Business-Higher Education Forum

A Commitment to America's Future:

Responding to the Crisis in Mathematics & Science Education

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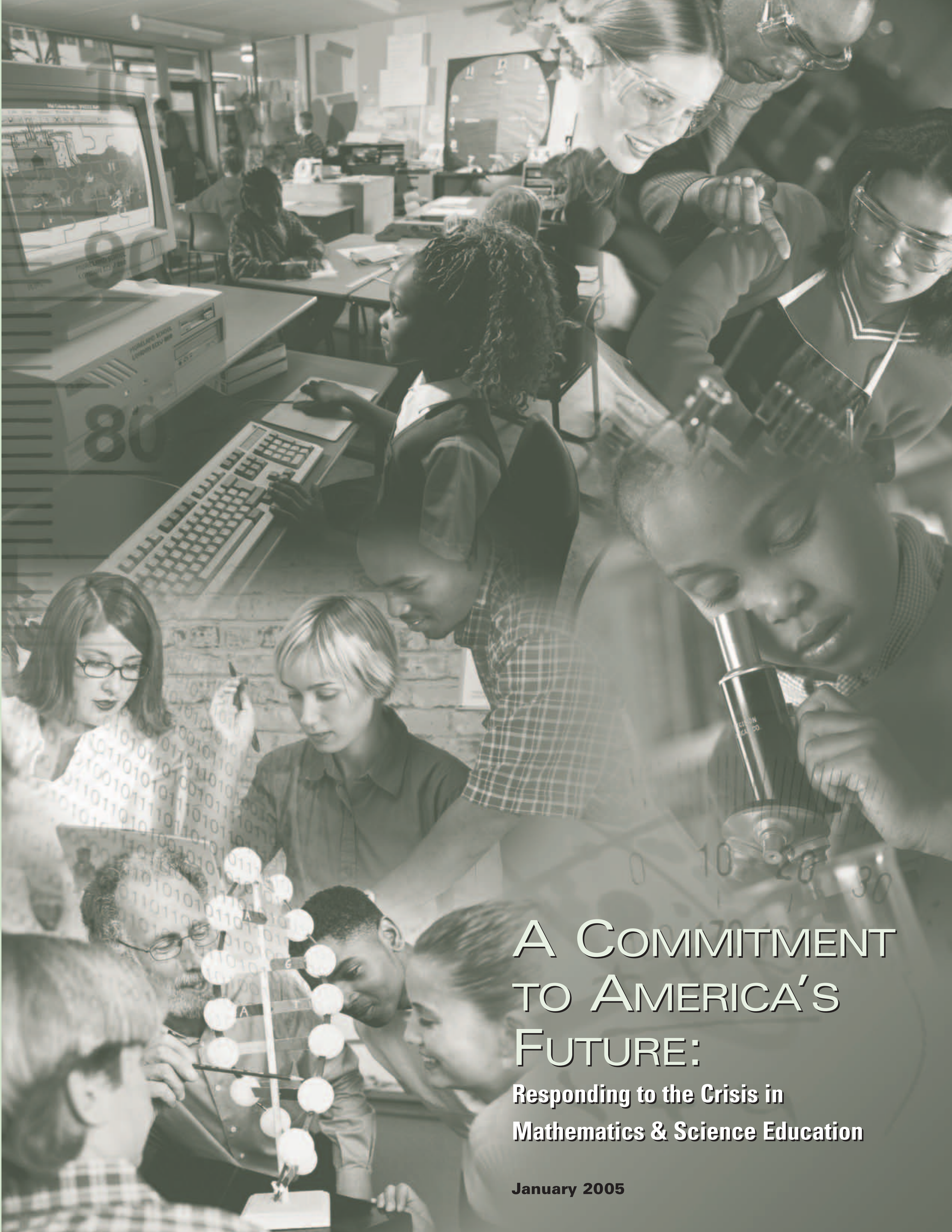

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Preface

Mathematics and science — and the technological innovation they support — are critical to our country's competitive position in the global economy and to its security in an increasingly perilous geo-political environment. Competence in mathematics and science are thus essential to us as individuals and as a nation. We all have a stake in ensuring that *all* Americans are educated properly in these fields.

Because the U.S. Constitution delegates primary responsibility for education to the states, there can be no nationally defined set of standards and expectations for mathematics and science education from pre-kindergarten though grade 12 (P-12). As a result, there is tremendous variability in the teaching of these subjects across the states. This state-to-state variability, coupled with a growing shortage of highly qualified teachers of mathematics and science, is creating a serious problem of underpreparation of high school graduates for further study and for work in the 21st-century economy.

Although the P-12 system of mathematics and science education in America cannot be *national*, it can be *nationwide* — that is, state-by-state and collaborative. What is needed to address the nation's systemic problems in mathematics and science education is comprehensive, state-by-state, system-level change. While we believe the educational community has identified the elements of a comprehensive approach, state-by-state reform efforts to date generally have involved well-intended but piecemeal solutions. The Business-Higher Education Forum (BHEF) is proposing a four-part plan in which business, higher education, and policy leaders support P-12 education leaders in achieving comprehensive, coordinated, system-level improvement from pre-kindergarten through postsecondary activity in college and into the workplace — a span referred to as "P-16." In this effort, we believe business has an important and active role to play in the development of state and national policy. This policy should support schools and teachers in creating learning environments that permit all students to discover the excitement of mathematics and science and the opportunities available to them through study of these vitally important disciplines.

As co-chairs of the BHEF's Mathematics and Science Education Initiative, we want to be certain to acknowledge the work of those who have led the way in exploring system reform. This work suggested the mechanism, operational principles, and targets of the BHEF plan. Their work also provided guidance on what not to do. As a companion to this report, the BHEF's *Handbook for a Commitment to America's Future* details their contributions and is offered as a toolkit to P-16 councils.

If America is to sustain its international competitiveness, its national security, and the quality of life of its citizens, then it must move quickly to achieve significant improvements in the participation of all students in mathematics and science. On behalf of the BHEF, we urge business, education, and policy leaders to consider this report carefully and then to come together all across the country during the *next five years* to ensure that the current generation and future generations acquire the core skills in mathematics and science needed to achieve success in the new century. America cannot afford to continue to lose ground in preparing all students in these key areas.

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Introduction

The Challenge to Business and Higher Education

Few Americans, if any, can recall a time when the United States was not the world leader in mathematics, science, technology, and innovation. For decades, America has known no rival. The expansion of research and development (R&D) in university and corporate laboratories, coupled with support for outstanding achievers in schools, colleges, and universities, fueled manufacturing productivity, reinvented entire industries and occupations, and created highly paid jobs.

Innovation — not military might or divine right — fueled the country's unprecedented prosperity after World War II. The nation's infrastructure for innovation put a man on the moon and a vehicle on Mars. It produced the now ubiquitous personal computer, microwave oven, and cellular phone. It ushered in an era of seminal change in health sciences. It pushed America beyond the Industrial Age and into the Information Age.

But now, the United States is losing its edge in innovation and is watching the erosion of its capacity to create new scientific and technological breakthroughs. Increased global competition, lackluster performance in mathematics and science education, and a lack of national focus on renewing its science and technology infrastructure have created a new economic and technological vulnerability as serious as any military or terrorist threat.

The BHEF calls upon business and higher education leaders — and, through them, policymakers — to commit to new and collaborative roles to improve the teaching and learning of mathematics and science from pre-kindergarten through high school (P-12).

While acknowledging the importance of government and corporate policies and investments related to America's role in the global marketplace, this paper is dedicated to the examination and resolution of the underlying problems associated with America's performance in mathematics and science education. Its goal is to engage business and higher education leaders (at both two-year and four-year institutions) in a long-term, coherent, and cohesive effort to improve the quality of U.S.

BHEF urges business and higher education leaders to champion the promising initiatives already begun by P-12 educators and to work with them to develop and implement new strategies, policies, and programs that will raise the mathematics and science achievement of all *of America's students.*

mathematics and science education to a level that will ensure the continued leadership of the United States in mathematics, science, technology, and innovation.

Specifically, the Business-Higher Education Forum (BHEF) calls upon business and higher education leaders — and, through them, policymakers — to commit to new and collaborative roles to improve the teaching and learning of mathematics and science in P-12.

In addition, the BHEF urges business and higher education leaders to champion the promising initiatives already begun by P-12 educators and to work with them to develop and implement new strategies, policies, and programs that will raise the mathematics and science achievement of *all* of America's students. The new and collaborative roles proposed are designed to advance the development of seamless state systems of education that extend from P-12 to higher education and the workplace (P-16).

Educators in the P-12 community will find much of this paper's contents familiar. That's because the four-part action plan outlined in it has been designed to give business and higher education leaders a deeper understanding of the complex problems with which P-12 educators have long been grappling and to provide the business and higher education communities with the tools to become more effective partners in the work of improving America's P-12 education system.

The four actions of the plan constitute a single agenda — a holistic approach to improving mathematics and science education of all students throughout the United States. For the plan to succeed, therefore, America must undertake *all four* actions *simultaneously* during the next five years.

In publishing a companion toolkit to this paper, the *Handbook for a Commitment to America's Future,* the BHEF provides business, higher education, and policy leaders with background information and proposed procedures for structuring and guiding implementation of the proposed plan.

Pre-College Education and Beyond:

Dimensions of the Challenge

The Foundational Role of Mathematics and Science Education

Mathematics and science are the foundation upon which rests America's leadership in innovation and its economic prominence. During the past century, an "educated elite" provided the mathematics and science expertise required to build and sustain America's economic and scientific leadership in a world whose focus evolved from agricultural to industrial to informational.

Although America has not wavered from its understanding of the power and potential of mathematics and science, it has failed to comprehend that in the highly competitive, global economy of the 21st century, mathematics and science are no longer pursuits for the few. They are requirements for *all*.

Other countries not only have accepted this fact, but have acted upon it. They are busy constructing their own foundation of mathematics and science expertise upon which will rest their challenge to America's leadership in innovation and its economic preeminence.

For America to meet this challenge and to maintain its leadership and its security — physical, economic, and civil — it has no choice but to improve and expand its mathematics and science base. More people *must* know more mathematics and science.

The first step in building this larger and better-informed base is to achieve a national commitment to deliver a high-quality mathematics and science education to all of America's children beginning in pre-kindergarten. Failure to succeed in this commitment guarantees America's immediate and accelerated decline in economic leadership and global influence.

P-12 Education: Cracks in the Foundation

While American students' performance in mathematics and science has steadily improved since 1990, their achievement falls far short of the level that represents solid academic performance — the level termed "Proficient".[1] In 2003, roughly 30 percent of fourth and eighth grade students participating in the National Assessment of Educational Progress (NAEP) reached or exceeded the Proficient level in mathematics[2] while the year 2000 mathematics scores for 12th graders indicate that only 20 percent reached or exceeded it.[3] NAEP science scores in 2000 reveal similar lackluster performance patterns for all three grade levels.[4]

Although America has not wavered from its understanding of the power and potential of mathematics and science, it has failed to comprehend that in the highly competitive, global economy of the 21st century, mathematics and science are no longer pursuits for the few. They are requirements for **all**.

A breakdown of achievement scores by race and ethnicity is even more alarming. In spite of significant increases in NAEP mathematics performance levels in 2003, Hispanic and African-American student achievement scores in mathematics remain lower than those of their white peers. At fourth grade, 43 percent of white students were Proficient. The rates for African-American and Hispanic students were 10 percent and 16 percent, respectively. For eighth grade, the Proficient rate for white students was 37 percent, and for African-American and Hispanic students, it was seven percent and 16 percent, respectively.[5]

The impact of these discrepancies takes on even greater significance when viewed through the lens of America's changing demographics. The Census Bureau predicts that the non-Hispanic white population will fall from 74 percent in 1995 to 64 percent in 2020 and to 53 percent in 2050.[6]

For America to increase its scientific and technological base, more students from the African-American and Hispanic subgroups must reach high levels of performance in mathematics and science. To succeed, America must eliminate its achievement gaps.

While academic performance is on the rise on national tests, a look at U.S. student performance on international assessments underscores the magnitude of America's task if it is to maintain its international leadership in innovation. America is being outperformed by a large number of nations.

The average U.S. student begins on top of the world in mathematics and science in elementary school, slips to near the middle of the pack by grade 8, and has sunk to near the bottom by grade 12. Even America's best and brightest aren't near the top.

Students with Advanced Placement Calculus performed at the international average when compared to all advance mathematics students in other nations. Those with Advanced Placement Physics didn't fare as well. They finished below the international average when compared to all advanced science students in other nations.[7]

In short, at a time when the demand for mathematics and science is at an all-time high, American elementary and secondary students are not achieving the level of skills and knowledge required for an internationally competitive scientific and technological workforce. While every student's future depends on high-level competence in mathematics and science, the vast majority fall below expected levels of performance in these subjects. At risk is the economic security of all American citizens, as well as the economic preeminence of the nation.

Undergraduate Education: Slowed Starts and Fewer Finishes

The mathematics and science achievement trends found in American elementary and secondary education extend into undergraduate education. Nationally, 22 percent of all college freshmen fail to meet the performance levels required for entry-level mathematics courses and must begin their college experience in remedial courses. The problem is widespread. In the fall of 2000, 71 percent of America's degree-granting institutions offered an average of 2.5 remedial courses in mathematics.[8]

Of those students entering college with plans to major in science or engineering, less than 40 percent graduate with a degree in that field within six years.[9] For underrepresented minorities (African-Americans, Hispanics, and Native Americans), the success rate drops below 25 percent.[10] In 2000, minorities received only 14 percent of the bachelor's degrees in engineering and mathematics and 17 percent of the computer science degrees.[11]

Although there is no easy way to compare the academic performance of America's higher education students with those of other countries, as is done for elementary and secondary students, international comparisons of baccalaureate degrees granted worldwide reveal startling statistics that bode poorly for America's future as a leader of innovation.

Even though the United States is in the middle of an undergraduate enrollment boom, enrollments in countries with emerging economies and populations many times larger (for example, China and India) are growing at startling rates — similar to those of the United States after World War II.

In China, for example, enrollments are expanding at a rate 10 times faster than that of the United States. The vast majority of Chinese students (three-quarters of all baccalaureates) earn degrees in mathematics, science, and engineering fields, compared to only about one-third of American students.

It is not only China that is beating the United States in the ratio of mathematicians, scientists, and engineers produced. An international comparison of the ratio of natural science or engineering first university degrees places the United States in 17th place.[12]

In 1999, America granted only approximately 61,000 bachelor-level engineering degrees, compared to more than 134,000 in the European Union, 103,000 in Japan, and more than 195,000 in China. Only seven percent of the 868,000 bachelor-level engineering degrees granted worldwide were earned in the United States.[13]

Noting the decrease in the number of American science and engineering degrees in every field outside the life sciences and the decrease in national resources applied to research, the Council on Competitiveness said: "This undercuts the long-term capacity for innovation; the required levels of R&D investment and technical talent cannot be declining in an economy driven by knowledge creation and the deployment of technology."[14]

Graduate Education: Increasingly a Foreign Idea

U.S. graduate education in science and engineering is experiencing an enrollment boom, but the good news isn't all that good. A review of the enrollment numbers by demographic group reveals trends that hinder the increase of America's scientific base.

A study of graduate education through 2001 found that full-time graduate student enrollment in science and engineering grew from a relative low in 1998 to a peak in 2001, surpassing the previous high recorded in 1993.

However, in 2001, the number of U.S. citizens and those with permanent resident status comprised about 60 percent of full-time graduate students in science and engineering, down from 70 percent participation in 1994. In engineering, the percentage dropped from nearly 60 percent to slightly more than 40 percent, while in computer science, the percentage dropped from slightly more than 50 percent to 35 percent.[15]

Of those who completed the doctoral degree in engineering, close to one-half were foreign students, as were more than 40 percent of the doctoral graduates in mathematics and in computer science.[16] U.S. graduate programs in science and engineering are increasingly popular, only not with its own citizens.

Until recently the flow of foreign students to U.S. graduate programs appeared to be without end. Students worldwide sought admission to America's world-class graduate schools and to the employment possibilities in America's R&D community that often followed graduation. This influx of outstanding foreign talent is no longer a certainty.

Foreign countries now are investing heavily in their own education and research infrastructures to keep their best and brightest at home. And now, those students still interested in graduate programs in the United States often are faced with red tape and delays generated by increased security measures.

A 2004 study found that roughly 60 percent of some 130 research universities and doctoral programs were seeing declines in graduate science applications from overseas students.[17] Those who do choose the United States for higher education now find it harder to obtain a visa that allows them to remain in the United States after they complete their graduate education.

Bare Shelves in the Employment Marketplace

America cannot afford this decrease in scientific and technologic talent. According to projections by the U.S. Department of Labor, jobs requiring science, engineering, and technical training will increase by 51 percent between 1998 and 2008, four times faster than overall job growth. By 2008, some six million job openings for scientists, engineers, and technicians will exist.[18]

Even jobs that don't require a bachelor's degree require higher levels of mathematics and science skills. More than 60 percent of new jobs will demand a solid high school education and some postsecondary education, while only 12 percent of new jobs will be available to workers without a high school diploma.[19]

Anticipated demands of jobs of the future include both integrated knowledge of science and skill in applying knowledge to solve real-world problems.[20] The growing need for interdisciplinary collaboration in the sciences is dictated by a changing world of science in which specialists from mathematics and several science sub-disciplines — medicine, physics, chemistry, and engineering — merge their talents to tackle complex problems.

Leaders from business, higher education, and the mathematics and science communities agree that employees and students must be able to integrate ideas from mathematics and science to solve problems.[21, 22]

According to Bruce Alberts, president of the National Academy of Science: "What we need is to get computer scientists together with the ecologists, and physicians together with physicists, because too often they tend to focus on their own little worlds. It leaves too many critical areas of research unexploited."[23] This skill in integrating ideas is in addition to, and not in place of, discipline-specific expertise.

First of all, each team member must be a very good physicist or chemist or mathematician or computer scientist or electrical engineer. But to function effectively as a member of the team, each also must have some basic understanding of connections of his or her field with the disciplines of other team members.

However, the current secondary school curriculum compartmentalizes science and mathematics concepts into courses named Biology A and Algebra II, a practice that works against an understanding of the connections within and between the broader fields of science and mathematics.

Similarly, the science curriculum across the grades fails to build connections between life science concepts and concepts in physical science and earth and space science. The curricular disconnect extends to colleges and universities that persist in teaching science and mathematics as a collection of discrete subjects.

Calling for More Highly Qualified Teachers: No One at Home

To ensure that students reach the higher levels of mathematics and science achievement required by the new economy, America's schools are calling for more, and more highly qualified, teachers of mathematics and science. But many of those calls are going unanswered. With increasing frequency, no one is at home in America to answer them.

Demand and supply statistics on mathematics and science teachers have ceased to be only depressing. They are alarming. Based on assumptions of increasing student enrollment and policies requiring decreasing student-to-teacher ratios, we predict that at least 280,000 new mathematics and science teachers will be needed in grades 7-12 between 2004-2005 and 2014-2015. Furthermore, this estimate does not take into account that many states are increasing their requirements for mathematics and science core courses, which will require additional teachers in those fields. As a result, many states have designated mathematics and science as areas of critical shortage.[24]

Moreover, the teachers that America is calling for simply aren't in the pipeline. Few U.S. students are drawn to teaching mathematics and science when such a choice means low pay, lock-step advancement opportunities, poor working conditions, and lack of support by the public, including government officials, business and community leaders, parents, and the media. In 1999-2000, nearly 50,000 more teachers left the profession than entered it.[25]

The teacher pool in mathematics and science education continues to shrink as prospects interested in those subject fields are being drawn away from teaching by broadening employment opportunities, jobs with higher salaries, career growth potential, and greater independence in work-related decision making. Increasing the number of students qualified for work or higher education won't happen unless America addresses the problem of developing and sustaining a highly qualified mathematics and science teacher workforce.

Because teachers are a class of "skilled workers," it is not surprising that states and school districts, like corporations, have tried to solve the shortage problem with long distance calls to recruit talent from other countries (for example, England, Germany, and India). Nationwide, districts employed more than 10,000 foreign-born teachers with H1B visas in public and private schools during the 2002-2003 school year.[26] But that off-shore supply now is threatened by a decrease in the overall number of available visas and an international shortage of teachers.

According to a 2003 report of the Organisation for Economic Co-operation and Development (OECD), 15 of 19 member countries surveyed soon will face teacher-recruiting challenges of their own.[27] Secondary schools in 14 OECD countries had an average of 12 percent of their teaching posts vacant at the beginning of the 2001-2002 school year. Science and mathematics were two areas where hiring difficulties were greatest.

Learned from the Past:

Defining the Problem to be Solved

Fundamentally Flawed Planning

The national and personal economic security crises attributed to American students' inadequate performance and flagging interest in mathematics and science have been widely reported for decades. During the last four years alone, a host of government agencies and commissions, professional societies and organizations, educational groups, public policy institutes, public and private foundations, institutions of higher education, and business organizations published reports that address the urgent need to improve mathematics and science education in the United States.[28, 29, 30, 31, 32]

These groups invested billions of dollars not only in trying to isolate the problem that is the underlying cause of students' poor achievement, but also in trying to solve that problem. Beyond simply reporting on the issue, they undertook initiatives to improve specific components of the P-12 education system that impact student achievement in mathematics and science education: standards; curriculum; assessment; teaching; accountability; and governance. While the initiatives yielded promising reform policies and practices, all national indicators point to the fact that the underlying problem persists.

What can be learned from these initiatives' collective failure to increase significantly American students' achievement in mathematics and science? One answer is that they provide information about what does not work. Achievement will not be increased significantly simply by replacing textbooks or testing programs. It will not be increased significantly simply by increasing the number of days in the school year or by reducing the number of students per primary school classroom. It will not be increased significantly by supporting the use of computer laboratories or, as some propose, by banning the use of calculators.

The failure of these initiatives to bring about lasting improvement in mathematics and science education is instructive. What they have in common reveals a fundamental flaw. What they have in common is that they have nothing in common. The action taken by each sought to improve one aspect of the P-12 education system while, for all practical purposes, ignoring resultant effects throughout the system. Each past initiative was fundamentally flawed because it failed to plan intervention as a system-wide event.

Consequences of Fundamentally Flawed Planning

Consequences of the states' flawed planning are easy to find. Although America has made substantial investments in further boosting the mathematics and science achievement of its most promising pre-college students, states' education systems have failed to ensure that *all* students at *every* grade level achieve in these subjects. They have failed to provide *all* students with access to crucial courses in mathematics and science. As a result, only about half (54 percent) of high school students take three years of science and only six in 10 (62 percent) take three years of mathematics.[33]

While most states have set standards for what should be learned in P-12 classrooms, studies have revealed that some standards are weak or incoherent, and that even the best standards are not aligned well with the expectations of higher education and the workplace.[34, 35, 36] In addition, states and districts often have not translated the expectations of the standards into year-by-year specifications for curricula and teaching methods.

The nature of pre-college coursework — curriculum — makes a difference, and the simple rule is: More … and more demanding … is better for all. Studies show that all students are likely to perform better — that is, learn more — in high-level courses than in low-level courses and that students who are the farthest behind at the outset will make the greatest gains.[37]

Evidence points to the appropriateness of state policies insisting on high-quality curricula that, beginning in elementary school, optimize the learning opportunities of *all* students, and are directed at preparing *all* students for postsecondary study in community colleges, colleges, universities, technical schools, the military, or the workplace.

Effective implementation of high standards for all students also lags. This can be traced to the absence of coherent teacher preparation programs and professional development experiences that are aligned with the higher standards that students are asked to achieve. As of 2002, only 10 states had policies requiring that professional development activities be directly linked to national or state content standards.[38]

At present, too many young people learn mathematics from teachers who lack basic knowledge of the field. One in three high school students is taught mathematics by a teacher who lacks a major in mathematics, mathematics education, or a related field (for example, engineering). In middle school, 61 percent of students are taught mathematics by teachers who do not have a major or minor in mathematics, mathematics education, or a related field. These problems are significantly worse in high-poverty schools that have more inexperienced and less qualified teachers.[39]

In addition, statewide pre-college testing programs have not been used effectively for diagnostic purposes or to determine the kinds of remediation that will be most effective for students who are falling behind. Neither are the skills and knowledge tested by those programs matched with the skills and knowledge needed to succeed in entry-level college courses and well-paying entry-level jobs.[40]

Shortcomings in academic counseling and information resources provided by middle schools and high schools, as well as the conflicting expectations of college entrance and placement assessments, are identified as probable causes of extensive remediation and of high college drop-out rates, rates that reach 50 percent in some university systems.[41] In effect, two separate systems of education exist that act independently and at cross-purposes to one another.[42]

"The need is for structural change, from the schoolhouse to the statehouse. … Fundamental change. Structural change. The education system must not only be better. It must be different."

The Problem to Be Solved

The BHEF believes the work of the past decade has been highly productive in establishing innovation and reform in some states and school districts. Some states have adopted student learning standards in mathematics and science that go beyond "knowing what" to include to demonstrating the use of what is known. Some states and districts have installed curriculum materials with content that better addresses society's higher level expectations of students. The student assessments of some states and districts are more rigorous, more comprehensive, and better aligned with P-12 standards.

Most states also have increased the number of higher level mathematics and science courses required for graduation. The quality of teacher education has been raised as some P-12 teacher preparation programs have increased the subject-area preparation expected in mathematics or science. Some states have developed policies under which students, teachers, and schools are held accountable for the quality of their work.

The past decade of work also has revealed the exact nature of the underlying problem — pointing to why efforts to improve student achievement and interest in mathematics and science have produced no significant and lasting results. The problem is that these efforts to improve mathematics and science education have been stand-alone interventions that were focused on reforming one or another component of the system. They were ultimately unsuccessful in permanently changing the system by which students are educated in mathematics and science because "it is simply unrealistic to expect that introducing reforms one by one, even major ones, in a situation which is basically not organized to engage in change will do anything but give reforms a bad name."[43] The system, being highly resistant to change, simply "absorbs" such interventions and returns to its original shape.

Therefore, despite the accomplishments in *some* states and districts, American education is failing to meet the needs of its clients. The reason for this is that no accomplishment of some states has been an accomplishment of *all* states, and no state has made substantial and lasting improvements in all key system components: standards; curriculum; assessment; teacher quality; and accountability.

More than a decade ago, researchers at the Education Commission of the States (ECS) concluded: "A little change, a few minor adjustments here and there will not do it. The need is for structural change, from the schoolhouse to the statehouse. … Fundamental change. Structural change. The education system must not only be better. It must be different."[44]

For America to improve overall mathematics and science achievement and to increase the base of students who have taken the right courses and have met standards grade by grade, it must do nothing less than implement a plan that guarantees sweeping and coordinated changes in entire education systems.

Individual recommendations in the BHEF plan to accomplish this goal are not new. The assembled knowledge and promising proposals generated by past initiatives point to what now needs to be done and how to go about doing it. The United States has only to put that knowledge to work through an immediate, concerted, and sustained nationwide plan. That plan must address *simultaneously* needed changes in system governance, in policy, and in programs related to *all* system components — student standards, curricula, student assessment, teacher quality, and accountability — and in engaging public commitment to enhanced mathematics and science education for *all* students. To date, such a plan has not been proposed for implementation throughout the United States.

Taking Action:

A Four-Part Strategy for Solving the Problem

Since the United States does not have a national system of education, the American context for tackling this problem is unique. Education is the independent responsibility of each of 50 states working with a total of approximately 15,000 school districts.

Moreover, the education decision-making power vested in a particular state government varies widely from Hawaii with its single school district to Texas with its approximately 1,100 independent school districts. Collaboration of P-12 and higher education varies from Wyoming with its single university and seven community colleges to California with its two systems of public universities, 108 community colleges, and dozens of private institutions of higher education.

In America, therefore, the task of organizing, leading, and implementing efforts to improve mathematics and science education must be tailored to match the education policies and priorities of each state. System change cannot be *national*, but it can be *nationwide* — that is, state by state — and collaborative as well.

A Nationwide Plan for Resolving a National Problem

In countries with centralized systems of education, such as Great Britain, France, and Japan, nationally identified education problems give rise to national — that is, centralized — programs of reform. In America, with its decentralized organization of education, nationally identified problems in education are resolved state by state.

However, the BHEF believes that the national imperative to improve mathematics and science education cannot be met by 50 wholly independent efforts. The task demands a nationwide plan to promote the establishment of common new elements of state education infrastructure with a common five-year timeline to achieve the common goal of organizing, leading, and implementing reform agendas that support the continuing improvement of P-12 mathematics and science education.

The proposed new element of state infrastructure, called a P-16 education council, is needed to establish and guide the implementation of policies that support the point of view that education is a *continuum from preschool through the baccalaureate degree*. Specifically, the long-term mission of a P-16 council is to promote the coordination of reform both across the key components of the state's education system (student standards, curricula, student assessment, teacher quality, and accountability) and across the different sectors of the education system: primary school (grades P-2); elementary school (grades 3-5); middle school (6-8); high school (9-12); and postsecondary (higher education and the workplace).

…because P-12 education is impacted by policies and practices of higher education, business, and government, P-12 system changes must be coordinated with changes in those related policies and practices.

The BHEF plan for resolving the underlying problem of mathematics and science education in America comprises four related actions:

1. Establish a P-16 education council in each state. P-16 council membership should have balanced representation from business, education, and policy leaders. Representation must include P-12 classroom teachers and administrators, since these leaders have unique understanding of what must and might be done to successfully bridge the final inch of the education gap between policies and pupils. Council membership also must include community college leaders, since the number of students taking basic undergraduate courses in mathematics and science at these institutions is both large and increasing. These P-16 education governance structures should be charged with defining, benchmarking, and initiating a statewide P-16 plan for ensuring that all P-12 students successfully complete a high-quality mathematics and science education.

2. Simultaneously address and align the five P-12 system components. Effective mathematics and science education requires the close alignment of a P-12 system's content standards, curricula, assessments, teacher preparation, and accountability practices. It follows that proposed changes in any one of the five aligned components demands attention to resultant effects in the other four. In addition, because P-12 education is impacted by policies and practices of higher education, business, and government, P-12 system changes must be coordinated with changes in those related policies and practices.

3. Engage business and higher education in more effective P-12 reform roles. Business needs to accept greater responsibility for leading state P-16 council work and for aligning all corporate education outreach initiatives with the state's vision of standards-based improvement of P-12 mathematics and science education. Higher education needs to implement policies and programs that place the education of teachers — in particular, teachers of mathematics and science — at the center of its mission.

4. Implement coordinated national and state-specific public information programs. These professionally designed programs should be based on a common set of core messages that will engage the public in the nationwide effort to strengthen the mathematics and science education of *all* students. The P-16 councils should guide the state-level campaigns to ensure that they both localize and support the core messages of the national campaign.

As will be shown, the goals of these four actions are interrelated and interdependent. They constitute a single agenda — a holistic approach to improving mathematics and science education of *all* students throughout the United States. For the plan to succeed, therefore, America must undertake *all four* actions *simultaneously*. The work, which must begin immediately, requires America's commitment to a five-year sustained effort.

Action 1:

Establish a P-16 Education Council in Each State

BHEF urges each state to establish a P-16 council composed of policy leaders, business leaders, and educators to support the development of a P-16 system of policies and oversight over the long term. The council should be organized as a non-governmental body with balanced membership from the three levels of the education system (P-5, 6-12, and postsecondary), the business sector, and government, with the business community having a unique opportunity to serve as an 'external' advocate for the work of the council. The council should build consensus for, promote, implement, and monitor the P-16 system of statewide policies, programs, and practices. To this end, its structure might include affiliated regional councils engaged in tailoring policy implementation to local conditions.

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Refining and Expanding the P-16 Council Concept

P-16 councils are not a new idea. The most recent and widespread endorsement of the P-16 approach is found in the formation of a network of state and district councils whose long-term purpose is to promote the coordination of reform systemically across the different sectors of the education system.[45]

In 2000, the ECS reported on efforts by 24 states to use a K-16, P-16, or P-20 approach to improve student achievement by creating "a seamless system in which all levels of education coordinate, communicate, and educate as one system instead of several."[46]

According to the report, many states are in the early stages of designing their programs. The report also states that this activity has been initiated by state agencies rather than mandated by state legislatures: "In many states, the voluntary cooperation between state boards of education and higher education systems is seen as the success behind the effort."[47]

A great deal of council-building work is yet to be done to deal with the static or deteriorating quality of P-12 mathematics and science education at a time when the demands for even greater knowledge and skills is increasing rapidly. At present, more than half of the states do not have a P-16 governance structure. These states must work to develop one quickly. In states where P-16 governance structures have been initiated, none is business-led. These states must work to expand their council leadership base by engaging the business community in policy formation and council management.

Efforts also must be made to connect to and collaborate with existing organizations that have adopted a focus on educational issues. Potential members or allies of a P-16 council include: state and local professional societies; parent-teacher-student-associations; chambers of commerce; Business Roundtable affiliates; church organizations; and community groups.

In addition to expanding P-16 council participation, the work of the council must also be revisited. The agendas of existing councils typically are restricted to the improvement of some single aspect of mathematics and science education (for example, teacher quality). Instead, councils must review their agendas to ensure that their programs address P-16 *system* improvement.

Planning Guidelines for P-16 Councils

Lessons learned from a decade of system reform initiatives in mathematics and science education have yielded basic guidelines for planning the work of a council. To achieve effective system reform, reform that will demonstrably improve the mathematics and science achievement of all P-12 students and will ensure the quality of their teachers, the council must establish the following:

A Shared Vision: The statewide vision for P-12 mathematics and science education must encompass all levels of the P-16 system. It must reflect the identified needs of the specific P-16 system being addressed and the consensus opinion of the all the major stakeholder groups. It must be understood, supported, and clearly stated by the state's educators, business leaders, and policymakers.

A Shared Plan: The plan for reaching the state's vision for P-12 mathematics and science education through coordinated change in policies and programs at every level of P-16 mathematics and science education must be understood and supported by the state's educators, business leaders, and policymakers. Clear proximate benchmarks in the plan are critical both for establishing council effectiveness and for sustaining members' commitment to council work. Roles and responsibilities for all stakeholders must be stated clearly.

Policy Coherence: The entire package of P-16 education policies at the state, district, and school levels must focus on standards-based improvement of P-12 mathematics and science education.

Program Coherence: Programs for students, teachers, or teacher educators intended to improve a P-16 system of mathematics and science education — whether offered by the state's department of education, school districts, institutions of higher education, businesses, or foundations — must be aligned with the state vision *and with each other* to avoid conflict of purpose or redundancy.

Program Coordination: A system-wide plan must be developed for the coordinated implementation of five related components of P-12 mathematics and science education: student content standards; curricula; student assessments; teacher quality; and system accountability.

P-16 Resource Alignment: Collaboration in the use of federal, state, district, and private funds must take place to ensure that the P-16 education programs they support are complementary and are consistent with the shared vision for improvement of mathematics and science education.

Plan Evaluation and Refinement Procedures: The council must collect data designed to assess how well its plan for improving mathematics and science education is working at all levels of the P-16 system. The plan itself must include a procedure for continuous refinement based upon what is learned from evaluation of its effectiveness.

Audience-Specific Progress Reporting Procedures: The council must develop procedures for reporting periodically to each of several audiences — including state educators, business leaders, policymakers, parents, and the general public — about its progress in implementing its plan to improve the P-16 system of mathematics and science education.

Action 2:

Simultaneously Address and Align the Five P-12 System Components

A P-16 council's plan to improve the P-12 mathematics and science education must encompass five interrelated system components:

A. P-12 student content standards in mathematics and science;
B. P-12 curricula in mathematics and science;
C. P-12 assessment in mathematics and science;
D. P-12 teacher quality; and
E. System accountability for P-12 education.

P-16 councils should not set out to improve any *one* of the above. Rather, they must improve *all* of the above. The five P-12 system components are inseparable. Intervention in any one of them requires interventions in the other four. It is critical that P-16 councils' plans anticipate and deal with the cross-component effects of change.

P-16 councils also must anticipate and promote related changes in institutions and agencies outside the P-12 system. The success of P-12 improvement efforts often will be dependent upon timely changes in the education policies and programs of higher education, business, and government. Therefore, coordinated P-16 attention to aligning issues both within and without the P-12 system is a necessary condition for the improvement of P-12 mathematics and science education.

The five P-12 system components are inseparable. Intervention in any one of them requires interventions in the other four. It is critical that P-16 councils' plans anticipate and deal with the cross-component effects of change.

System Component A: P-12 Student Content Standards in Mathematics and Science

Rather than take great pride in the small percentage of students currently excelling in mathematics and science, each state must set high standards for *all* students and must work to ensure that every student achieves the standards set for each grade from the earliest years of education through the baccalaureate degree. In planning guidance of the student content standards component of the system, a state's P-16 council should:

1. Encourage the state and its school districts to regularly review and revise their mathematics and science content standards. P-12 content standards — that is, statements of what all students should know and be able to do in mathematics and science — should be reviewed and updated periodically to ensure that they are of high quality and that they are aligned with state assessments, school curricula, and entry-level expectations of higher education and the workplace. The nature and relationship of evolving content, admission, and employment standards should be communicated to the public.

2. Insist that the state and its school districts hold all students to the same high standards in mathematics and science. All students, including those historically underserved, must successfully complete a high-quality curriculum based on these standards.

3. Ensure that leaders of postsecondary institutions examine both general and program-specific admission standards. Those standards should be directly related to the knowledge and skills required for success in the institutions' entry-level courses. They should match the agreed-upon entry-level expectations for postsecondary work of high school graduates.

4. The content knowledge and teaching skills defining teacher education programs should be related directly to the grade-level content standards of the students they teach. Teacher education programs should be assessed to ascertain their effectiveness in developing teachers' ability to deliver age-appropriate instruction related to those standards.

System Component B: P-12 Curricula in Mathematics and Science

States and districts must ensure that every school implements high-quality curricula in P-12 mathematics and science that are, by default, the curricula available to and required of *all* students. Course content should enable all students to meet college entrance requirements and meet employers' expectations for mathematics, science, and technological skills and knowledge.

The high-quality curricula should be built upon the expectations expressed in a state's content standards and should be measured periodically by state assessments that are carefully aligned with those expectations. High-quality curricula are not intended to be *elected by some* students. They are to be *expected of all* students. Students may choose to do more, but they should not be permitted to do less.

In planning guidance of the P-12 curricula component of the system, a state's P-16 council should:

1. Ensure that all students successfully complete high-quality curricula in P-12 mathematics and science. All students at all grade levels — elementary, middle, and high school — should complete mathematics and science curricula centered on core courses aligned with the standards judged to be most important. Successful completion of these curricula should prepare students for successful entry into postsecondary study in higher education or the workplace.

Trivial and unconnected topics, activities, units, and courses must be eliminated from the curricula and should be replaced with experiences designed to increase student understanding of and interest in mathematics and science. These experiences should include laboratory-based investigations; extended problem-solving activities that promote understanding of key concepts and their application in the real world; use of technology tools in doing mathematics and science; and introduction to mathematics- and science-related careers.

Secondary school teachers of mathematics and specialist teachers of mathematics and science in the elementary and middle grades should cycle through courses of the curricula with a cohort of students. In so doing, they should take responsibility for: the overall mathematics and science education of all students in that cohort; maintaining familiarity with an entire curriculum at that level; and continually assessing and improving their teaching effectiveness.

To free up secondary school mathematics and science staff to teach courses of the high-quality curricula to all students, it may be necessary to reduce or eliminate courses now offered only for students who exhibit exceptional interest or ability in those subjects. To meet the needs of these exceptional students, arrangements could be made for tuition-waived enrollment in appropriate courses at community colleges and colleges as part of their secondary school program. If no postsecondary institution is nearby, students could be given access to postsecondary coursework via distance-learning facilities. Supporting tutorial services could be provided by employees of local businesses who have backgrounds in mathematics or science.

2. Ensure that the implementation of high-quality P-12 curricula in mathematics and science is coordinated with the implementation of necessary changes in other key elements of the education system. Not only should the curricula be focused on established content standards, but also it should exhibit coherent development of the standards across P-12; use instructional materials aligned with the standards; assess daily and year-to-year progress of students using techniques that measure many levels of learning; and be taught by teachers who have studied and practiced methods shown to be effective in helping all students achieve the expected higher levels of learning.

3. Promote collaboration among P-12, higher education, and business leaders to facilitate the development of curricula that make connections within and between major areas of mathematics and the sciences. The long-term goal of this effort is to graduate high school students who have had an integrated experience with the subjects. A necessary byproduct of this collaboration is that colleges and universities develop mathematics and science courses that will expose all graduates — and teachers, in particular — to this connected view.

System Component C: P-12 Student Assessment in Mathematics and Science

The two primary purposes of assessments in mathematics and science should be to inform students, schools, and parents of students' progress toward achieving state and district learning standards and to judge the effectiveness of system initiatives to improve student learning. The states should themselves be the objects of continuous evaluation to determine if the data that they gather is adequate for those purposes.

In planning guidance of the P-12 student assessment component of the system, a state's P-16 council should:

1. Ensure that state and district assessment systems are aligned with the P-12 standards in mathematics and science. Alignment should ensure that, at each grade level tested, the assessment system appropriately assesses all standards at that level and does not assess trivial or irrelevant concepts and skills. Alignment should ensure the definition of "Proficient" is sufficiently demanding at each grade level tested and that the definition of "Proficient" is consistent across grade levels.

2. Ensure that assessments are used to measure progress and to drive intervention and not to exclude students or schools from opportunities or to otherwise punish them. Student assessments should provide policymakers, parents, teachers, and principals with data that will facilitate the diagnosis of the academic needs of individual students and will guide the management of resources to ensure improved achievement for all students. Assessment data should be interpreted and reported in formats specifically designed to ensure understanding by the different groups of stakeholders. This will require state development of data systems that relate data from student assessments with data on the status and progress of curriculum development, teaching quality, intervention opportunities for students, and professional development opportunities for teachers.

3. Insist that the state design a uniform statewide P-12 assessment system that reports the year-to-year performance of both schools and individual P-12 students in mathematics and science. Longitudinal tracking of student performance can reveal the "value-added contributions" of implemented changes in curricula, instructional materials, teacher preparation, or teacher professional development, as well as the summary impact of those changes on student success in postsecondary education. The design and implementation of any such longitudinal tracking scheme must address the issues of student mobility within the state, and student transfers from other states and countries.

Admissions and placement tests administered by institutions of higher education should be viewed as elements of P-12 assessment, since they influence the course-taking of secondary school students. Sample placement tests should be made available online so that secondary school students can gain a better understanding of program's entry-level expectations. Admission and placement test results should be summarized for each high school and reported to the schools for the purpose of identifying and correcting school-to-college expectation mismatches.

The success of P-12 improvement efforts often will be dependent upon timely changes in the education policies and programs of higher education, business, and government. Therefore, coordinated P-16 attention to aligning issues both within and without the P-12 system is a necessary condition for the improvement of P-12 mathematics and science education.

System Component D: P-12 Teacher Quality

Each student deserves highly skilled, committed, and supported teachers of mathematics and science at each level of schooling. Teacher "quality" includes, but is not limited to, strong and relevant subject-matter knowledge. Teachers also must have a deep interest in the subjects they teach, a commitment to lifelong professional improvement, the desire and skill to help P-12 students share that knowledge, and the resources necessary to do their work.

In planning guidance of the P-12 teacher quality component of the system, a state's P-16 council should:

1. Facilitate collaboration among the state's department of education, the state's teacher certification unit, and the state's two-year and four-year institutions of higher education in the redesign of teacher preparation programs in mathematics and science. Program admission requirements, specialized content courses, and graduation standards for teacher candidates should be aligned with the state's P-12 content standards. Both content and teaching methods courses should be redesigned to help future teachers make insightful connections between the mathematics and science they are learning and the mathematics and science they will teach.

Colleges of education and content departments in mathematics and the sciences must share the responsibility for achieving this alignment. Although these programs must address the unique professional demands of teacher candidates at each of three levels of instruction — elementary, middle, and high school — they also must provide teachers at each level with the in-depth content and teaching skills of previous or subsequent levels that will allow them to detect and correct students' misconceptions and to teach in a way that anticipates future learning.

In addition, higher education faculty must collaborate with the P-12 teaching community in redesigning teacher preparation programs to meet the new demands of mathematics and science education.

Experienced P-12 teachers have a wealth of practical knowledge: experiences of what works in P-12 classroom instruction; insight into student learning problems; skill in navigating the P-12 system; and understanding what it takes to engage P-12 students in mathematics and science. This infusion of practical knowledge can be a valuable resource to higher education in its effort to overhaul teacher preparation courses. P-12 teachers are in a unique position to help identify and remediate deficiencies in teacher preparation programs. Higher education must take the lead in establishing an environment of mutual respect and equality that will allow this cross-system sharing to grow.

The work of higher education in improving teacher education programs must be led by college and university presidents and provosts, who must make teacher education central to the mission of their institutions; lead institutional change on campus; connect to the P-12 community; and engage in public debate directed at shaping public policy on teacher education.

For its part, each state must provide colleges and universities with incentives for evaluating and modifying teacher education programs; increasing the number of teachers of mathematics and science (especially teachers drawn from underrepresented minorities); and producing teachers who are prepared to work in hard-to-staff schools.

To solve mathematics and science teacher shortages, states should actively pursue mathematicians, scientists, and engineers who are retiring or seeking a career change and make available to them alternative teacher certification programs that help them acquire the teaching skills and knowledge needed to teach the new, high-quality curricula.

2. Ensure that the policies and practices of the state and its school districts provide a supportive professional environment for teachers. To improve the professional environment of new teachers, a state's system of teacher education should include at least three years of transition-to-the-profession support. To improve the professional environment of experienced teachers, it should make every effort to equip classrooms with the best instructional tools available; encourage and support participation in professional organizations; reward performance; and celebrate both teachers and their profession.

The initial education of a teacher extends beyond college graduation. Colleges and universities provide teacher candidates with not only subject-content knowledge and with knowledge of teaching materials and techniques. However, the effective use of that knowledge is learned on-the-job in P-12 classrooms. A state's system of teacher education must support teacher candidates during this "apprentice" period. In particular, teaching assignments of new hires must include scheduled time for mentoring by master teachers in their content area, and master teachers must have release time to provide that mentoring.

Orientation programs, designed and led by master teachers, should thoroughly acquaint new teachers with district curriculum and instructional materials at all levels, so that instruction at any level can be understood in the context of what has come before and what will follow. Finally, district policies should limit the extracurricular assignments of new teachers and should prohibit the assigning of new teachers to work with the most challenging students.

To facilitate professional growth, the class schedules of all teachers of mathematics and science should be restructured to provide in-school time for group study and for work on improving teaching and learning. Districts also should encourage and support participation of all teachers of mathematics and science in the activities of local, state, and national professional organizations in their fields.

To provide field-based data on the effectiveness of current teacher education programs, each institution of higher education should establish a formal feedback mechanism which includes its recent teacher education graduates. An advisory body of graduates with one, two, three, and five-plus years in the field should meet at least once a year to review the institution's programs and to propose changes.

3. Promote the teaching of P-12 mathematics and science as an attractive and honored profession. Initial salaries of mathematics and science teachers must be made competitive with the salaries of other jobs available to persons with baccalaureate degrees in those fields. Advancements in salary and leadership opportunities should be tied to accountability measures that include student performance.

However, any increase in compensation for teachers will fail unless the public has greater respect for the profession. Respect only will come if other leading professions work together to build public esteem for teachers and teaching. Business and higher education are well positioned to reverse the downward spiral of prestige and respect for the P-12 teaching profession.

Business leaders should support and celebrate the profession with programs that recognize teaching in general and with awards that honor outstanding teachers, especially ones that include a monetary component. They should work across the professional community to create a culture of support that would encourage young people to enter the profession.

Higher education is in the unique position of raising the esteem of P-12 teachers by recognizing them as equal partners in the work of improving mathematics and science education. Collaborative work focused on, and growing out of, the experience, skills, and knowledge of teaching mathematics and science at all levels of education will build mutual respect and understanding between higher education and the P-12 teaching community. Both higher education faculty and P-12 teachers have much to learn from this collaboration.

A concerted effort must be undertaken to increase public understanding of who teachers are, what they do, and the conditions under which they do it. Myths that anyone can teach, that teacher education consists only of methods courses, that teachers keep "banker's hours," and that "those who can, do and those who can't, teach," must be dispelled by an accurate portrayal of teachers and teaching, including the physical conditions of teaching. To leave such misrepresentations unchallenged demeans education in the eyes of students, hastens the exodus of current talent from the profession, and is a barrier to engaging much needed new talent.

4. Ensure that the state and its school districts establish programs of professional development that build, maintain,

and support a knowledgeable and effective teacher workforce in mathematics and science. For teachers to help all students achieve higher standards, professional development programs must be tailored to help all teachers acquire the requisite content knowledge and teaching skills. Professional growth experiences should be locally planned and implemented. They should focus on enhancing teachers' ability to make specific improvements in student learning of mathematics and science; should be assessed for effectiveness; and should be long-term and continuous rather than episodic. The school day should be restructured to allow for the inclusion of professional development activities in the daily life of the teacher.

System Component E: System Accountability

Use of the term *system accountability* is meant to imply that it is the entire education system, *not only parts of it* that must be held accountable for student achievement. The system includes government officials, teacher educators, school leaders, teachers, and students. Data on each group's performance (not only students and schools) must become public record so that each can be called to task as appropriate.

To date, education accountability policies have used data on student test performances, attendance patterns, and graduation rates both to reward schools with public praise, increased funding, and greater operational freedom, and to sanction schools through public embarrassment, forced re-staffing, loss of funds, reduced budgetary control, or support of voluntary student transfers. A balanced accountability system would seek data on the design and implementation of policies and programs and on the equitable allocation of resources and would use that data as grounds for comparable praise or sanction of public officials.

In planning guidance of the system accountability, a state's P-16 council should:

1. Establish a balanced accountability system that requires that the contribution of each stakeholder group be subject to continuous assessment. Currently, many stakeholder groups are not held accountable for their unique role in efforts to improve the achievement of all students. A balanced accountability system ensures every stakeholder group an equal opportunity to share both credit for system improvements and blame for system failures.

2. Urge that the state's P-12 education accountability policies encompass the responsibilities of all key stakeholders of its education system: the governor and legislature; members of the state department of education; faculty and administrators of institutions of higher education; district- and school-level leaders; teachers; and students. Under a comprehensive accountability program, each group should be held responsible both for its performance in improving the effectiveness of its unique role in the system and for its performance in coordinating improvement efforts with other stakeholder groups to increase the effectiveness of the system overall.

State policymakers (the governor and legislators) should be held accountable for formulating, funding, and assessing the effects of a coherent set of accountability policies governing all levels of the state's P-16 system. If schools are to be held accountable for the academic success of all students entrusted to them, then state government should be held accountable for the performance of policies that define, implement, support, and assess its strategies for improving schools' effectiveness. In particular, policymakers are responsible for guaranteeing that districts and schools have equitable access to human and material resources.

The state's department of education should be held accountable: for collecting, analyzing, and reporting (in formats understandable to the different audiences who need to be informed) data on the status and progress of students' P-12 performance and their success in postsecondary study; for providing performance-improvement services to low-performing schools and districts; and for making subject-specific assessments and predictions regarding the demand for and supply of highly qualified teachers.

The state's teacher certification unit should be held accountable for defining and enforcing credentialing standards that mirror and support schools' responsibility to prepare all students for successful transition to postsecondary education or the workplace. Credentialing standards should focus on content and performance standards for teachers that are directly related to the higher expectations in mathematics and science that have been set for all students. The standards should be reviewed periodically to ensure that they reflect evolving student expectations.

The state's institutions of higher education should be held accountable for producing highly qualified teachers of mathematics and science for all levels of the state's P-12 system. The quality of teachers should be viewed as the responsibility of the entire institution — that is, of the departments charged with developing teaching skills, the departments charged with developing content knowledge, and the administrative officers responsible for allocation of resources to the teacher education program.

District- and school-level leaders, both administrators and school teams, should be held accountable for the planning, implementation, and evaluation of long-term, school-specific improvement programs that ensure all students the opportunity to meet the state's academic performance standards. Along with this plan should come the flexibility to manage the available resources and to meet the goal of the improvement program. School-level accountability should be based on annual value-added assessments of the performance of each school rather than annual comparisons among schools.

Teachers should be held accountable for the performance of their students. Teachers in need of strengthening their teaching skills and-or their content knowledge should be provided with appropriate professional development opportunities and individualized assistance. After careful experimentation and evaluation, school systems should adopt pay and bonus plans that link individual teacher's compensation directly to his or her ability to foster student learning.

Students should be held accountable for completing high-quality core curricula in mathematics and science and for meeting the high academic standards set by the state and district. Extra "resources" should be made available to students experiencing problems meeting the standards. Students may need multiple opportunities to pass tests or extra time to reach their goals.

3. Ensure that state and district sanctioning of P-12 students (for example, requiring that a student repeat a grade or a high school diploma be withheld) is based on multiple, appropriate measures of standards-related student performance. No test should be the sole criterion for imposing a sanction. In addition to state and district grade-level assessments in mathematics and science, appropriate measures would include performances in state or national academic competitions; end-of-course test results in selected courses in the core curricula; portfolios of work on extended tasks; and written and oral presentations of research. Promotion and graduation decisions also should include both input from teachers who know the student and consideration of the educational opportunities available to the affected student in the school and district.

4. Facilitate the collaboration of businesses and institutions of higher education in linking student achievement of the state's P-12 academic standards to an array of desired postsecondary goals. Decisions made by institutions of higher education relative to admission, scholarships, and participation in special programs should be based at least in part on students' performance on the state's standards-based assessments. Employers should request and use such data in hiring, in setting initial salary rates, and in selecting candidates for training programs leading to higher-paying positions. These postsecondary uses of P-12 performance data should be made clear to students and parents at the time that students enter middle school.

Action 3:

Engage Business and Higher Education in More Effective P-12 Reform Roles

Business and higher education need to take on new leadership roles that provide more effective support to P-12 educators in achieving system change. It is imperative that business increase its investment in high-impact activities that are focused on P-16 system change and reexamine its entire education outreach investment portfolio to make certain that all parts — however large or small — are aligned with and are in direct support of the system's change plan.

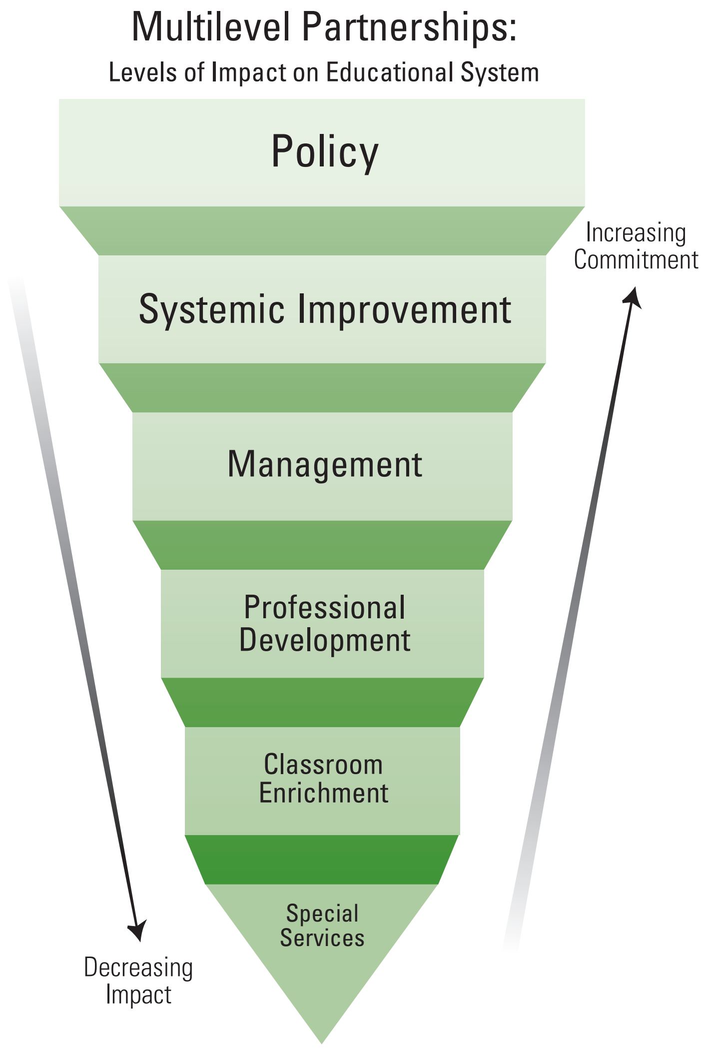
Higher education, because it is the source of the P-12 teacher force and because it is positioned between P-12 education and the workplace, needs to place teacher preparation at the center of its mission and work to eliminate the "expectations gap" between the knowledge and skills required for graduation from high school and the knowledge and skills expected for successful entry into postsecondary courses.

It is imperative that business increase its investment in high-impact activities that are focused on P-16 system change and reexamine its entire education outreach investment portfolio to make certain that all parts — however large or small — are aligned with and are in direct support of the system's change plan.

Maximizing the Effectiveness of Business Participation in System Reform

The interest and investment in a state's system of education by business is second only to that of the state's government. Business leaders understand that supporting a good system of education is good business, and the corporate community has not hesitated to annually invest millions of dollars and uncounted hours of time in efforts to improve education. Unfortunately, that cumulative investment has had little cumulative effect. It's time for business to look carefully at its education investment portfolio.

About 15 years ago, the National Alliance of Business (NAB) analyzed the business community's education investment portfolio



Based on a Diagram in the National Alliance of Business's The Fourth R: Workforce

in terms of the types of partnerships through which businesses were supporting improved student learning.[48] It identified six types of partnerships in that portfolio. While each type of partnership contributed to reform's bottom line, the relative impact of the six types of partnerships was judged to decrease significantly from Policy Partnerships (highest impact) to Special Services Partnerships (lowest impact).

The two high-level partnerships, Policy and Systemic Improvement, are focused on coordinated and continuing change of an entire education system. Their purpose is to make the system self-examining, self-correcting, and self-renewing by bringing about fundamental changes in the system's education policies, programs, and practices. While they typically require a large upfront investment in strategic planning and in building trust and commitment within a broad partnership before the first measurable improvements appear, they eventually yield significant and sustained improvements that continue to affect the education of a large number of students over an extended period of time.

As one moves down the remaining partnership levels of the inverted pyramid from Management to Special Services, the educational interventions require decreasing commitments of corporate time and funds. These partnerships are effective in responding to specific and immediate needs or interests of districts, schools, or individuals, and are valued by those served. However, they are of neither the size nor the duration required to influence the education of large numbers of students or to make basic and lasting changes in an education system.

NAB's analysis of the relative impact of the six levels of business involvement in education led to the conclusion that businesses "must analyze their level of involvement and escalate and expand their investments toward those [levels] which bring about systemic educational improvement and policy change."[49]

The BHEF calls upon business to improve its overall impact on education by using two related strategies: leading P-16 system reform ***and*** aligning all of its education outreach investments with the system's reform agenda. Implementation of these two strategies is ordered, since the definition, wide acceptance, and initiation of a coherent P-16 system change plan are prerequisite to the alignment of corporate education investments with specific and prioritized needs identified through that planning.

Leading P-16 System Reform

The role of P-16 councils is to organize and guide the complex work of system change. For a number of reasons, the role of business in participating in system reform at the Policy and Systemic-Improvement levels, as described by the NAB, is to lead council work.

A federal government study of two states, in which statewide gains in mathematics scores were both significant and ongoing, underscored the importance of the deep and sustained involvement of a core group of business leaders.[50] Such a core group advances effective system change by studying all sides of education issues, establishing relationships with decision makers at all levels, and explaining the situation to other, less involved, business leaders.[51]

Business leaders are free to propose and promote system change in important ways that educators and state department of education officials cannot, since the latter council members are under legal obligations to implement existing policies and programs.

Business leaders have direct access to high-level elected officials and can advocate for policy changes. By contrast, higher education faculty and, with a few exceptions, administrators are barred from such activity.

Because the participation of business leaders in council activity is not at the mercy of the election cycle, they provide stability to council work in implementing and refining a long-term plan for system improvement.

Therefore, to achieve greater return on businesses' investment in mathematics and science education, business leaders should take the following actions:

Policy

- Chair a state-level P-16 council committed to the long-term goal of continuous improvement of P-12 mathematics and science education.
- Lead the council in developing a strong case statement that addresses the need for improving mathematics and science education statewide; that articulates the council's vision for meeting that challenge; and that outlines the council's action plan to reach that vision, including associated benchmarks and assigned responsibilities.
- Advocate the council's reform agenda with policymakers — governors, legislators, and state-board-of-education members.
- Develop a deep understanding of the state's P-16 system of education and its decision-making structure, and communicate that understanding to the business community in terms it can understand and act upon in supporting change.
- Be a consistent voice in the political arena for policies and programs that promote the improvement of the mathematics and science achievement of all students starting in elementary school and continuing through high school. Science and mathematics educational reform and improvement should be given a place of prominence as part of business's lobbying agenda.
- Encourage corporations to align their education outreach initiatives, grant making, employee volunteerism, public relations, and governmental affairs work with the council's vision of standards-led improvement of P-12 mathematics and science education. High-level sponsorship and coordination may be required to tie local business efforts to the council's strategy for educational improvement.
- Promote, with the assistance of higher education, a national education initiative similar to the Morrill Act. Where the Morrill Act focused on agriculture and supported the development of land grant universities, this new initiative would focus on expanding the university's capacity and responsibility for the improvement of P-16 mathematics, science, and technology education.

Systemic Improvement

- Share business' expertise in management systems. Initiate and-or extend the strategic application of business practices to the problems of P-12 education reform — strategic planning, data-driven decision making, and measurement of customer satisfaction.
- Promote participation in P-16 councils with business peers to ensure a continuous business-leadership base. Established groups, such as the Business Roundtable, should be tapped to provide leadership and coordination. CEOs should be sought as active participants in council work.
- Promote and sponsor policies, programs, and investments that will make the teaching profession a more attractive career option. Publicly support all aspects of the profession: recruitment; preparation; initiation; retention; and professional development.
- Act locally to assist school districts in attracting and supporting qualified mathematics and science teachers.
- Encourage other business leaders to speak out on the importance of mathematics and science education for *all* students.
- Provide annual feedback to schools on specific academic strengths and weaknesses of cohorts of graduates entering the workforce. If characteristics other than academic knowledge (for example, reliability, work habits, personal appearance) are assessed, feedback should be directed to parent and community groups.
- Encourage business groups to help parents, educators, and citizens understand the benefits of higher standards,

high-quality curricula, better assessments, and sensible accountability systems.
- Communicate workplace academic skill requirements to leaders of P-12 and higher education, to parents, and to students.
- Help "sell" parents and students on the value of a strong preparation in mathematics and science by communicating how it can help students achieve "The American Dream."
- Address parents honestly and directly on their responsibility to set high expectations for their children's education and to support them in their efforts to attain it.

Aligning Business Investments with Identified P-16 System Needs

Corporate education investments in the four lower levels of education partnerships identified by NAB should be directly linked to priorities of a P-16 system's overall plan for improvement of mathematics and science education. Contributions to management assistance, professional development of educators, classroom interventions, and special service activities are most effective when they address specific, documented needs of the system. Random acts of intervention conceived without consideration of the system's plan for improvement must be avoided.

Too often, the positive results of interventions at these lower levels are minor and short-lived. The system quickly reverts to performing as it did prior to the intervention, except that the levels of frustration of business and education leaders often have increased.

However, guided by the comprehensive planning of a P-16 council, even small corporate investments can contribute to lasting positive improvements. Redundant and conflicting efforts can be avoided; formerly separate efforts can be connected to achieve greater impact; ineffective interventions can be modified or replaced; and system needs can be addressed coherently and in the order of their importance.

All business interventions to support P-12 education should be aligned with the comprehensive reform plan of the P-16 council. As the council's plan takes shape, the following actions are examples of business interventions at the lower levels of the NAB pyramid that could prove valuable to the extent that they are directly related to specific elements of system reform:

Education Management

- Provide training and technical assistance to district and school administrators in system change methods, organizational management, and evaluation techniques.
- Assist districts in establishing data management systems.
- Invite school administrators to participate in business-run management programs, retreats, and conferences.

Professional Development

- Provide certified volunteer substitute teachers or support for certified regular substitute teachers to allow teachers to participate in professional development activities.
- Sponsor a series of summer institutes or summer work experiences for teachers that offer real-world applications in mathematics and science.
- Sponsor the planning and operation of a professional development *program* or a series of activities on a topic of high priority to the district (for example, the teaching of algebra throughout P-12 or the analysis and use of test data).
- Support teacher participation in activities of state and national professional organizations such as the National Council of Teachers of Mathematics (NCTM) and the National Science Teachers Association (NSTA).

Classroom Enrichment

- Participate in a district-trained tutoring network that provides in-person or online assistance to students studying advanced topics or to students needing assistance in meeting state standards in mathematics and science.
- Sponsor a mathematics or science lab for long-distance, higher level coursework in schools limited by geographic location and technology resources.
- Provide access to informal education activities that support the learning goals of the district (for example, a field trip to a research facility to experience scientific research).

Special Services

- Support a program that encourages middle and high school students to take mathematics and science courses every year.
- Support a program that provides information about, and help in applying for, admission and financial assistance to attend institutions of higher education.
- Purchase and maintain specialized equipment for mathematics and science instruction.
- Provide incentives such as awards, recognition programs, and scholarships that encourage students to pursue mathematics and science in higher education.

Maximizing the Effectiveness of Higher Education Participation in System Reform

Institutions of higher education, both two-year and four-year, are gatekeepers of teacher quality. Together, two-year and four-year colleges control the design, implementation, and evaluation of program changes needed to improve both the initial preparation and the continuing professional development of P-12 teachers of mathematics and science. They set the standards for entry into teacher education programs; for placement in particular courses; and for institutional endorsement that graduates have demonstrated the content knowledge and teaching skills necessary to teach mathematics or science at each level of P-12 schooling.

Two-year colleges have become highly attractive to a large number of students and play an important role in their postsecondary education. In the year 2000, more than 40 percent of all undergraduates were enrolled in public community colleges. Approximately 30 percent of enrollees later transfer to four-year institutions.[52] Rising enrollments have been attributed to open admissions policies; proximity to jobs and family; primary institutional commitments to instruction rather than research; and low tuition and fees.

Of the 1,100 community colleges in the United States, 100 institutions spread across 22 states have teacher-preparation programs.[53] Approximately 20 percent of teachers currently begin their work in community colleges.[54] While most states operate a 2-plus-2 system in which community colleges offer only the first two years of a teacher-preparation program before candidates move to a four-year institution to complete their work, some community colleges recently have sought and received approval to offer bachelor's degrees in education.[55] It is estimated that community college programs could provide about a quarter of the new teachers needed over the next decade.

Approximately six million students now are enrolled in two-year colleges and take their entry-level college courses in mathematics and science in those institutions.[56] A survey conducted by the Conference Board of the Mathematical Sciences found that two-year college mathematics programs taught about 41 percent of all undergraduate mathematical sciences (mathematics, statistics, and computer science) enrollments in the United States.[57]

In the year 2000, those community college enrollments included 18,000 students who were taking Mathematics for Elementary School Teachers.[58] Also, almost all (98 percent) public community colleges currently offer remedial courses; the largest number of which are in mathematics and which account for 55 percent of all community college mathematics program enrollments.[59] In 2000, about 35 percent of community college freshmen were enrolled in a remedial course in mathematics.[60]

Leading P-12 Reform by Setting Higher Standards for Higher Education

The work of improving a state's system of mathematics and science education cannot succeed without the participation of leaders from its institutions of higher education. They must redesign the postsecondary education of all students — and of prospective teachers, in particular — with broad goals that:

- focus education on lifelong learning skills and attributes needed for a nation of learners;
- create content that is challenging, motivating, and relevant;
- encourage learning through more interaction and individualization;
- increase opportunities and access to education; and
- adapt objectives to specific outcomes and certifiable job-related skills.[61]

That redesign work will both serve and be served by participation in a P-16 council. As members of such a council, higher education leaders should take the following actions:

Directly support the mathematics and science education system reform work of the state's P-16 council by:

- designating senior administrators and faculty to work with the council;
- encouraging council participation of business school faculty, since their expertise in business practices could positively impact the organization, management, and work of the council;
- collaborating with the state department of education, school districts, schools, and teachers in council efforts to develop extended, school-specific professional development programs focused on the teaching and learning of the high-quality mathematics and science curricula — activities might include site-based or distance-learning experiences focused on teaching innovations, content knowledge, or scientific research methods;
- guiding council work with school districts seeking to

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provide induction and mentoring support for new mathematics and science teachers;
- fostering and supporting mathematics and science teacher performance evaluation systems calibrated with educational standards;
- assisting council efforts to better define, gather, and report data on P-16 system issues in mathematics and science education, such as teacher supply and demand, high school graduates' performance in entry-level courses, and postsecondary program completion rates;
- informing and supporting council efforts to increase the quantity and quality of P-12 teachers of mathematics and science;
- informing and supporting council efforts to increase minority groups' interest in and access to careers in mathematics and science, including teaching;
- integrating the training of teachers more fully within the science and liberal arts curricula, providing them with more interaction with non-education peers and faculty;
- developing programs for teachers that support them in their efforts to stay abreast of developments in their fields, including opportunities to work with mathematics, science, engineering, and technology faculty; and
- reforming the university's general education requirements to foster wider and deeper mathematics and science literacy for all university graduates.

Engage with business and P-12 education leaders in evaluating higher education's admission procedures and courses of study by:

- providing prospective students with detailed information regarding program admission standards and entry-level course expectations;
- seeking the experience of the business community in the review and restructuring of college programs to better prepare students for challenges of the changing workplace;
- providing cross-disciplinary mathematics and science courses and approaches to instruction that provide students with the integrated understanding of mathematics and science necessary to succeed in cross-disciplinary work environments; and
- articulating the mathematics and science knowledge and skills expected of high school graduates to begin non-remedial, credit-level work.

Raise the priority of developing highly qualified mathematics and science teachers to a central role in the mission of institutions of higher education by:

- requiring the collaboration of faculty from arts and sciences and teacher education with experienced P-12 teachers on all aspects of teacher preparation and professional development courses and programs: design; implementation; evaluation; and modification;
- adopting a mutually agreed upon set of stage-sequenced learning outcomes for mathematics and science teacher education students;
- recognizing and rewarding the teaching expertise of subject-area faculty who succeed in delivering content that is challenging, motivating, and relevant;
- supporting collaborative efforts between college faculty and P-12 teachers to identify and disseminate innovative practices in P-16 mathematics and science education such as inquiry-based approaches to teaching and learning;
- scheduling periodic reviews of the quality of teacher education programs by both a broad-based faculty group and an external commission;
- ensuring that all mathematics and science teacher education courses address the acquisition of content knowledge and the teaching skills required to teach to the new higher-level P-12 mathematics and science curricula;
- allocating the financial, human, and material resources that mathematics and science education programs require to prepare the quantity and quality of teachers that schools need — and, when necessary, reallocating limited resources to give priority to the high-need teaching fields of mathematics and science;
- producing not only majors in mathematics and science, but also graduates who are specialists in the teaching of elementary or middle school mathematics or science; and
- undertaking an initiative to increase the number of doctorates in mathematics and science education.

ACTION 4:

IMPLEMENT COORDINATED NATIONAL AND STATE PUBLIC INFORMATION PROGRAMS

An education system will not change for the better only because abundant evidence points to its poor performance. No combination of scholarly analysis, public outcry, or issue-by-issue tinkering with the system will produce significant and sustained improvement in the mathematical and scientific education of *all* of its students.

[No] issue-by-issue tinkering with the system will produce significant and sustained improvement… .

A system changes — improves — only as the result of informed and concerted actions of people, including both those who are responsible for developing and delivering the services of the system and those for whom the system is designed to serve — the students.

The BHEF believes that students — and their parents — must be convinced that high levels of mathematics and science education are not only accessible to all, but also that they are a requirement for a very broad range of desirable careers. Also, the public has yet to be convinced that mathematics and science are key to national security, economic prosperity, and social stability.

A COORDINATED TWO-TIERED CAMPAIGN

The BHEF proposes a sustained, five-year public information campaign to secure broad public commitment to strengthening the mathematics and science education of all students. It should be *designed by public information professionals* and be of the quality of that which altered the attitude and practices of the American public with regard to highway littering, a campaign with an icon as powerful as the anti-litter image of the weeping Native American.

The campaign must be a coordinated two-tiered effort that will drive home a common set of core messages at both the national and state levels. The national campaign — led by the business community — must cultivate an understanding of why the goal of ensuring that all students reach high standards in mathematics and science is both a top public priority for the nation and a top personal priority for students. State-level campaigns guided by P-16 councils should be designed to leverage the national effort by translating the broad national priorities expressed in the core messages into state priorities.

If successful, the coordinated campaigns will motivate all students to take full advantage of what their education systems offers; will prepare parents to assist their children in gaining full access to the educational opportunities available; and will stimulate improved performance in higher-level mathematics and science by all students.

Therefore, the BHEF proposes that:

1. The business community should lead a sustained, professionally designed national public information campaign to make mathematics and science education a public priority. It should commit to a minimum of a five-year program to help students and their parents to understand the nature and value of the mathematics and science education now being expected of all high school graduates. The program, designed around a small set of core messages, should engage all major media — newspapers, radio, and public and commercial television — in a coordinated and long-term campaign to "sell the product" through up-to-date information about the increasing relevance of the two subjects in the educational, economic, and civic life of all citizens.

The national campaign should serve as a model for state-level campaigns and should offer planning advice to designers of state-level campaigns. The business community needs to take the lead in this work because business has the required expertise. A business-led effort also would not be labeled "self-serving," whereas an education-led effort likely would, and business can proceed free of regulations on promotional activities that constrain education agencies.

2. State P-16 councils should initiate and guide statewide, professionally designed information campaigns to make mathematics and science education a public priority. A five-year state public information campaign should leverage the national model and tailor the national campaign's core messages to the state's P-12 content standards, employment opportunities in the state, and entry-level expectations of the state's postsecondary institutions. The campaign should document promising P-12 programs of mathematics and science education in the state, exemplary school leadership in improving mathematics and science education, and exemplary performances by students and teachers.

The state campaign should go beyond simply making students and parents *aware* of such issues as the adoption of higher standards at various levels of education; the need for academic planning beginning in the middle grades; the procedures and opportunities associated with going on to postsecondary education; and the educational expectations of employers. It should provide parents and students with clear, specific, upon-request information on these issues. The campaign should be linked to, and should serve advancement of, a state P-16 system of education.

Two Campaigns: One Set of Core Messages

The idea of a national information campaign addressing the need for improved mathematics and science education has been raised by the U.S. Department of Education (DOE). A committee of volunteers working with the DOE proposed that such a campaign must:

- make clear that the next generation needs greater knowledge of mathematics and science than was required of their parents;
- describe the benefits of mathematics- and science-oriented careers and of the need to prepare for them throughout school; and
- develop a realization that U. S. competitiveness in the global economy is dependent upon all students learning more mathematics and science.[62]

The BHEF supports these messages and seeks to incorporate them into its proposal for a national information campaign that is augmented with state-level, state-specific information campaigns.

The campaigns should be designed and executed in collaboration with the business community and professional organizations of mathematicians, scientists, and engineers. Businesses and government agencies also should work with educators in developing the messages, leveraging dissemination efforts, and coordinating the development of programs and materials with state standards and initiatives in mathematics and science.[63]

The national campaign should focus on a set of core messages to students and parents. In addition, because the details of mathematics and science education are determined by the states, state-by-state counterparts must localize and support the core messages of the national campaign.

The following are offered as examples of potential messages that will need review and refinement by public information specialists:

Core Message #1: America's economic preeminence, national security, and social stability are dependent on the mathematics and science abilities of its citizens. Low mathematics and science achievement of its students and decreases in its number of mathematics, science, and engineering professionals threaten the country's economy, security, and social structure. However, by raising the level of mathematics and science education of *all* students America has the capacity to generate new businesses, to create new well-paying jobs, and to increase the pace of overall economic growth.

- **America has a proven track record of "meeting the challenge."** Americans' sense of national pride, ambition, and inspiration has been instrumental in successfully meeting many education and technological innovation challenges. Those American characteristics fueled the prosperity boom that followed World War II, delivered victory in the "space race," and created the Information Age. And in every instance, America not only met the challenge, but also gained academic and economic strength in the process.
- **Mathematics and science education in the United States must change.** The education experienced by the current generation of U.S. adults is not good enough for its current generation of children. Their world of work will require more, and different, kinds of skills and knowledge.
- **High-level mathematics and science knowledge and skills are required for all postsecondary education and all post-high school jobs.**
- **Mathematics and science are tickets to rewarding challenges, to a great career, and to a stable economic future.**
- **Low-skill (or no-skill) jobs are disappearing.** Mathematics, science, and technology know-how have replaced hard work as the primary sources of workplace success. Those who simply work harder will lose to those who work smarter.
- **Current workplace requirements of employees include the acquisition of new mathematics, science, and technology skills.** Workers must be able to apply the knowledge they already have learned, and be prepared to learn the mathematics, science, and technology they need as the workplace changes.
- **Entry-level achievement scores in mathematics and science may be gatekeepers for advancement to higher-level positions.** In some work environments, entry-level achievement scores are used to determine which employees are provided training opportunities that open the door to in-house advancement.
- **Full participation in our democracy requires increased mathematics and science knowledge.** Civic and personal decisions regarding health, the environment, bioethics, spending priorities, retirement planning, etc., are demanding ever greater understanding of mathematics- and science-based issues.

Core Message #2: American students are competing globally for jobs. To be competitive, *all* students must be: better prepared in mathematics and science; held to the same high-level mathematics and science standards; and given the same opportunities to succeed in mathematics and science.

- ***All* students can learn more and higher level mathematics and science.** All students must believe that they can be successful in learning mathematics and science. Students in other cultures believe it and are successful.
- **Successfully completing a high-quality mathematics and science course of study is worth every student's efforts.** Mathematics and science courses require perseverance, but the payoff is large. High-paying, interesting jobs are available to those who make the commitment to succeeding in mathematics and science.
- **Students' concern about low or failing grades, a concern that often leads them to elect an academic program devoid of high-quality mathematics and science, must be replaced with an appreciation of the opportunities open to those who complete a high-quality mathematics and science curricula and with a willingness to do the work necessary to successfully master those curricula.** Particular efforts must be made to reach women and minorities with this message and, thereby, to increase their participation in mathematics and science.
- **It is a myth that mathematics and science are in a world unto themselves — a different culture — and therefore not accessible to everyone.** This two-culture view must be replaced with a view that mathematics and science are within reach of *all* students.
- ***All* students should complete high-quality curricula in mathematics and science that start in elementary school and continue through high school.** All students should have access to mathematics and science coursework that will prepare them for successful postsecondary study in higher education or the workplace. Failure to complete high-quality curricula closes doors now and in the future.
- **All educators must demand higher mathematics and science achievement of *all* students.** P-12 teachers, counselors, administrators, and higher education faculty and administrators must believe in and act on the idea that *all* students can attain higher level mathematics and science achievement.
- **Parents should insist that their child take mathematics and science every year.** Avoiding mathematics and science classes closes the door to postsecondary education and to interesting and well-paying jobs. Students cannot wait until after they

have entered college to take mathematics and science courses needed to fulfill their career aspirations. They must have a solid pre-college foundation in these subjects to succeed in college-level work or in the workplace.

- **Parents should guard against transferring their negative personal prejudices or feeling about mathematics and science.** Mathematics and science are subjects that can be challenging, but responding by working hard makes them doable. Parents should not provide, nor tolerate, excuses for poor performance in mathematics and science.
- **A college education is accessible to all students.** Resources are available in locating and applying for financial assistance.
- **Teachers, counselors, and administrators must know and provide information on the mathematics and science requirements for postsecondary education and employment.** They share the responsibility of providing parents and students with accurate information related to what must be accomplished in middle school and high school to prepare for postsecondary education and employment.
- **Students who are inadequately prepared in mathematics and science have a high probability of dropping out of college.** They also face higher costs because of the extra semesters needed to take remedial classes that don't "count" toward graduation requirements.

Core Message #3: Mathematics and science education for *all* students requires an overhaul and alignment of the entire system of education — content standards, curricula, student assessment, teacher quality, and system accountability — from pre-kindergarten through higher education. Random "acts of intervention" should be replaced with the implementation of a systemic plan of action.

- **A mismatch exists between high school exit requirements and college entrance and placement requirements.** Students need to be aware of these expectations gaps to ensure that their high school curricula prepare them for successful, remediation-free entrance into higher education.
- **Collaboration is needed between higher education and P-12.** The two-way learning and mutual respect that result from such collaboration benefits students throughout the P-16 system.
- **Teacher preparation must be at the center of the institutional agendas of colleges and universities.** The responsibility for preparing future teachers of mathematics and science must be shared across the campus and include the departments of education, mathematics, and the various sciences, as well as the college and university administrators at the highest levels.
- **Collaboration is needed between higher education and the state's teacher certification unit.** Improvements in the teacher preparation programs of institutions of higher education must be supported by the state's requirements for teacher certification.
- **Students have a responsibility for their mathematics and science education.** The P-16 system is required to offer every student the opportunities necessary to succeed. The student is required to invest the energies necessary to master high-quality curricula.

Core Message #4: Teachers are prime assets in the solution of the P-12 mathematics and science education crisis and are not the cause of the crisis.

- **The work of teachers needs to be much better understood.** Teachers today are dealing with increased responsibilities mandated by changes in society, in the characteristics and needs of students, and in the expectations established for public education.
- **The work of teachers needs to be publicly celebrated.** The negative attitude of society toward the profession must be reversed. Recognition programs for outstanding mathematics and science teachers, especially ones that carry financial awards, should be supported by business and higher education at the national, state, and local levels. Leaders from other professions must speak to the prestige of and respect for the teaching profession.
- **Mathematics and science teachers must be adequately compensated.** America's best and brightest will respond more favorably to a career in teaching if it is recognized as a respected and worthwhile profession. Compensation is one measure of a career's value. Salaries commensurate with other mathematics- and science-based professions must be promoted.
- **The teacher shortage that threatens the nation's capacity to provide all students with a highly qualified teacher of mathematics and science is growing.** The recruitment, preparation, retention, and professional development of mathematics and science teachers must be priority concerns for the government, business, higher education, and the general public.
- **Teachers need both instructional and professional resources.** Among the items that must be made available for teachers to do their work are: laboratory equipment and supplies; technology equipment; technology support services; student materials; telephones; office space; and Internet access.

Supporting and Tracking Implementation of the Plan

The BHEF commitment goes beyond words. During the next five years, it is committed to measuring and communicating the plan's progress. While BHEF must be prepared to commit energy and resources to the essential agenda, it also must measure progress and communicate it to the state leaders working on the agenda, to the public, to the media, and to policy leaders at every level.

The BHEF will establish a program to promote, monitor, and report the work of the states. The program will support efforts of state P-16 councils by gathering, organizing, and reporting data that will assist the councils in their decision making. In collaboration with the councils, and using data collected from them, it will track and report nationwide progress in the implementation of the plan's agenda.

Information collected and disseminated by the program might include:

- mathematics and science achievement trends by grade level to include NAEP and state data where available;
- updates on international comparisons in mathematics and science education;
- syntheses of national reports and research on mathematics and science standards and curriculum;
- course-taking trends;
- characteristics of and changes in assessment systems;
- descriptions of accountability systems;
- state-by-state information on the supply of and demand for mathematics and science teachers;
- effective programs to attract and maintain talented people into teaching mathematics and science;
- universities' activities to make teacher education central to the university;
- information on P-16 councils: leadership structure; focus of their programmatic work; accomplishments; future plans; and needs;
- policy actions at the state and national levels that affect mathematics and science education;
- summaries of information related to the implementation of the No Child Left Behind Act of 2001 (NCLB); and
- national media campaign information transmitted to the states to assist in state-level media campaigns.

The BHEF Handbook:

A Toolkit for Leaders of State-level P-16 Councils

To assist immediately the efforts of business, education, and policy leaders to implement the plan presented in this paper, the BHEF has developed the *Handbook for a Commitment to America's Future.* The Handbook provides P-16 council leaders with a toolkit of background information and proposed procedures for structuring and guiding implementation of BHEF's proposed action plan.

The Handbook expands the research foundation of the actions proposed here; provides experience-based guidelines for the structure and agenda of a P-16 council; examines the current state of efforts to improve the components of state education systems; suggests goals and procedures for coordinated and lasting improvement of state systems of mathematics and science education; and highlights effective projects and resources.

Among other things, the Handbook:

- details the case for the establishment of a P-16 system approach to improving P-12 mathematics and science education;
- outlines guidelines for organizing a P-16 council and proposes key elements of a council's work plan;
- provides information on the status of each of five interrelated education system components that affect the quality of students' performance in mathematics and science (student standards; curricula in mathematics and science; student assessment; teacher quality; and system accountability);
- recommends actions that P-16 councils should consider for improving each component and the interaction of those components;
- provides brief descriptions of projects and resources of probable interest to P-16 councils;
- outlines new directions and opportunities for the engagement of business and higher education communities in long-term, high-impact, system-wide efforts to improve the mathematics and science achievement of all students; and
- revisits the need for and dimensions of a public information campaign designed to gain sweeping public commitment to strengthening the mathematics and science education of all students.

Copies of the Handbook are available from the BHEF upon request. Please contact: info@bhef.com

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At its summer 2002 meeting, the Business-Higher Education Forum (BHEF) held major discussions on the growing concerns over the quality of U.S. technological and scientific workforce. While Forum members recognized the existence of many successful independent models to improve mathematics and science education in K-12, they were alarmed by the fact that these programs could not be offered to all children nationwide — a *sine qua non* condition for achieving system reform in mathematics and science education. At that meeting, the Forum launched the Mathematics and Science Education Initiative, led by a working group and co-chairs. *A Commitment to America's Future: Responding to the Crisis in Mathematics and Science Education* represents part of the outcome of this two-year project.

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