically do not pursue degrees in science and engineering.[48] Women, while reaching similar levels of achievement in secondary school as men, also shy away from science and engineering fields in their undergraduate work.

Some progress, albeit uneven, is being made. According to the National Action Council for Minorities in Engineering (NACME), the enrollment of minorities into engineering was at its highest level ever in 2001; more than 15,000 minority first-year students enrolled as engineering majors, eclipsing the previous standard set in 1992.[49] However, the NACME report also noted that, as a portion of the total freshman class enrolling in engineering majors, the proportion of minorities fell from its 2000 levels.[50]

The long-term trend (starting from 1971) shows an increased participation of blacks in science and engineering, though it has slowed over the past decade. The percentage of first-year black students intending to major in science and engineering fields, as a proportion of all first year students intending to major in science and engineering, increased from roughly 6 percent in 1971 to 11.7 percent in 1988.[51] The proportion has remained slightly below that figure since then, coming in at 11.5 percent in 2000.

Hispanic students, meanwhile, have made significant gains in this area. During the last three decades, the proportion of incoming first year Hispanic students intending to major in science and engineering fields increased fourteen-fold. Yet, Hispanic students represent only 7.1 percent of the incoming class in 2000, compared to the 17.4 percent of the total population of 18- to 24-year-olds that is of Hispanic origin.[52]

The number of women selecting majors in science and engineering (including behavioral sciences) has increased over time, although the rate of growth also slowed in the 1990s.[53]

While improving enrollment data is a necessary first step, success depends on an increase in the number of degrees actually conferred. Overall, less than 40 percent of students who enter college planning to major in science or engineering graduates with a degree in that field within six years. For underrepresented minorities, less than one-quarter of entering science and engineering students do so.[54] Women also move out of science and engineering fields at an above average level.

Possible Explanations for the Decline in Total Science and Engineering Degrees

Many of the reasons for this decline were explored in Chapter 2. It is no surprise that students, with only a mediocre mastery of math and science in middle and high school, shy away from math- and science-dependent majors in college. They are not drawn to these majors and do not think of themselves as adept in the necessary knowledge and skills to succeed. Among those who do go forward, there is a new set of obstacles. The obstacles can be formidable since, by their sophomore year, a third of students intent on majoring in science and engineering have dropped out of those fields.[55]

One problem may arise from the grading policies of science and engineering departments. It is well documented that science and engineering faculty members grade their students more critically than their colleagues in the humanities. In part this reflects poor preparation: students receive low scores in college because they do not have the tools and knowledge to succeed in undergraduate courses. Faculty should not inflate grades to make students feel better; they do have an obligation, however, to encourage and help students seek remediation. Large numbers of failing students should not be viewed as an acceptable outcome.

Comparing grades in different departments at seven colleges, researchers Richard Sabot and John Wakemann-Linn found "low scoring" departments award a third fewer "A"s than "high scoring" departments, and "low scoring" departments are twice as likely to give grades below a "B-," with some 40 percent of grades falling in that second category.[56] Chemistry and math are among the "low scoring" departments, while no science or engineering departments appear on the "high scoring" list.

Researchers at Duke University performed a similar study during the 1998-1999 school year. This study found that the difference in the mean grade given by Duke faculty was almost a half a letter grade, from an average of 3.54 in humanities to 3.05 in the natural sciences and math.[57]

Students' low grades in science and engineering courses can have an impact on their future course choice. The Duke University study found that these grade differentials could lead to as much as a 50 percent reduction in the number of elective courses students take in the natural sciences or math.[58] Thus, students who may have the potential to become successful scientists and engineers are being driven away prematurely.

Equally problematic is the quality of the instruction and nature of the curriculum in introductory courses. Students who intended to major in science and engineering often point to the quality of instruction in their first classes as reasons for leaving.[59] A recent study by the National Research Council found that most faculty members who teach undergraduate courses have received little training in classroom instruction or grading.[60]

The vertical structure of the science and engineering curriculum also creates drawbacks for those who are undecided as to a major. Since many departments view these courses simply as content-heavy prerequisites for advanced classes, they often turn into "litanies of facts," with little connection to the broader scientific context or other fields of study.[61] Instead of acting as a "pull" into science and engineering departments, these classes then become a filter, with faculty focusing on those who show obvious potential and interest in science and engineering, instead of attempting to increase student interest across the board.

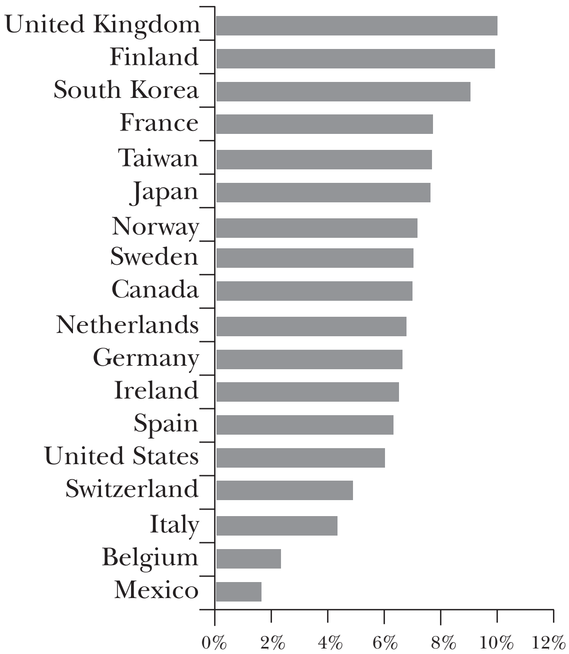
International Comparisons

Many nations currently produce a higher proportion of science and engineering undergraduates than the United States. And while these nations increase the number of their scientists and engineers, the number in the United States continues to decline. (See Figures 9 and 10.)

Putting the data presented in these two figures in context demonstrates the dramatic decline the United States has seen in its creation of science and engineering majors. While the United States still has one of the highest rates of total first university degrees among its 24-year-old population (currently over 35 percent), that is no longer a unique advantage, in which increased numbers of students pursuing degrees would allow spillover into science and engineering. In Figure 9, the U.S. is fourteenth in the share of the population receiving science and engineering degrees; in 1975, it was third. Figure 10 illustrates the rapidity of this decline.

Figure 9

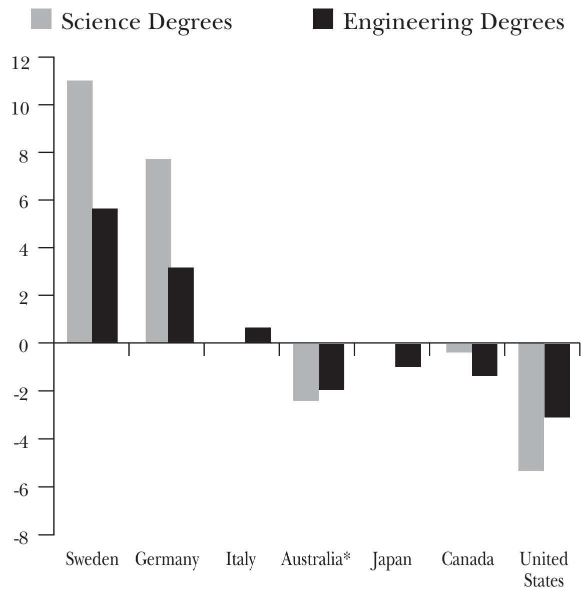
First University Degrees in Natural Sciences and Engineering as Percentage of 24-year-old Population, 1999*



*In some cases, 1998
SOURCE: National Science Board, *Science and Engineering Indicators: 2002,* NSB 02-01 (Washington, D.C.: U.S. Government Printing Office, 2002), Appendix Table 2-18.

Figure 10

Percentage Change in First University Degrees in Science and Engineering Degrees Awarded in Selected Countries, 1985-1995



SOURCE: National Center for Education Statistics, *International Education Indicators: A Time Series Perspective, 1985-1995*, NCES 2000-021 (Washington, D.C.: U.S. Department of Education, 2000), Tables 15.1 and 15.4.
*Australia, science-change from 1993 to 1995; Australia, engineering-change from 1987-1995.

IMPLICATIONS FOR THE PROFESSIONAL TECHNICAL LABOR MARKET

Currently, our colleges and universities are struggling to meet the needs of the domestic economy for technically skilled workers.

Expanding the Labor Force to Meet the Needs of a Dynamic Economy

During the expansions of the 1980s and 1990s, the number of science and engineering jobs increased 159 percent.[62] That growth led employers to scramble to hire science and engineering talent.

As a strong U.S. economy reemerges, strong job growth in science and engineering fields is expected to occur. In general, job growth is expected to be around 15 percent, whereas the expected growth for scientists and engineers is about 47 percent, or the creation of 2.1 million new jobs.[63] By way of comparison, in 1999 the private sector employed over 1.5 million scientists and engineers who held bachelor's degrees.[64] Thus, the need for an additional 2 million scientists and engineers is significant. Although a large percentage of these new jobs will be in the computer sciences, other sectors will experience job growth, as well as confronting the

Table 3

Total Science and Engineering Jobs, 2000 and 2010 (projected)

	2000	2010	New	Total Openings
All Science and Engineering	4,296	6,412	2,116	2,717
Scientists	2,831	4,809	1,978	2,285
Life Scientists	184	218	34	93
Computer and Mathemetics	2,408	4,308	1,900	2,068
Computer Science	2,318	4,213	1,895	2,032
Mathematics	89	95	5	26
Physical Scientists	239	283	44	124
Engineers	1,465	1,603	138	432

NOTE: Totals do not include Social Sciences. In Thousands of Jobs. Numbers do not sum due to rounding.
SOURCE: Daniel E. Hecker, "Occupational employment projections to 2010," *Monthly Labor Review*, vol. 124, no.11, November 2001, pp. 57-84.

retirements of those who went into science and engineering in the Sputnik era. Over the next 10 years, the percentage of scientists and engineers that have reached retirement age will triple.[65] The pressing need to increase the pipeline of scientists and engineers is clear. (See Table 3.)

A sizable number of jobs for scientists and engineers are in the public sector. It is increasingly difficult, however, for the public sector to compete with the private section in attracting the best talent. A further complication is that a significant portion of these positions must be filled by native-born employees, for reasons of security.

Finally, the shortage of qualified elementary and secondary math and science teachers is already in a crisis stage. Over the next decade, though, there will be some 200,000 job openings for secondary science and mathematics teachers. (This includes both retirements and new positions.)[66]

The importance of trained scientists and engineers across these varied sectors shows the reliance that our economy has on these fields for growth, and the necessity of ensuring an adequate supply of them.

The so-called PhD "glut" might lead some to question these projections. Indeed, the number of PhDs in some fields seeking academic positions now outnumbers the available tenure-track positions, forcing individuals to spend years in post-doctorate positions that do little to further their career.[67] One contributing factor could be a lack of information about the technical labor market. A survey of PhD candidates found that "university faculty do not promote non-academic careers for PhDs."[68] If provided better information regarding the career possibilities in science and engineering fields in the public or private sectors, many of these PhD candidates could explore careers outside of academia. In fact, better information about the technical labor market should be available to bachelor's and master's candidates as well.

Aside from the jobs specifically meant for science and engineering majors, "knowledge jobs" that require some math and science skills will also increase faster than the average. According to recent estimates from the Bureau of Labor Statistics, all seven categories of jobs that require a postsecondary degree will expand at above-average rates over the next 10 years.[69]

Technical Jobs as a Source of Economic and Social Mobility

Growing economies almost always create new jobs, but a significant portion of the job growth often occurs in low-wage industries. This is not true in the expansion of the technical labor force. Most of the new positions created for scientists and engineers will be in the highest quartile of annual earnings.[70] The current scarcity has helped keep wages high for those with professional technical skills. As the market begins to tighten again, these wages will likely see a further spike.

The availability of a good job is a powerful incentive for students to seek degrees in science and engineering. For underprivileged students, this opportunity is a way to escape poverty or otherwise improve their socioeconomic status.

THE IMPACT OF FOREIGN-BORN STUDENTS AND WORKERS

Immigration and foreign workers have allowed the United States to avoid confronting its problems in the professional technical labor market. The influx of students into our colleges and universities has kept enrollment strong, while the use of special immigrant visas has helped plug holes in the labor market that have resulted from the lack of qualified domestic workers in these areas.

Foreign Students in Science and Engineering

The last half of the 20th century witnessed a dramatic increase in the number of foreign students studying at American universities. Though the percentage of foreign science and engineering students at the undergraduate level has remained relatively low, foreign students have begun to dominate graduate enrollment. Although graduate education at large lies outside the realm of this Policy Statement, these trends deserve mention. Almost 50 percent of engineering doctorate degrees conferred by American universities in engineering in 1998-9 went to foreign-born students. For mathematics/computer science and the natural sciences, the rate of foreign enrollment is more than one-third.[71] Similar trends exist at the master's levels.

Foreign Workers in the Technical Labor Market

During the labor shortage of the late 1990s, high-tech firms lobbied Congress to expand the number of H1-B visas approved each year, citing a lack of qualified domestic candidates for the open positions. In response, Congress expanded the limits on several occasions. The expanded limits are due to expire soon and are unlikely to be renewed in the current economic and political climate, despite a warning from the scientific community of the necessity of maintaining a flow of foreign scientists and engineers into the country.[72] Unless steps are taken now to increase the number of native-born scientists and engineers, American companies will be unable to sustain innovation-led growth in the near future. Some fear that firms will inevitably take their research efforts abroad, where the talent is plentiful.

Even those foreigners who were educated in the U.S. and qualify for extended visas are showing a lower propensity to stay in this country. The new global economy is making it possible for people to return to their country of origin for employment. Instead of a "brain drain" overseas, there is a system of "brain circulation" as workers leverage their skills and contacts worldwide.[73] This arrangement increases the instability in the domestic labor market and increases the quality of our foreign competition. And as their home countries continue to improve their own technical standing, this trend will persist.

Chapter 4

CHANGING THE CULTURE OF K-16 MATH AND SCIENCE EDUCATION AND INCREASING THE SUPPLY OF SCIENTISTS AND ENGINEERS

Improving the math and science performance of America's students and drawing them into careers in science and engineering requires a culture change. This change in math and science education will involve all of the stakeholders in education — from states and local school districts, to higher education, to business.

Although the need to improve student achievement in math and science is not new, the nature of the debate has changed. The No Child Left Behind Act, passed in early 2002, requires states to implement a system of standards-based assessments in reading and mathematics, with assessments at selected grade levels beginning in the 2002-2003 school year, and in all grades 3-8 by 2005-2006.[†] These assessments must be aligned to state standards; hence the standards must be sufficiently rigorous to guide real progress. After two years, all schools and school districts will be held accountable for all major student groups making "adequate yearly progress" toward being "proficient" against the state academic standards. The analogous effort in science comes later: states are not required to have high quality science standards in place until 2005-2006, with tests beginning in 2007-2008 at selected grade levels.

As part of the effort to improve student scores, the No Child Left Behind Act also authorized programs to improve professional development. One such program is the Math/Science Partnership Program, which is considered in more detail later in this chapter.

The movement to define high standards, to make schools accountable for low scores, and to improve data collection on individual student performance is not new. National standards in mathematics and science have been available since 1989 and 1995, respectively. Most states have also developed their own standards in math and science. An increasing number of states are using these standards to establish exit exams for high school graduates, as seen in the examples of California, Massachusetts, and Virginia in Chapter 2. Some states are also administering assessments at select grade levels along the K-12 continuum to identify and remediate weaknesses. States that have adopted such programs have shown a measure of success and should be considered models for other states and programs.

Although changes made at the federal and state levels are encouraging, continued vigilance by all stakeholders is required. Education policy is largely a state responsibility, performed by local school districts. Colleges and universities often develop curricular materials and prepare the next generation of teachers and scientists, mathematicians, and engineers. In the end, business is the ultimate consumer of the labor force prepared by the education system. Thus, each group must play a role in reform.

This chapter presents recommendations for all stakeholders to improve math and

† Before the passage of the No Child Left Behind Act, federal mandates required systems of assessment only for schools that accepted federal Title I funds.

science education and increase the supply of scientists and engineers. To reflect the interrelated roles of the different stakeholders, we describe three Challenges that must be addressed to change the culture of math and science education:

- *Increasing student interest in math and science to maintain the pipeline*
- *Demonstrating the wonder of discovery while helping students to master rigorous content*
- *Acknowledging the professionalism of teachers*

The first two Challenges focus on the "demand" side of math and science education, which CED believes will ultimately be the most important lever to encourage more students to succeed in math and science at the elementary and secondary level, and to pursue a career in science and engineering after they have entered college.

The third Challenge addresses the "supply" side of math and science education. Stoking a child's interest in math and science requires excellent teaching, yet many school districts lack enough qualified math and science teachers.

Action on all of these fronts is critical to the success of a reform program, although change in any one area would be a positive step. The active participation of business in partnership with local schools will greatly aid progress in these areas.

CHALLENGE ONE: INCREASING STUDENT INTEREST IN MATH AND SCIENCE TO MAINTAIN THE PIPELINE

One of the important goals of math and science education reform is to increase students' excitement for math and science, thus increasing the likelihood of a related career choice.

Excitement for math and science will be fueled by intriguing subject matter, the presence of knowledgeable and enthusiastic adults, and a wide array of opportunities that reward a mastery of math and science. This Challenge addresses those goals.

Ensuring Widespread Scientific and Quantitative Literacy

Efforts to actively engage students in learning math and science will likely be most successful in promoting and sustaining their interest and ensuring that each child attains scientific and quantitative literacy.

Reconsidering the K-12 Curricula

Local school districts should review their adopted curricula to ensure that they adequately engage students, promote active learning, and align to state and local standards of student performance and knowledge.

Math and science hold limitless potential for a fertile imagination. Science programming has been a staple of children's entertainment for generations, from "Mr. Wizard" to "Bill Nye, the Science Guy." Field trips to the local science museum or zoo are often the most anticipated of the year.

Unfortunately, textbooks and curriculum plans often fail to capture the student's imagination in a similar manner. Curricula based upon the memorization and recitation of facts will not stimulate an active mind. Given a basic understanding of a topic area and the watchful, guiding eye of a knowledgeable teacher, students have the ability to make discoveries; this path to learning should be encouraged.

Assisting School Districts with Curriculum Enhancement

Businesses should collaborate with school districts to develop enhancements to the district-adopted math and science curricula that integrate state-of-the-art applications of mathematical and scientific principles into the classroom setting and provide an insight into

the work scientists and engineers perform every day.

Among the most important assets that industry brings to its partnership with schools is its content knowledge. Scientists and engineers who work in state-of-the-art environments possess skills and knowledge not always captured in the curriculum.

The import of knowledge from local firms could have an impact on learning in a number of areas. Certainly, there is a need for a standard curricula that ensures coverage of all the basic skills and ideas needed to understand math and science. This information, though, often lacks a practical context. Business has the ability to add to the curriculum in a way that supplements the information and makes the models more concrete by using true-life examples that children can understand. (See text box, "ExxonMobil's Science Ambassadors Program.")

Promoting Extracurricular Math and Science Activities

Business should provide financial and logistical support to extracurricular math and science activities, as well as the time and talents of their employees, to enrich the learning experiences of students. Educators should organize student groups to participate in such activities, if they do not already exist, and work to integrate business support into these programs.

The classroom alone is not always sufficient to meet the needs of inquisitive students. Extracurricular math- and science-based activities can provide an outlet for a child's imagination and desire to learn more about the scientific world. Potential programs range from local science fairs to national competitions, such as For Inspiration and Recognition of Science and Technology, or FIRST (see accompanying text box). Programs like these can be good for students and business alike.

The students who participate in these programs often come away with a variety of positive experiences. A fulfilling extracurricular activity can spark a long-term interest in science and engineering. An important additional effect of these programs is learning problem-solving skills, especially in a team environ-

EXXONMOBIL'S SCIENCE AMBASSADORS PROGRAM

ExxonMobil sponsors a range of programs aimed at improving math and science education throughout the country, spending more than $13 million annually. One such program is the Science Ambassadors Program, created in conjunction with schools around Houston, Texas. This program encourages employees to participate as Science Ambassadors in activities that promote math and science education, such as judging science fairs or participating in career day events.

The larger effort helps concentrate corporate outreach efforts where they are most needed by the partner districts. Specific programs under this umbrella include providing classroom materials, providing teacher training based on school district needs, and opportunities for field trips to ExxonMobil facilities and on-the-job shadowing. Grants are also made available to participating schools.

A corporate Education Advisory Board administers the programs, with representatives called District Ambassadors selected to work with each school district individually. The designation of specific contacts for a district helps to maintain a dialogue as to the specific goals of the program and the effectiveness of previous efforts.

SOURCE: The Council for Corporate and School Partnerships, *Guiding Principles for Business and School Partnerships,* (September 2002), available at <http://www.nabe.org/documents/GP.pdf>. Accessed March 17, 2003.

FIRST: FOR INSPIRATION AND RECOGNITION OF SCIENCE AND TECHNOLOGY

Inventor Dean Kamen founded the FIRST program almost 15 years ago. His goal was to inspire children to become more involved in math and science by providing them with an interactive and challenging opportunity to explore the world of math and science.

The FIRST program is based around an annual robotics competition. Teams are given six weeks to work with a standardized set of materials to build a robot that can accomplish a specified set of tasks. Teams then participate in a series of competitions, cumulating in a championship event, held at the EPCOT Center at Walt Disney World, attracting more than 20,000 participants.

Every FIRST team is based upon the tripartite relationship between the participating schools, mentors, and sponsors. Working with practicing engineers, scientists, and technologists provides a unique opportunity for students and raises the bar for their performance. It also provides businesses with an opportunity for community outreach and provides a talent base for recruitment into internship and other programs.

The goals of FIRST go beyond simply teaching the students to build a robot. The structure of the program also encourages teamwork and developing strategies for problem solving. These skills will be more valuable to students in their future studies than the simple lessons of technology.

The success of FIRST has also led to a spin-off competition for children aged 9 to 14. The FIRST LEGO League was created in coalition with the LEGO Company and provides younger children similar opportunities to work with simpler robots. Often members of a FIRST team will assist in mentoring their younger cohorts at a school in their district.

SOURCE: www.usfirst.org

ment, a skill that is increasingly valuable in the marketplace. Finally, there is the benefit of increased self-esteem for the students. Students that have successfully completed these programs gain the confidence that comes with building a robot or successfully explaining a science fair project to a judge.

Employers and employee volunteers also gain from the experience of participating in these programs. Volunteers cite the excitement of working with the young children as a means of reenergizing themselves and their work. The creative thinking employed by the students can help spur the mentors' own creativity. And frequently, by "managing" teams in development, mentors gain real-life management training that is not often available to junior staff members at a firm. The experience at X-Rite, a high tech firm in Grandville, MI demonstrates these principles well. Employees who worked with FIRST teams felt they could work better in a team environment after the experience, and found that it stretched their own skills as well. Management reported that "walls" between departments also fell as employees learned to communicate better.[74]

Increasing the Number of Students Completing Degrees in Mathematics, Science and Engineering Fields

Over the next 10 years, job growth in science and engineering fields will outpace that of most other sectors. But unlike some other sectors, in which labor can move in or out with ease, entry into the professional technical labor market is the culmination of a process that takes many years, beginning when students receive their very first lessons in math and science. Currently, many of these students are being lost at the undergraduate level, a problem that must be addressed.

Reforming Undergraduate Curriculum to Improve the Perception of Science and Engineering Fields

Colleges and universities should pay close attention to the number of graduates they yield each year when evaluating the effectiveness of their science and engineering programs.

Experienced professors should be assigned to introductory classes, among their teaching responsibilities. Classes taught by inexperienced teaching assistants or novice faculty, while more cost effective, can work against efforts to increase the number of majors in the department.

Grading policies should be monitored in STEM (science, technology, engineering, and mathematics) classes for accuracy and fairness, to ensure alignment with other departments in the institution.

Additionally, articulation between higher education and K-12 should be increased to better prepare students for the rigors of higher education. Addressing this gap will help ensure that students enter college prepared to face the rigor of university-level science and engineering courses.

Finally, meaningful laboratory exploration should be an integral part of science coursework. These lab experiences are engaging and challenge students to think independently.

Making Professional Technical Careers Visible to Students

Scientifically-based businesses should collaborate with institutions of higher education to highlight the professional opportunities that are available to those with a background in STEM fields. Businesses should also offer internships to undergraduate STEM majors.

Internship opportunities can provide a unique application of classroom lessons not foreseen by the student. By working in such an environment, students can also gain a better appreciation of the lessons they have learned in the classroom.

Often times, students who work with a mentor will seek later employment at the firm. And firms that make these efforts an important part of their community outreach program will have an advantage in later recruitment.

Increasing the Interest and Success of Women and Minorities in Math and Science

Widespread implementation of the following recommendations must take into account the emerging demographics of this country. Around three-fifths of the professional technical workforce is comprised of white males, yet they comprise only 40 percent of the labor market at large. To meet future employment needs, greater efforts must be made to ensure that female and minority students have the opportunity and enter science and engineering fields.

I*mproving Minority Performance in K-12 Math and Science*

Programs with proven effectiveness to support high achievement among traditionally underrepresented groups of students in K-12 STEM courses should be replicated. Disaggregated assessment data for all groups of students must be used to identify areas of content deficiency and immediate remediation must be undertaken. Business leaders should partner with educators to ensure that the collection of such data and remediation is ongoing and timely. The business community should call on state and federal governments to provide the necessary support for this process of assessment, accountability, and action.

Before more minority students enter the fields of science and engineering, their performance in the classroom must be improved. This will require breaking them out of a culture that often expects little from them academically and discourages their pursuits in math and science.

Federal Title I programs, part of the Elementary and Secondary Education Act (the predecessor to the No Child Left Behind Act, which continued Title I), target children living in poverty, of which a disproportionate number are minority. Title I provides funds for schools to assist them in improving student performance. Programs undertaken using Title I funds should be reviewed, so that the lessons learned from them can be applied to new, as well as ongoing, efforts in this field.

Increasing the Number of Underrepresented Undergraduates in Science and Engineering Fields

Businesses must redouble their efforts to provide support to traditionally underrepresented groups of undergraduate and graduate students in STEM fields. They should encourage higher education institutions to actively recruit STEM majors among minority and female students, with practices such are scholarships, mentoring programs and faculty outreach. Business must also provide a significant number of internships for minority and female students and encourage their minority employees to mentor students.

Reaching minority students who have an affinity for math and science must become a priority of both institutes of higher learning and employers in science and engineering fields. (See text box, "Berkeley Foundation for Opportunities in Information Technology.")

Minority students who do persist in science and engineering fields cite their relationship with a mentor in their field as having more influence on their decision to enter science and engineering than their parents, friends, or teachers.[75]

CHALLENGE TWO: DEMONSTRATING THE WONDER OF DISCOVERY WHILE HELPING STUDENTS TO MASTER RIGOROUS CONTENT

CED strongly supports the nationwide movement towards standards and accountability. To make these reforms successful, teachers must have the knowledge and skills they need. Teacher preparation and ongoing professional development opportunities, therefore, must be revitalized so that every classroom is graced with a caring, highly competent teacher.

This Challenge focuses on the knowledge and skills that teachers can bring to the classroom to make math and science subjects more engaging to their students, without compromising the level of rigor. Recommendations to address this issue include reforming teacher education, providing more opportunities for teachers to work with those in the technical labor force, increasing the effectiveness of professional development, and encouraging local experimentation in math and science education.

BERKELEY FOUNDATION FOR OPPORTUNITIES IN INFORMATION TECHNOLOGY

The Berkeley Foundation for Opportunities in Information Technology (BFOIT) was created to address the problem of minority underrepresentation in science and engineering. The program is open only to minorities, and in the past year worked with students who are black, Asian, Hispanic, and American Indian. Females outnumbered males in the program by a margin of almost two-to-one.

Organized by the Industrial Advisory Board of the electrical engineering and computer science department at the University of California at Berkeley, BFOIT operates with the philosophy that students have a number of options available to them, and their choices are often affected by specific events at key points in their academic life.

BFOIT runs the IT Leadership Program (ITLP), which consists of a summer institute in connection with year-long outreach efforts. The summer institute is an intensive two-week program that provides the participants the opportunity to work with some basic computer programming and web page design. While the time constraints of the program limit what can be taught, it does provide students with a taste of computer science that they cannot find at their local schools. During the rest of the year, the participants in the ITLP meet for presentations and discussions led by technology experts, academics, and civic leaders that address relevant global and local issues involving technology. Additional events include museum visits, conferences, and other activities.

BFOIT and ITLP are sponsored by a number of high-tech firms that provide both financial and logistical support. These firms also provide employees to present the events described above and work with the program facilitators.

SOURCE: Susan McLester, “Working Toward Diversity,” *Technology & Learning*, vol. 22, no. 3 (2001); www.bfoit.org.

Improving Math and Science Teacher Education

Colleges and universities that educate future and current teachers must ensure that their courses of study emphasize acquisition of content knowledge, an understanding of the place of that knowledge in society, as well as the pedagogical training to deliver that knowledge to students of all backgrounds and abilities. Higher education must track the success of their graduates in teaching careers (as measured by student performance and teacher retention), so that their own course offerings can be continually improved as needed. Colleges and universities should tailor summer courses in mathematics, science and engineering to the content needs of current teachers, and, with school districts, actively seek their enrollment and successful completion.

The undergraduate education a teacher receives is important. It provides prospective teachers with the pedagogical and psychological tools to teach and nurture young students on their path to knowledge. However, content knowledge is also important for a teacher at all levels, although the problem is exacerbated for prospective elementary teachers who are called upon to teach an array of subjects. This is especially true in math and science.

Effective teacher training should also be supplemented by building feedback into the program. Tracking the performance of graduates can help determine the success of individual teachers in the field, as well as informing the program regarding areas for improvement.

Tailoring summer class offerings to current teachers can allow graduates to extend their professional training and ensure that their knowledge of content and pedagogy stays up-to-date.

Focusing these classes towards current teachers can also be a way by which to address the dilemma of out-of-field teachers who have been assigned to teach math and science classes without the necessary knowledge base.

Providing Opportunities for Teachers to Work With Those in the Technical Labor Force

Math and science teachers and practicing scientists and engineers both have important knowledge and experiences that can be gainfully shared. This connection is rarely made as professional and logistical barriers separate them. Improving the opportunities for communication between these individuals is an important step for improving math and science instruction.

Providing a Forum for Teachers to Work With Other Scientists and Engineers

Businesses should partner with local school districts to establish programs that provide scientists and engineers as resources for schools. These forums should facilitate direct contact between teachers and scientists and engineers, and as appropriate, direct contact between scientists and students. Employers should actively encourage their employees' participation, making clear that it is a highly valued professional responsibility. Businesses should also practice greater stewardship over local areas that lack an abundance of scientifically-based firms by providing web portals or other manners of assistance.

Creating relationships between math and science teachers and scientists and engineers will be an important step towards improving math and science education. Scientists and engineers will provide teachers ready access to cutting edge information about their fields. The key concept is partnership; neither business groups, nor educators, have all of the answers, but they share responsibility for implementing the solution.

The example of ChevronTexaco is instructive. Through the East Bay (San Francisco) Partnership Program, ChevonTexaco provides employees as resources to schools, to assist with filling gaps in need areas such as math, science, and literacy. ChevronTexaco encourages its employees to participate in the program by making available up to four paid hours a month to spend working on the program.[76]

Providing Summer Experiences for Math and Science Teachers

Businesses, colleges and universities, and school districts should jointly develop effective programs to provide summer experiences for teachers. Businesses should create mechanisms within their firms that allow the fruitful participation of teacher/interns in their work. These efforts can include hosting program meetings, offering technical and financial assistance, supporting employee efforts to participate in these programs, or any other needs, as determined in consultation with partner organizations.

Programs that provide pre- and in-service teachers the opportunity to work in research settings could allow teachers to stay in front of changes in their field that might affect their students and deepen their own understanding of the topic. The ability to continue or assist with research can also deepen a teacher's own interest in the subject area.

A good example of such a program is the Maryland Educators' Summer Research Program (MESRP, profiled in more detail in the accompanying text box). MESRP places educators in positions at academic, government, and industrial labs. Participants are expected to complete original research and work in teams to develop curriculum modules based upon their experiences. The experience promotes a better understanding of the teacher's role in inquiry-based exploration and "hands on" science, as well as providing teachers with the "credibility and experience needed to incorporate current content and authentic data into science and mathematics curriculum."[77] The success of that program, and ones like it, depends on the successful partnership between business, higher education, schools, and teachers.

Expanding Effective Professional Development Programs

Business, higher education, and K-12 school districts should collaborate to provide staff development to enrich and expand teacher knowledge and talent. Teachers' meaningful participation in these programs should be expected as part of their career path and should be valued.

Research has shown that few professional development programs are of high quality. One-day 'wonder' workshops proliferate, tak-

THE MARYLAND EDUCATORS' SUMMER RESEARCH PROGRAM

The Maryland Educators' Summer Research Program (MESRP) was formed in 1999 to expand upon the efforts of two previous programs. MESRP offers summer research opportunities for both pre-service and in-service teachers to work in academic, government, and industrial lab environments.

The goal of the internship is to provide teachers with authentic research experiences. The "hands-on" nature of the program is designed to help teachers appreciate the value of interactive experiences in learning science. Each intern is provided with a mentor at the work site that directs his or her research during the six- to twelve-week program. Mentors are expected to design projects that can be completed in that time, while also providing value to the host firm. If possible, pre-service and in-service teachers are paired together at a site, so that the in-service teacher can serve as an additional mentor.

In order to promote the research experience as part of a continuing development process, participants in the MESRP are expected to continue in year-round outreach experiences. The most prominent of those is the Classroom Implementation Project (CIP). The development of CIP modules is an attempt to bring the unique experience a teacher had during their time in the field back into the classroom. The modules are designed so that they can be distributed to other educators in Maryland for their own use.

MESRP also includes assessment as a goal of the program. Candidates are surveyed before and after their participation in the program to evaluate its impact. Areas of focus include classroom practice, teaching strategy, and changes in attitudes and perceptions of math and science. These surveys will be ongoing in a participant's career, in an attempt to measure the lasting impact of the experience.

So far, the program has met with great success and it has been sought as a model for expansion on a larger scale. Organizers hope that the positive responses seen in the initial evaluations mean that the program can have a significant and lasting impact on math and science education policies.

SOURCE: Sherry McCall Ross and Katherine Denniston, *The Maryland Educators' Summer Research Program,* (April 2002), available at <http://k12s.phast.umass.edu/stemtec/pathways/Proceedings/Papers/Ross-p.doc>. Accessed March 17, 2003.

ing teachers out of the classroom for something of little value. Making the time available is not enough; effective professional development requires a comprehensive approach that includes follow-up and accountability.

Over the past few years, the Houston Independent School District (HISD) has reviewed and reformed its professional development system. The burden of planning professional development activities has shifted to individual schools, allowing the programs to be more focused on areas of need. The new approach also involved a move away from one-day sessions to a more continuous development program that includes "study groups, online training, partnerships with local universities, summer workshops, and training though lead teachers."[78]

Since it is locally-managed, the Houston program can be adapted as needed, enabling targeted follow up learning opportunities and discussion keyed to individual district or school concerns.

Scientifically-based businesses can play a role as partners in effective teacher development, such as the Merck Institute for Science Education, as seen in the accompanying text box.

MISE: THE MERCK INSTITUTE FOR SCIENCE EDUCATION

The Merck Institute for Science Education (MISE) was created in 1993 by Merck & Co., Inc. to direct the company's efforts in K-12 math and science education reform. Based in Rahway, New Jersey, MISE has established a long-term education partnership with several school districts in New Jersey and Pennsylvania. This partnership focuses on the professional development of teachers, helping them improve their science knowledge and strengthen their teaching skills. In addition, MISE supports organizations and science centers whose mission is to stimulate students' interest in the study of math and science.

To accomplish its goals, the Institute works with

- teachers, to align curriculum and teaching strategies with state and national standards;
- parents, to engage families in science and math activities at school and further investigation at home;
- business leaders, to provide a model of a business/education partnership for other corporations to emulate; and
- employees and community members, to support volunteer activity in the schools.

MISE also provides and maintains two science Resource Centers—one in Rahway and the other in West Point, Pennsylvania. These Centers house curriculum modules, books, and periodicals that focus on mathematics and science teaching. Teachers use the Centers to expand their "teaching repertoire," while districts use the materials to inform their curriculum choices.

To evaluate the impact of its partnership with the school districts, MISE has contracted with the Consortium for Policy Research in Education (CPRE) at the University of Pennsylvania to conduct annual assessments of its work. Factors considered in the evaluation include "student performance and course selection; the quality of professional development; and changes in classroom teaching, school culture and district policy." MISE then uses the CPRE findings to adjust its own work.

SOURCE: www.mise.org; MISE, personal correspondence.

As part of the No Child Left Behind Act, the Department of Education and the National Science Foundation have established the Math/Science Partnership program. The former provides funds that will be available through state departments of education, whereas the latter is available through a national competition. A key feature of both programs is the need for partnerships — as described throughout this report — among the various education stakeholders. For the first time, this federal legislation requires higher education institutions to partner with school districts. Other partners, such as business and nonprofit organizations, are encouraged to participate as well. All of the aforementioned groups must take full advantage of this opportunity.

Promoting Local Experimentation in Math and Science Education

Local school districts should be encouraged to seek innovative and promising approaches to improve math and science teaching and learning. Local businesses and state governments and departments of education should encourage and contribute to the development and execution of these plans. State governments should also provide funds to schools to scale up programs that have demonstrated success. A fear of change or failure should not impede new programs that have potential for success, just as many businesses have transformed themselves through process-oriented "continuous improvement." Like businesses, however, all educational innovations should be regularly evaluated for effectiveness and modified as indicated by the results of the evaluation.

Possibilities abound for forward thinking educators and administrators to implement innovative plans to improve math and science education. "Magnet" schools, or schools that focus on specific subject areas, provide students with a dedicated interest in math and science the opportunity to focus their academic energies in that area. Magnet schools teach all of the other core subjects, teach all core subjects, but have special expertise, facilities and depth of course offerings in specific disciplines. In this manner, magnet schools develop scientific thinking skills in students that will give them an advantage at the undergraduate level. (The formation of charter schools can have a similar impact. For an example, see the text box, "High Tech High.") For elementary schools, dedicated practitioners — expert teachers who move between classes to teach only the math or science lesson — could ease the burden on teachers by providing an expert source of knowledge. The use of an expert teacher in this manner allows all teachers to teach to their strengths and improves the quality of the content presented to students.

Promoting Science Education in the Era of No Child Left Behind

As mentioned in the introduction to this chapter, federally mandated assessments for math are scheduled to begin during the 2002-2003 school year, with assessments for science beginning in 2007-2008. The five-year lag may have an unintended negative consequence: increased attention and resources focused on math and reading could come at the expense of science teaching and learning. This could seriously compromise the knowledge base of a significant number of American youngsters at a critical point in their scientific education. In order to prevent this outcome, states should work proactively to ensure that science education is not neglected in the quest to achieve high marks in reading and math.

The scientifically-based business community should expand efforts to work with state governments and boards of education in the ongoing process of reviewing and revising state standards for science education. The business community should advocate that

HIGH TECH HIGH

Located on a decommissioned Navy base in San Diego, the Gary and Jerri-Ann Jacobs High Tech High Charter School provides a unique opportunity for students to learn math and science. The philosophy is based on three principles: personalization, adult-world connection, and a common intellectual mission.

High Tech High offers students a more interactive, project-based curriculum. Students work independently or on teams on approved projects that help them apply the concepts learned in class and expand their understanding. Teachers guide students through their projects, though the responsibility for learning is mostly on the student. That is a reinforcement of the "adult world" emphasis of the school, which includes a business casual dress code and working environment that has the appearance similar to that of an office of a high-tech firm. Additionally, industry experts are brought in for "power lunches" with the students, while older students also have the opportunity to intern at local companies for part of the school day.

Professional development is also an important part of the day at High Tech High. Each morning starts off with a staff meeting that allows a discussion of pertinent issues, such as methods of assessing the success of project-based learning and finding overlaps in the curriculum.

High Tech High owes part of its existence to the work of local high-tech companies. Representatives of 40 local companies came up with the idea of a technology-based high school as a strategy to address their own labor needs. Many of the firms continue to contribute to the school through grants, employee volunteers, and by participating on the school's board of directors. Their continued support will be crucial as High Tech High expands, adding facilities for sixth through eight graders.

SOURCE: Lawrence Hardy, "High Tech High" *American School Board Journal*, vol. 188, no. 7 (2001); Amy Poftak, "High Tech High: An Education Startup," *Technology & Learning*, vol. 22, no. 3 (2001); www.hightechhigh.org.

science teaching and learning occupy a prominent place in education. We urge the federal government to provide grants to states that seek to develop and/or revise science standards and assessments that reflect ambitious learning goals for students. States and local school districts should monitor the amount of classroom time dedicated to science instruction. States that currently conduct science assessments should publicize the results in a manner similar to that required for reading and math under the No Child Left Behind Act. Moreover, business can describe the STEM knowledge and skills that new entrants to the workforce must possess, with an eye towards influencing the standards and assessments that are emerging by federal requirement.

Prior to the passage of No Child Left Behind, 46 states had a set of science standards in place, and 33 provided some kind of science assessment.[79] In some cases, these standards and assessments will need to be revised to meet the demands of the new policy, as well as other educational and workplace needs. The business community can assist in revising the science standards. As the ultimate consumers of the students that schools produce, business can help link standards with an understanding of the skill sets necessary for success in the labor market. When Delaware undertook a reform of their educational system under the “New Directions” program, the business community played a key role in standards reform by identifying the skills students would need in the workplace and helping translate that information into academic standards.[80]

Florida exemplifies a state that has improved its science standards, even before the passage of the No Child Left Behind Act. In March 2003, fifth-, eight-, and tenth-graders were tested on their science knowledge, as part of the Florida Comprehensive Assessment Test (FCAT), for the first time. The exam is formatted to demonstrate how well a student understands science by requiring eight- and tenth-graders to provide written explanations of their responses, alongside multiple-choice questions. The new FCAT format has forced schools to reevaluate how they teach science, and many schools have responded by increasing the quantity and quality of the laboratory experiences for students.[81]

CHALLENGE THREE: ACKNOWLEDGING THE PROFESSIONALISM OF TEACHERS

Teachers prepare the workforce of tomorrow in an economy that increasingly favors high levels of skill. Making math and science education effective requires developing the highest quality teaching force possible.

This Challenge promotes the view of teaching as a valued profession by looking at issues of compensation and certification. The recommendations call for competitive teacher salaries, the establishment of alternative paths to certification, and the development of systems of license and pension reciprocity for teachers.

Many of these reforms have been proposed before and many people are working to promote reform in these areas. We encourage their efforts and present some of their recommendations here again for the purpose of restating the case for these important reforms.

Compensating Teachers to Promote Quality in the Math and Science Teaching Force

State governments should work with local school districts to increase starting teacher salaries to better reflect local labor market conditions. The salary structure should take note of the many highly remunerative opportunities open to skilled math and science graduates apart from teaching. New salary scales should be viewed as an investment in the schools, similar to other capital improvements. Accordingly, state governments should ensure that there is adequate funding for these increases**.**

The recent actions by the schools in New York City are a good example. In the summer of 2002, facing a severe shortage of qualified teachers similar to that seen in many urban districts, New York City increased the starting salary for teachers from $31,910 to $39,000. This increase appeared to help offset the shortage that the school district expected, while also improving the quality of the teachers the program recruited. Certified teachers filled more than 90 percent of the 8000-plus openings the district faced for the 2002-2003 school year, compared to a rate of about half of the teachers hired the previous year. (The number for 2002 includes those trained under an alternative certification program initiated along with the pay increases, though participants are expected to receive their master’s degrees within five years to become fully certified.)[82] The experience in New York demonstrates that qualified candidates are willing to teach, if it is made economically feasible for them. It will be instructive to follow this cohort of teachers to see if they remain in the field, as recruitment without retention is of little help.

Establishing Alternative Paths to Certification

State governments and boards of education should implement high quality programs for teacher certification of professional scientists, mathematicians, or engineers who seek to enter teaching. Business can inform the development of these programs by providing technical assistance and helping to ensure that the programs meet the needs of mid- or post-career workers. Firms can also promote teaching as an option for post-employment workers who still desire to be active. Federal, state, and local funds should be used to provide stipends for participants in these programs, thus offsetting income forfeited during the period of training. Schools that hire teachers from these programs should provide support and mentoring to assist the newly certified teachers in their transition to the classroom. Experienced teachers should be recruited to serve as mentors to new faculty and mentoring should be recognized by the school administrations.

Alternative certification programs can help to broaden the pipeline of entrants into the teaching labor market. They also recognize the fact that most modern workers pursue multiple careers during their time in the labor force. Yet quality and rigor cannot be compromised in such programs. They should include the necessary pedagogical and psychological information to help practicing scientists transmit their content knowledge to young minds.

Programs that offer alternative certification also have the advantage of drawing a more diverse group of candidates than traditional education programs. A review of alternative certification programs demonstrates that the graduates of these programs are more likely to be minority, female, and older than those who emerge from the traditional system. They also bring practical and workplace experience to supplement their content knowledge. Finally, the retention rates for these programs is similar to that of traditionally-prepared teachers, and the alternatively certified teachers plan to stay in the field just as long as the average teacher.[83]

School districts in Houston, Chicago, and New York have developed alternative certification programs over the past few years to address their respective teacher shortages. Additionally, the federal government sponsors Troops-to-Teachers, a program for retired military personnel, as well as the Teach for America program. These programs have seen some success and bode well for states that seek to develop similar programs. Reports commissioned by the National Commission on Mathematics and Science Teaching for the 21st Century and the National Research Council provide outlines of what effective alternative certification programs could look like.[84]

Allowing for License and Pension Reciprocity

State governments should partner together to develop systems of license reciprocity. But we warn that the integrity of the licenses should not be compromised; partner states should review their standards, so that all states meet similar standards of licensure.

State pension programs should create policies that provide additional incentives for experienced teachers to continue working in new locales. To compensate for the potential pension costs to new districts, assets equal to the previous school system's benefit obligation to the teacher should be transferred when teachers move between states.

Business can help implement license and pension reciprocity for teachers by sharing relevant experiences. Ongoing technical assistance from business partners would be highly valued.

The geographic movement of teachers exacerbates the problems of turnover in the teaching force. Quite often, teachers are forced to move due to family obligations or changing personal circumstances. While these qualified, previously licensed teachers would be interested in positions in their new location, the burden of recertification can serve as a deterrent, especially if other opportunities exist in the area.

The portability of pensions is also a concern for teachers moving between states. Some states or localities require experienced teachers to start over in the new system, or face benefit penalties that endanger previously accumulated pension rights.[85] This problem strikes hardest at the most experienced teachers, meaning that a valuable cache of knowledge and experience goes unused in the new state.

Educators have been voicing these concerns for a number of years and some progress is being made. The Mid-Atlantic Regional Teachers Project, a consortium of states that includes Virginia, Maryland, Delaware, and Pennsylvania, as well as the District of Columbia, have developed a proposal to extend license reciprocity for beginning educators. The similarity in licensure requirements between the states and the District makes the adoption of this policy possible. Programs for license reciprocity for more experienced teachers and plans for pension reciprocity within the consortium are also under development.[86]

Chapter 5

CONCLUSION

The challenges confronting math and science education in the United States and the resulting implications for the labor force are critical. Numerous groups have addressed this problem in a series of valuable reports. In this Policy Statement, CED has reframed the issue by looking at the culture that affects math and science education, and, in particular, the "demand" side of education — increasing student interest in math and science.

We have outlined three areas for action, all interdependent, yet each important on its own. *Increasing student interest in math and science to maintain the pipeline* focuses on ways to improve the way students view math and science disciplines. *Demonstrating the wonder of discovery while helping students to master rigorous content* offers programs to help teachers reinforce student interest and success in math and science. *Acknowledging the professionalism of teachers* considers problems facing the teacher labor market. In all of these areas, we have provided examples of programs that demonstrate the recommendations and attitudes embodied in this report. Many of these programs involve a partnership between business and education providers. We applaud the efforts of businesses that have involved themselves with these programs and encourage others to join them.

This report has articulated a vision for the role of business in math and science education, as an advocate, advisor and partner. The involvement of business partners is the first step in a larger strategy to improve math and science education and maintain the pipeline into science and engineering fields. This is a commitment that all business people, both inside and out of the scientific establishment, should consider.

The perils facing math and science education in America have been foretold for decades. It is now time to act, as businesspeople and academics, leaders and citizens to solve these problems.

ENDNOTES

1. Committee for Economic Development, *America's Basic Research: Prosperity Through Discovery* (New York, NY: Committee for Economic Development, 1998).
2. Committee for Economic Development, *America's Basic Research*, p. 41.
3. Committee for Economic Development, *America's Basic Research*, p. 42.
4. Committee for Economic Development, *Reforming Immigration: Helping Meet America's Need for a Skilled Workforce* (New York, NY: Committee for Economic Development, 2001), p. ix.
5. National Center for Education Statistics, *NAEP 1999 Trends in Academic Progress: Three Decades of Academic Performance*, NCES 2000-469 (Washington, D.C.: U. S. Department of Education, August 2000), Figure 1.1.
6. National Center for Education Statistics, *NAEP 1999 Trends in Academic Progress*, Figure 1.1.
7. National Center for Education Statistics, "National Assessment Shows Encouraging Trends in Mathematics Performance" (press release, Washington, D.C., August 24, 2000).
8. Committee for Economic Development, *Measuring What Matters: Using Assessment and Accountability to Improve Student Learning* (Washington, D.C.: Committee for Economic Development, 2001).
9. California Department of Education, "California Department of Education Corrects Statewide Pass Rates for High School Exit Exam" (press release, Sacramento, CA, October 9, 2002).
10. Associated Press, "More than 50 percent of students fail high-stakes graduation test," *San Jose Mercury News*, October 1, 2002.
11. Massachusetts Department of Education, *Spring 2002 MCAS Tests: Summary of State Results* (Malden, MA: Massachusetts Department of Education, 2002).
12. Virginia Department of Education, "2002 Achievement Strong on Graduation-Linked SOL Tests" (press release, Richmond, VA, October 8, 2002).
13. National Science Board, *Preparing Our Children: Math and Science Education in the National Interest,* NSB 99-31 (Washington, D.C.: U.S. Government Printing Office, March 1999), p. 15.
14. National Science Board, *Preparing Our Children,* p. 15.
15. Gary W. Phillips, "Pursuing Excellence: Comparisons of International Eighth-Grade Mathematics and Science Achievement from a U.S. Perspective, 1995 and 1999" (briefing prepared for the release of *Pursuing Excellence: Comparisons of International Eighth-Grade Mathematics and Science Achievement from a U.S. Perspective, 1995 and 1999,* Washington, D.C., December 5, 2000).
16. National Center for Education Statistics. *Teaching Mathematics in Seven Countries*, NCES 2003-013 (Washington, D.C.: U.S. Department of Education, March 2003).
17. National Center for Education Statistics, *Pursuing Excellence: Comparisons of International Eighth-Grade Mathematics and Science Achievement from a U.S. Perspective, 1995 and 1999*, NCES 2001-028 (Washington, D.C.: U.S. Department of Education, December 2000).
18. National Center for Education Statistics, *Outcomes of Learning: Results from the 2000 Program for International Student Assessment of 15-Year-Olds in Reading, Mathematics, and Science Literacy,* NCES 2002-115 (Washington, D.C.: U.S. Department of Education, December 2001), pp. 25-26.
19. National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000,* NCES 2001-517 (Washington, D.C.: U.S. Department of Education, August 2001), Table B.87.
20. National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000*, Table B.87
21. Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development, *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology* (Washington, D.C.: U.S. Government Printing Office, September 2000), pp. 59-65.
22. Tom Loveless, *How Well Are American Students Learning?* (Washington, D.C.: Brown Center Report on American Education, September 2002), pp. 19-20.
23. Kathleen Kennedy Manzo, "North Wind Bows to Rising Sun" *Education Week,* vol. 22, no. 4 (2002), p. 31; Ina V.S. Mills, Michael O. Martin, Albert E. Beaton, and others, *Mathematics and Science*

Achievement in the Final Year of Secondary School: IEA's Third International Mathematics and Science Study (TIMSS) (Chestnut Hill, MA: Center for the Study of Testing, Evaluation, and Educational Policy, 1998), Table 4.8.

24. Manzo, "North Wind Bows to Rising Sun."

25. Christopher Barnes, *What Do Teachers Teach? A Survey of America's Fourth and Eighth Grade Teachers,* Research Paper No. 28 (New York, NY: Center for Civic Innovation at the Manhattan Institute, September 2002).

26. J. Becker, "Differential treatment of females and males in mathematics class," *Journal for Research in Mathematics Education,* vol. 12, no. 1 (1981), pp. 40-53.

27. Council of Great City Schools with Manpower Demonstration Research Center, *Foundations For Success: Case Studies of How Urban School Systems Improve Student Achievement* (Washington, D.C.: Council of Great City Schools, 2002).

28. National Research Council, *Learning and Understanding: Improving Advanced Study of Mathematics and Science in U.S. High Schools* (Washington, D.C.: National Academy Press, 2002), p. 48.

29. Studies that focus on math and science, include, but are not limited to, Dan D.Goldhaber, and Dominic J. Brewer, "Why Don't Schools and Teachers Seem to Matter? Assessing the Impact of Unobservables on Education," *Journal of Human Resources*, vol. 32, no. 3 (1997), pp. 505-523; Dan D. Goldhaber and Dominic J. Brewer, "Does Teacher Certification Matter? High School Certification State and Student Achievement," *Educational Evaluation and Policy Analysis*, vol. 22 no. 2 (2000), pp. 129-145; and D. H. Monk, "Subject Area Preparation of Secondary Mathematics and Science Teachers and Student Achievement," *Economics of Education Review*, vol. 13, no. 2 (1994), pp. 125-145.

30. Linda Darling-Hammond, *Teacher Quality and Student Achievement: A Review of State Policy Evidence*, Document R-99-1 (Seattle, WA: Center for the Study of Teaching and Policy, December 1999).

31. National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000*, Tables 5.1 and 5.2.

32. National Center for Education Statistics, *The Nation's Report Card: Science Highlights 2000,* NCES 2002-452 (Washington, D.C.: U.S. Department of Education, November 2002), p. 11.

33. National Center for Education Statistics, *Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-field Teaching 1987-88 to 1999-2000,* NCES 2002-603 (Washington, D.C.: U.S. Department of Education, May 2002).

34. National Center for Education Statistics, *Qualifications of the Public School Teacher Workforce.*

35. Craig D. Jerald, *All Talk, No Action: Putting an End to Out-of-field Teaching* (Washington, D.C.: The Education Trust, August 2002), p. 7.

36. Urban Teacher Collaborative, *The Urban Teacher Challenge: Teacher Demand and Supply in the Great City Schools* (Washington, D.C.: Council of Great City Schools, 2000).

37. American Association for the Advancement of Science, Project 2061, "Few Middle School Math Textbooks Will Help Students Learn, Says AAAS' Project 2061 Evaluation" (press release, Washington, D.C., January 22, 1999); American Association for the Advancement of Science, Project 2061, "Heavy Textbooks Light on Learning: Not One Middle Grades Science Text Rated Satisfactory by AAAS's Project 2061" (press release, Washington, D.C., September 28, 1999).

38. National Research Council, *Adding It Up: Helping Children Learn Mathematics* (Washington, D.C.: National Academy Press, 2001), p. 4.

39. William H. Schmidt, Curtis C. McKnight, Richard T. Houang, and others, *Why Schools Matter: A Cross-National Comparison of Curriculum and Learning* (San Francisco, CA: Jossey-Bass, 2001).

40. National Commission on Mathematics and Science Teaching for the 21st Century, *Before It's Too Late* (September 2000), p. 16.

41. National Center for Education Statistics, *Projections of Education Statistics to 2012*, NCES 2002-030 (Washington, D.C.: U.S. Department of Education, October, 2002), Table l; U.S. Census Bureau, *Projections of the Total Resident Population by 5-Year Age Groups, Race, and Hispanic Origin with Special Age Categories: Middle Series, 2016 to 2020,* (January 13, 2000), available at <http://www.census.gov/population/projections/nation/summary/np-t4-e.pdf>. Accessed April 10, 2003.

42. Council of Chief State School Officers, *State Indicators of Science and Mathematics Education: 2001* (Washington, D.C.: Council of Chief State School Officers, 2001), Table 32.

43. Richard M. Ingersoll, "The Teacher Shortage: A Case of Wrong Diagnosis and Wrong Prescription," *NASSP Bulletin*, vol. 86, no. 631 (2002), pp. 16-31.

44. Texas Center for Education Research, "The Costs of Teacher Turnover" (background paper prepared for the Texas State Board for Educator Certification, Austin, TX, November 2000), p. 16, available at <http://www.tasb.org/tcer/publications/teacher_turnover_full.doc>. Accessed March 17, 2003.

45. Richard M. Ingersoll, "Turnover Among Mathematics and Science Teachers in the U.S." (background paper prepared for the National Commission on Mathematics and Science Teaching for the 21st Century, Washington, D.C., February 2000), p. 7, available at <http://www.ed.gov/inits/Math/glenn/Ingersollp.doc>. Accessed March 17, 2003.

46. National Science Board, *Science and Engineering Indicators: 2002*, NSB 02-01 (Washington, D.C.: U.S. Government Printing Office, 2002), Table A2-16.

47. National Center for Education Statistics, *Digest of Educational Statistics: 2001,* NCES 2002-130 (Washington, D.C.: U.S. Department of Education, April 2002), Table 268.

48. American Association for the Advancement of Science, *In Pursuit of A Diverse Science, Technology, Engineering, and Mathematics Workforce* (Washington, D.C.: American Association for the Advancement of Science, 2001).

49. National Action Council for Minorities in Engineering, "NACME Reports Record Minority Engineering Enrollments and New Challenges" (press release, New York, NY, September 17, 2002).

50. National Action Council for Minorities in Engineering, "NACME Reports Record Minority Engineering Enrollments and New Challenges."

51. National Science Board, *Science and Engineering Indicators: 2002*, Table A2-12.

52. U.S. Bureau of the Census, *Statistical Abstract of the United States: 2002* (Washington, D.C.: Department of Commerce, 2002), Table 15.

53. National Science Board, *Science and Engineering Indicators: 2002*, Table A2-12.

54. National Science Board, *Science and Engineering Indicators: 2002*, Figure 2-9.

55. National Science Board, *Science and Engineering Indicators: 2002*, Figure 2-9 and p. 2-19.

56. Richard Sabot and John Wakemann-Linn, "Grade Inflation and Course Choice," *Journal of Economic Perspectives*, vol. 5, no. 1 (1991), Table 2.

57. Valen E. Johnson, "An A Is an A Is an A…And That's The Problem," *New York Times*, April 14, 2002, p. 14.

58. Valen E. Johnson, "An A Is an A Is an A," p. 14.

59. National Research Council, *Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology* (Washington, D.C.: National Academy Press, 1999), p. 15.

60. National Research Council, *Evaluating and Improving Undergraduate Teaching in Science, Technology, Engineering, and Mathematics* (Washington, D.C.: National Academy Press, 2000), p. 14.

61. National Research Council, *Transforming Undergraduate Education*, p. 26.

62. National Science Board, *Science and Engineering Indicators: 2002*, p. 3-6.

63. Daniel E. Hecker, "Occupational employment projections to 2010," *Monthly Labor Review*, vol. 124, no. 11 (2001), pp. 57-84.

64. National Science Board, *Science and Engineering Indicators: 2002*, Table A3-12.

65. National Science Board, *Science and Engineering Indicators: 2002*, p. 3-31.

66. National Research Council, *Attracting PhDs to K-12 Education* (Washington, D.C.: National Academy Press, 2002), p. 11.

67. National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Enhancing the Postdoctoral Experience for Scientists and Engineers* (Washington, D.C.: National Academy Press, 2000), p. 14.

68. National Research Council, *Attracting Science and Mathematics PhDs to Secondary School Teaching* (Washington, D.C.: National Academy Press, 2000), p. 4.

69. Hecker, "Occupational employment projections to 2010."

70. Hecker, "Occupational employment projections to 2010."

71. National Science Board, *Science and Engineering Indicators: 2002*, Figure 2-20.

72. National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine, "Current Visa Restrictions Interfere with U.S. Science and Engineering Contributions to Important National Needs" (press release, Washington, D.C., December 13, 2002).

73. National Science Foundation, *International Mobility of Scientists and Engineers to the United States*, NSF 98-316 (Arlington, VA: National Science Foundation, 1998).

74. Emily M. Smith, "teamwork with the next generation," *Mechanical Engineering*, June 2002 (online), available at <http://www.memagazine.org/backissues/june02/features/feat_toc.html>. Accessed March 17, 2003.

75. Educational Testing Service, *Meeting the Need for Scientists, Engineers, and an Educated Citizenry in a Technological Society* (Princeton, NJ: Educational Testing Service, 2002), p. 24.

76. Council for Corporate and School Partnerships, *Guiding Principles for Business and School Partnerships,* (September 2002), pp. 22-23, available at <http://www.nabe.org/documents/GP.pdf>. Accessed March 17, 2003.

77. Sherry McCall Ross and Katherine Denniston, *The Maryland Educators' Summer Research Program*, (April 2002), available at <http://k12s.phast.umass.edu/stemtec/pathways/Proceedings/Papers/Ross-p.doc>. Accessed March 17, 2003.

78. Council of Great City Schools, *Foundations for Success*, pp. 86-87.

79. Council of Chief State School Officers, *Key State Education Policies on K-12 Education: 2000* (Washington, D.C.: Council of Chief State School Officers, 2000), Tables 13 and 27.

80. Business Coalition for Education Reform, *From the Boardroom to the Blackboard: The Business Role in Improving Education in Delaware*, p. 1, accessible at <http://www.bcer.org/projres/Blackb.pdf>. Accessed April 10, 2003.

81. Denise-Marie Balona, "Experiments help students prepare for science FCAT," *Orlando Sentinel*, December 3, 2002, p. A1.

82. Abby Goodnough, "Shortage Ends as City Lures New Teachers," *New York Times*, August 23, 2002, p. A1.

83. Beatriz Chu Clewell and Laurie B. Forcier, "Increasing the Number of Mathematics and Science Teachers: A Review of Teacher Recruitment Programs" (background paper prepared for the National Commission on Mathematics and Science Teaching for the 21st Century, Washington, D.C., March 2000), p. 18, available at <http://www.ed.gov/inits/Math/glenn/ClewellForcier.pdf>. Accessed March 17, 2003.

84. National Commission on Mathematics and Science Teaching for the 21st Century, *Before It's Too Late*; National Research Council, *Attracting PhDs to K-12 Education*.

85. Julia E. Koppich, *Investing in Teaching* (Washington, D.C.: National Alliance of Business, 2001), pp. 35-36.

86. Julie Blair, "Regional Teaching License Pushed for 2003," *Education Week*, vol. 22, no. 10 (2002), pp. 19-20.

MEMORANDUM OF COMMENT, RESERVATION, OR DISSENT

Page 3, PETER A. BENOLIEL

While I agree that grading policies should be in “alignment with other departments in the institution,” I suspect that STEM policies more accurately reflect needed outcomes than those in other departments, which tend to be more lax and permissive.

OBJECTIVES OF THE COMMITTEE FOR ECONOMIC DEVELOPMENT

For 60 years, the Committee for Economic Development has been a respected influence on the formation of business and public policy. CED is devoted to these two objectives:

To develop, through objective research and informed discussion, findings and recommendations for private and public policy that will contribute to preserving and strengthening our free society, achieving steady economic growth at high employment and reasonably stable prices, increasing productivity and living standards, providing greater and more equal opportunity for every citizen, and improving the quality of life for all.

To bring about increasing understanding by present and future leaders in business, government, and education, and among concerned citizens, of the importance of these objectives and the ways in which they can be achieved.

CED's work is supported by private voluntary contributions from business and industry, foundations, and individuals. It is independent, nonprofit, nonpartisan, and nonpolitical.

Through this business-academic partnership, CED endeavors to develop policy statements and other research materials that commend themselves as guides to public and business policy; that can be used as texts in college economics and political science courses and in management training courses; that will be considered and discussed by newspaper and magazine editors, columnists, and commentators; and that are distributed abroad to promote better understanding of the American economic system.

CED believes that by enabling business leaders to demonstrate constructively their concern for the general welfare, it is helping business to earn and maintain the national and community respect essential to the successful functioning of the free enterprise capitalist system.

CED BOARD OF TRUSTEES

**Life Trustee*

CED HONORARY TRUSTEES

CED RESEARCH ADVISORY BOARD

CED PROFESSIONAL AND ADMINISTRATIVE STAFF

STATEMENTS ON NATIONAL POLICY ISSUED BY THE COMMITTEE FOR ECONOMIC DEVELOPMENT

SELECTED PUBLICATIONS:

Exploding Deficits, Declining Growth: The Federal Budget and the Aging of America *(2003)*
Justice for Hire: Improving Judicial Selection *(2002)*
A Shared Future: Reducing Global Poverty *(2002)*
A New Vision for Health Care: A Leadership Role for Business *(2002)*
Preschool For All: Investing In a Productive and Just Society *(2002)*
From Protest to Progress: Addressing Labor and Environmental Conditions Through Freer Trade *(2001)*
The Digital Economy: Promoting Competition, Innovation, and Opportunity *(2001)*
Reforming Immigration: Helping Meet America's Need for a Skilled Workforce *(2001)*
Measuring What Matters: Using Assessment and Accountability to Improve Student Learning *(2001)*
Improving Global Financial Stability *(2000)*
The Case for Permanent Normal Trade Relations with China *(2000)*
Welfare Reform and Beyond: Making Work Work *(2000)*
Breaking the Litigation Habit: Economic Incentives for Legal Reform *(2000)*
New Opportunities for Older Workers *(1999)*
Investing in the People's Business: A Business Proposal for Campaign Finance Reform *(1999)*
The Employer's Role in Linking School and Work *(1998)*
Employer Roles in Linking School and Work: Lessons from Four Urban Communities *(1998)*
America's Basic Research: Prosperity Through Discovery *(1998)*
Modernizing Government Regulation: The Need For Action *(1998)*
U.S. Economic Policy Toward The Asia-Pacific Region *(1997)*
Connecting Inner-City Youth To The World of Work *(1997)*
Fixing Social Security *(1997)*
Growth With Opportunity *(1997)*
American Workers and Economic Change *(1996)*
Connecting Students to a Changing World: A Technology Strategy for Improving Mathematics and Science Education *(1995)*
Cut Spending First: Tax Cuts Should Be Deferred to Ensure a Balanced Budget *(1995)*
Rebuilding Inner-City Communities: A New Approach to the Nation's Urban Crisis *(1995)*
Who Will Pay For Your Retirement? The Looming Crisis *(1995)*
Putting Learning First: Governing and Managing the Schools for High Achievement *(1994)*
Prescription for Progress: The Uruguay Round in the New Global Economy *(1994)*
*From Promise to Progress: Towards a New Stage in U.S.-Japan Economic Relations *(1994)*
U.S. Trade Policy Beyond The Uruguay Round *(1994)*
In Our Best Interest: NAFTA and the New American Economy *(1993)*
What Price Clean Air? A Market Approach to Energy and Environmental Policy *(1993)*
Why Child Care Matters: Preparing Young Children For A More Productive America *(1993)*

*Statements issued in association with CED counterpart organizations in foreign countries.

Restoring Prosperity: Budget Choices for Economic Growth *(1992)*
The United States in the New Global Economy: A Rallier of Nations *(1992)*
The Economy and National Defense: Adjusting to Cutbacks in the Post-Cold War Era *(1991)*
Politics, Tax Cuts and the Peace Dividend *(1991)*
The Unfinished Agenda: A New Vision for Child Development and Education *(1991)*
Foreign Investment in the United States: What Does It Signal? *(1990)*
An America That Works: The Life-Cycle Approach to a Competitive Work Force *(1990)*
Breaking New Ground in U.S. Trade Policy *(1990)*
Battling America's Budget Deficits *(1989)*
*Strengthening U.S.-Japan Economic Relations *(1989)*
Who Should Be Liable? A Guide to Policy for Dealing with Risk *(1989)*
Investing in America's Future: Challenges and Opportunities for Public Sector Economic Policies *(1988)*
Children in Need: Investment Strategies for the Educationally Disadvantaged *(1987)*
Finance and Third World Economic Growth *(1987)*
Reforming Health Care: A Market Prescription *(1987)*
Work and Change: Labor Market Adjustment Policies in a Competitive World *(1987)*
Leadership for Dynamic State Economies *(1986)*
Investing in Our Children: Business and the Public Schools *(1985)*
Fighting Federal Deficits: The Time for Hard Choices *(1985)*
Strategy for U.S. Industrial Competitiveness *(1984)*
Productivity Policy: Key to the Nation's Economic Future *(1983)*
Energy Prices and Public Policy *(1982)*
Public Private Partnership: An Opportunity for Urban Communities *(1982)*
Reforming Retirement Policies *(1981)*
Transnational Corporations and Developing Countries: New Policies for a Changing World Economy *(1981)*
Stimulating Technological Progress *(1980)*
Redefining Government's Role in the Market System *(1979)*
Jobs for the Hard to Employ: New Directions for a Public-Private Partnership *(1978)*

CED COUNTERPART ORGANIZATIONS

Close relations exist between the Committee for Economic Development and independent, nonpolitical research organizations in other countries. Such counterpart groups are composed of business executives and scholars and have objectives similar to those of CED, which they pursue by similarly objective methods. CED cooperates with these organizations on research and study projects of common interest to the various countries concerned. This program has resulted in a number of joint policy statements involving such international matters as energy, assistance to developing countries, and the reduction of nontariff barriers to trade.

CE	Circulo de Empresarios Madrid, Spain
CEAL	Consejo Empresario de America Latina Buenos Aires, Argentina
CEDA	Committee for Economic Development of Australia Sydney, Australia
CIRD	China Institute for Reform and Development Hainan, People's Republic of China
EVA	Centre for Finnish Business and Policy Studies Helsinki, Finland
FAE	Forum de Administradores de Empresas Lisbon, Portugal
IDEP	Institut de l'Entreprise Paris, France
IW	Institut der deutschen Wirtschaft Koeln Cologne, Germany
経済同友会	Keizai Doyukai Tokyo, Japan
SMO	Stichting Maatschappij en Onderneming The Netherlands
SNS	Studieförbundet Naringsliv och Samhälle Stockholm, Sweden

Committee for Economic Development

2000 L Street, N.W., Suite 700
Washington, D.C. 20036
Telephone: (202) 296-5860
Fax: (202) 223-0776

261 Madison Avenue
New York, New York 10016
Telephone: (212) 688-2063
Fax: (212) 758-9068

www.ced.org