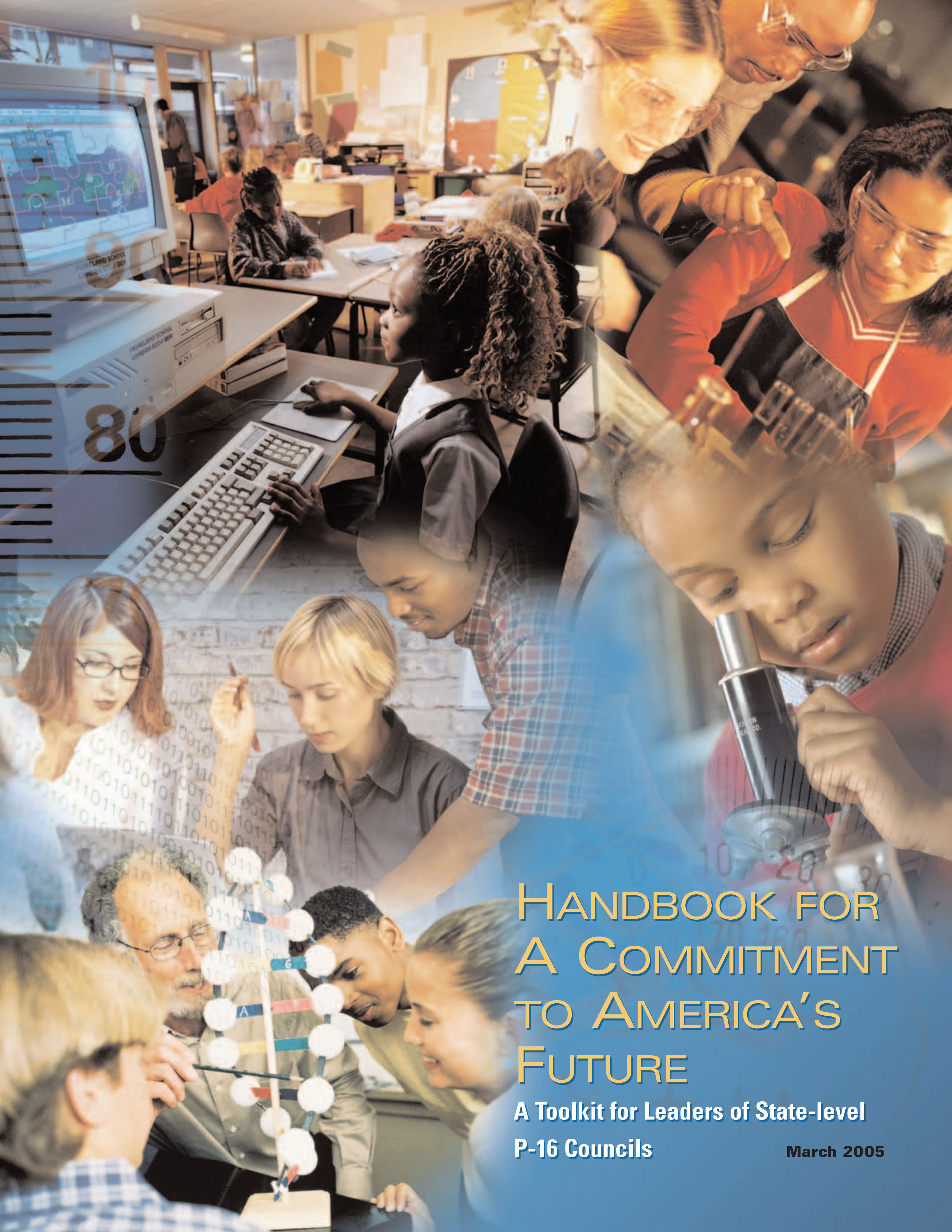

Handbook for A Commitment to America's Future

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

March 2005

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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. As a companion to its report, *A Commitment to American's Future: Responding to the Crisis in Mathematics and Science Education,* the BHEF presents this *Handbook for A Commitment to America's Future, A Toolkit for Leaders of State-level P-16 Councils,* which details their contributions.

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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Executive Summary

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In publishing the *Handbook for a Commitment to America's Future, A Toolkit for Leaders of State-level P-16 Councils,* the Business-Higher Education Forum (BHEF) details a four-part nationwide action plan to improve overall pre-kindergarten through high school (P-12) mathematics and science achievement in America through sweeping and coordinated changes in entire education systems.

The BHEF plan recognizes that a P-12 education system cannot improve itself by itself. New directions and improved performance in P-12 education is dependent upon corresponding new directions and improved performance in higher education. Higher education and the business community must join the P-12 community as equal partners in implementing a systems approach to improving P-12 education.

Specifically, 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 P-12 mathematics and science.

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).

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Educators in the P-12 community will find much of this *Handbook'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.

Business-Higher Education Forum Action Plan

The four actions of the BHEF plan are expressions of BHEF's belief that the improvement of P-12 mathematics and science education is a P-16 responsibility:

Action 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.

Action 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 student standards, curricula, student assessment, teacher quality, and accountability. 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 the policies and practices of higher education, business, and government.

Action 3: Engage business and higher education in more effective P-12 reform roles. Business needs to accept 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.

Action 4: Implement coordinated national and state-specific public information programs. These professionally designed programs need to 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.

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.

Handbook Outline

The BHEF has designed the *Handbook* for business, higher education, and policy leaders as a toolkit of background information and proposed procedures with which P-16 council leaders might structure and guide implementation of BHEF's four-part action plan. It provides a research foundation for the actions proposed, offers 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 eight sections of the *Handbook*:

- detail the case for the establishment of a P-16 system approach to improving P-12 mathematics and science education;
- outline guidelines for organizing a P-16 council and proposes key elements of a council's work plan;
- provide 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);
- recommend actions that P-16 councils should consider for improving each component and the interaction of those components;
- provide brief descriptions of projects and resources of probable interest to P-16 councils;
- outline 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
- revisit 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.

Chapter 1 (Leading System Change: Structure and Goals of a P-16 Council) presents the case for the establishment of a P-16 system approach to improving P-12 mathematics and science education. In particular, it outlines guidelines for organizing a P-16 governance structure — a P-16 council — and its work plan.

To guide the work of the council, Chapters 2-6 give information on the history and 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. This information serves as background for recommended actions that P-16 councils should consider for each component. New roles for business and higher education in leading and implementing council work are described in Chapter 7, and core messages of a public information campaign to build widespread support of council work are outlined in Chapter 8.

The underlying message of the *Handbook* is that the five system components described in Chapters 2-6 cannot be treated separately. Effective reform of mathematics and science education requires that the components be addressed as one *system*. To be successful, intervention in any component must anticipate and carry out related changes in the other four. While the *Handbook* highlights each component in a separate chapter, overlap in the research, discussions, examples, and recommendations of those chapters attest to the components' systemic interdependence.

Chapter 2 (P-12 Student Content Standards in Mathematics and Science) traces the emergence of standards — statements of what *all* students should know and be able to do — as the foundation of P-12 education in America. It examines the problems caused by disparities in the definition and implementation of content standards across states and across levels of education. The chapter's recommendations for actions by a P-16 council focus on the elimination of these disparities so that all students will be held to the same high standards and will be provided with the resources necessary to achieve those standards.

Chapter 3 (P-12 Curricula in Mathematics and Science) establishes the need for high-quality P-12 core curricula in mathematics and science for *all* students. The principal criterion for judging the quality of the core curricula is that they prepare all students for successful entry into higher education or the workplace. In guiding the selection and implementation of core curricula, leaders of P-16 education reform are urged to favor curricula that connect concepts both within and across areas of mathematics and science — connections that now are in high demand in both higher education and the workplace.

Chapter 4 (P-12 Student Assessment in Mathematics and Science) deals with a component of state systems of education currently undergoing considerable change, a direct result of the federal government's No Child Left Behind Act of 2001 (NCLB). Increased costs associated with expanding the size of state assessment programs, in terms of both the number of grade levels and students tested, are running up against shrinking state education budgets. States are grappling with the challenges of the alignment of tests and content standards and the comparability of assessment results across grade levels. Because of states' heavy dependence on test results in judging system performance, P-16 councils are urged to review carefully the quality of test data, the manner it which it is analyzed, and the uses to which it is put.

Chapter 5 (P-12 Teacher Quality) documents the central role of well-educated, highly committed, and well-supported teachers in the success of students. Based on the premise that effective mathematics and science education demands that every student have access to such teachers every year of his or her P-12 schooling, it presents the challenges of solving the current (and growing) supply and demand problems — that is, of attracting, preparing, and retaining highly qualified teachers. To address that challenge, P-16 council leaders are urged to take actions that will elevate teacher education as an institution-wide priority in higher education; elevate the quality of programs of teacher preparation and lifelong professional development; elevate support for the quality of the teaching environment; and elevate public perception and appreciation of the profession of teaching.

Chapter 6 (System Accountability) refocuses attention on the BHEF objective to improve the *system* of education. The chapter's title speaks to the need to hold the entire P-16 system accountable for P-12 students' performance in mathematics and science. Examining the growth of the concept of education accountability in America leads to the conclusion that an effective accountability system must hold the feet of all key education participants to the fire — government officials, college and university administrators, teacher educators, school leaders, teachers, and students. P-16 council leaders are urged to identify the accountability role of each category of participants; to gather relevant data with which to assess performance of each; and to urge each to accept responsibility for its role in ensuring the system's effectiveness in educating students.

Chapter 7 (Roles for Business and Higher Education) 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. Business is asked to increase its investment in such high-level activities while ensuring that its existing outreach efforts align with and support the school system's strategic plan for improvement. Higher education is asked to increase its involvement in activities that: support the reform work of the state's P-16 council; address higher education's admission procedures and courses of study; and raise teacher education to a central role in the mission of the institution.

Chapter 8 (Coordinated National and State Public Information Programs) discusses the need for a sustained, five-year public information programs to gain sweeping public commitment to strengthen the mathematics and science education of *all* students. The proposed campaign is a coordinated two-tiered effort that will stress a common set of core messages at both the national and state levels. State-level campaigns will leverage the national effort by translating broad national priorities for mathematics and science education into state-specific priorities. A set of core messages is offered for discussion with the understanding that professional public information specialists must design the overall information campaign and work with the education and business communities in the refinement and integration of the core messages.

Chapter 1.

Leading System Change: Structures and Goals of a P-16 Council

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The American Context for Education Reform

Since a national system of education does not exist in the United States, the American context for tackling the improvement of mathematics and science education is unique. Instead, the U. S. Constitution makes education the responsibility of each of 50 states, and those states must share that responsibility with a total of approximately 15,000 school districts.

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In addition, 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.

Until recently, efforts to improve education usually were efforts that addressed a single core aspect of an education system. In the late 1950s, for example, reform efforts focused on the retooling of the mathematics and science teacher workforce. In the 1960s, attention shifted to the design and introduction of new curricula in mathematics and science. By the 1970s, the spotlight had moved to nationwide testing. Most recent activity is directed at improving school and district accountability.

These stand-alone interventions have generated some change, but they have failed to improve the overall *system* of education. They are, in the words of Michael Fullan, author of *Change Forces: Probing the Depths of Educational Reform*, examples of "large-scale tinkering" that cannot be expected to repair a system, 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 reform a bad name." [1]

A Brief History of System Reform

Federal Initiation of P-12 System Reform

In the early 1990s, the National Science Foundation (NSF) undertook a bold initiative intended to improve entire state systems of mathematics and science education. During the course of its funding period, NSF's Statewide Systemic Initiative (SSI) program promoted a systems approach to improving P-12 mathematics and science education in 25 states and Puerto Rico.

The funds granted to a state were to support a five-year process that engaged state leaders in planning and implementing coordinated changes of nine system elements: P-12 student content standards; P-12 curricula; P-12 student assessment; teacher professional development; state education policies; P-16 partnerships; convergence of fiscal resources; equity in educational opportunities; and the gathering, interpretation, and use of data.

System reform was a learn-as-you-go process for all involved in the SSI program, including NSF itself. Since then, NSF and its grantees have grown in their understanding, conceptualization, and implementation of systemic reform of mathematics and science education.

A 1998 study of the SSIs noted accomplishments in classroom impact, instructional materials, teacher professional development, alignment of state policy, leveraging other funds, mobilizing stakeholders, development of a leadership pool, and understanding what works.[2] Collectively, the SSI project directors concluded that:

- no one best way exists to improve a system;
- coordination of a state's diverse efforts to improve education is essential to achieving coherence;
- quality control during implementation at the local level must be maintained;
- fundamental change takes time;
- all teachers in a system must be included in high-quality professional development;
- strategies must be developed to mobilize the higher education community that is responsible for the preservice education of teachers;
- community and parental support is essential;
- state assessments must provide data on achievement gaps between groups of traditionally underserved and their better-served peers; and
- accumulation and appropriate use of data on all aspects of system change must be improved and, in some cases, created.

Technical and Political Aspects of System Reform

In 2002, a Horizon Research report on the SSIs underscored two aspects of the strategic thinking necessary for planning and implementing an SSI — the technical strategy and the political strategy.[4]

"The technical strategy, which spans both the planning and implementation phases of the initiative, addresses specific elements of the system: teacher capacity; infrastructure for delivering assistance to schools and teachers; and policies related to curriculum standards, instructional materials adoption, and student assessment."[4]

The political strategy, which was new a new concept for some SSIs, includes some combination of the following:

- "involvement of important and influential individuals, groups, and organizations within the state mathematics and science education system and context;
- communications that allow the initiative to monitor the state context, disseminate information to key stakeholders, and to obtain timely input; and
- a plan to position the initiative as the voice for science and mathematics reform within the state."[5]

According to the Horizon study, most SSIs addressed the technical aspects of the project first, while few attended to political demands from the outset. In short order, however, each SSI was operating in a political environment where the political strategies were as important as the technical ones.

The directors of successful system reform efforts were those who learned how to forge new relationships with policymakers and with leaders at all levels of the state's education system; to made compromises on goals and procedures; and to adjust the technical strategies of the initiative.

The P-12/Postsecondary "Disconnect" in System Reform

Although funding for the SSI program has expired, the systemic approach to the reform of mathematics and science education continues at state and local levels. The collective experiences and studies generated by the SSI effort have had a major influence on the thinking and work of educational reformers.

The systemic, P-16 approach to improving mathematics and science education has gained widespread attention and acceptance by states and districts because it addresses the typical disconnect among component parts of the education system — a disconnect that is a major impediment to improving academic achievement for all students.

The Stanford University's Bridge Project has reported several characteristics of a disconnected system:[6]

- High school assessments stress knowledge and skills different from college entrance and placement requirements.
- Because of a difference in an underlying set of standards, a disconnect between high school and college coursework has occurred.
- Many students and parents do not know what is expected of students when they enter college.
- Data collection and analysis procedures are not designed to address issues across levels of the education system.
- No one is responsible for guiding reform of the overall P-16 system.

Research conducted for the Bridge Project has produced several recommended actions directed at properly connecting the P-12 and postsecondary segments of a P-16 system.

Consequences of the P-12/ Postsecondary Disconnect

The disconnect between P-12 and higher education causes many significant problems. Where postsecondary institutions have developed admission and placement standards without input from P-12 educators and policymakers, students fall into assessment and communication gaps.

Disconnected P-12/Postsecondary Assessment Goals

Two tests heavily relied upon by colleges and universities, the American College Test (ACT) and the Scholastic Aptitude Test (SAT), were not designed to align with new state P-12 standards. For nearly 50 years, the sole purpose of the SAT has been to measure student aptitudes — developed abilities that are inde-

Stanford University's Bridge Project: Connecting P-12 and Postsecondary Education

Stanford's Bridge Project, a six-year national study that began in 1996, sought to answer questions related to how states are developing K-16 reforms, such as: "What are the policy structures in place that support, assist, or confuse students, their parents, and K-12 educators? How are postsecondary education admissions standards and placement policies, as well as relevant state-level reforms, communicated to, and interpreted by K-12 stakeholders? Are there differences in how students receive and interpret those policies?"

The Project investigated these issues in regions of California, Illinois, Georgia, Maryland, Oregon, and Texas. Researchers interviewed state agencies and university and community college staff and faculty; talked with high school teachers, counselors, and administrators; surveyed high school students and their parents; and spoke with groups of high school students and community college students. The research highlighted a number of disconnections between high school and college that prohibit a smooth transition to postsecondary education and, for many students, terminate their aspirations for successful completion of postsecondary training.

In its report, *Betraying the College Dream: How Disconnected K-12 and Postsecondary Education Systems Undermine Student Aspirations,* the Bridge Project describes problems that exist in a K-16 system; provides context for why those problems exist; and offers recommendations to improve the system. The following three actions are identified as highly promising for initiating reform:

- "Provide all students, their parents, and educators with accurate, high-quality information about, and access to, courses that will help prepare students for college-level standards…
- Focus on the institutions that serve the majority of students. Shift media, policy, and research attention to include broad access to colleges and universities attended by the vast majority of students (approximately 80 percent)…
- Create awareness that getting into college is not the hardest part. Expand the focus of local, state, and federal programs from access to college to include success in college."

The Bridge Project
The Stanford Institute for Higher Education Research
http://www.stanford.edu/group/bridgeproject/

pendent of school experience — and to use those measures to predict success in college work.

However, the College Entrance Examination Board (CEEB) is developing a new version of the SAT — the New SAT — designed to serve a new purpose.[7] The New SAT will surpass the previous test's goal of predicting college success and instead aim to influence secondary school curricula. The CEEB also is making specific recommendations regarding what schools should teach: "The idea is that the test's rigorous new curricular demands will lift all boats — that all schools will improve because they want their students to do well on the test."[8]

Disconnects in Communicating With Traditionally Underserved Students

Minority, immigrant, and economically disadvantaged students who strive for good grades as the basis for college admission often do not realize that the admission decision depends heavily on the results of tests of which neither they nor their parents have knowledge — ACT, SAT, and college placement tests. Lack of clear communication about higher education's entry-level expectations of students and its use of placement tests designed without regard to P-12 standards and curricula adds to the cost and length of postsecondary education. Evidence of this is the high rates of enrollment in postsecondary remedial courses.

In the fall of 2000, 71 percent of America's degree-granting institutions offered an average of 2.5 remedial courses in mathematics.[9] The probable causes of extensive remediation and high college drop-out rates, rates that reach 50 percent in some university systems, point to shortcomings in academic counseling and information resources provided by high schools, and conflicting expectations of college entrance and placement assessments.[10]

Disconnected P-12/Postsecondary Expectations

And while this situation likely is exacerbated by mismatches between P-12 graduation standards and entry-level expectations of higher education, simply aligning those standards will not solve the problem. Expectations must be clearly communicated among all stakeholders — students, parents, teachers, secondary and higher education counselors, higher education faculty, and employers — and tied to policies that bind together the P-16 system.

Too often, the only attention given to these problems is finger pointing. Postsecondary institutions blame high schools for graduating poorly prepared students. High school administrators blame colleges for doing a poor job of preparing teachers. High school teachers blame elementary and middle schools for not preparing students for high school. In short, "everyone is to blame; no one is responsible."[11]

Refocusing System Reform: A P-16 Approach

State leaders are finding that a P-16 view of education is a logical way to unite standards-based instruction, new assessment programs, strong interest in accountability, and a systemic approach to reform.

According to the Education Commission of the States (ECS), "creating a more integrated, seamless education system involves grappling with a host of complex issues, including standards, testing, teacher education, college admissions policies, governance, funding streams and institutional turf issues, to name just a few. During the past decade, states have begun to move away from dealing with such issues on a piecemeal basis in favor of a more comprehensive approach."[12]

The most recent and widespread endorsement of the approach is found in the formation of a network of state and district K-16 or P-16 councils, the NASH/EdTrust State K-16 Network, whose long-term purpose is to promote the coordination of reform systemically across the different sectors of the education system.[13]

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.

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. However, the BHEF believes that the national imperative to improve mathematics and science education cannot be met by 50 wholly independent efforts.

While system change in America cannot be *national*, it can be *nationwide* — that is, state-by-state and collaborative. Specifically, the task demands a nationwide plan to promote the establishment of common new elements of state education infrastructures — P-16 councils — each with a 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.

Some Lessons Learned About System Reform

System-to-System Transplants: The Search for "What Works"

In 2002, the U.S. Department of Education (DOE) funded the What Works Clearinghouse (WWC) to encourage informed decision making in education. The goal of the Clearinghouse is to assist states, districts, and schools in sorting through the plethora of educational interventions — programs, practices, products, and policies — and sifting through the evidence of success associated with each.

Simply put, the WWC's task is to put claims about "what works" in education on a scientific footing. It is to "transform educational improvement into an evidence-based field by clearly establishing scientifically based research as a benchmark for determining the effectiveness of replicable educational interventions; making scientifically based research evidence more available to educators and policymakers; and encouraging its use by educators, researchers, policymakers, and the public."[14]

The WWC is focusing on research that examines those educational interventions that will improve student outcomes.[15] Its Evidence Reports are to be useful to decision makers in their efforts to determine whether specific interventions are appropriate for meeting the educational needs of their state or district.

WWC research review standards to be used in the preparation of the Evidence Reports have been approved by a team of nationally recognized methodology experts, and work has begun on three reports related to curriculum-based interventions for increasing K-12 mathematics achievement. A report on middle school mathematics' interventions will be followed by a report on elementary school interventions and, finally, high school interventions.

A Network of State K-16 Education Systems

The National Association of System Heads (NASH), an organization of chief executive officers of 52 public higher education systems across the United States, and The Education Trust, an organization that encourages higher education support of K-12 education reform, have collaborated to form The NASH/EdTrust State K-16 Network.

The Network supports interactions among 22 state organizations composed of public higher education, K-12, and civic leaders focused on statewide K-16 improvement strategies. It helps states build a common framework among higher education and K-12 leaders by creating a system-wide approach to education reform and by increasing the capacity of senior K-16 staff leaders to carry out the tasks of K-16 initiatives.

National Association of System Heads
and The Education Trust
NASH/EdTrust State K-16 Network
http://www2.edtrust.org/EdTrust/State+and+Local+K-16+Initiatives/nash.htm

How a P-16 system implements the work of improving mathematics and science education is as important as what it seeks to accomplish.

Avoiding Transplant Rejection: Making "What Worked" Work Again

The What Works Clearinghouse is, in fact, the What *Worked* Clearinghouse. Its contribution to education reform is in verifying that certain interventions have worked with some teachers and students in the educational context of some P-16 systems.

Although the WWC is careful to label those interventions as *potentially* replicable, decision makers who see the "What Works" in the Clearinghouse title, but miss the "potentially" in the small print of the Clearinghouse work plan, are likely to infer that WWC-researched programs are easily transportable from one system to another with a high probability of success. That infer-

How a system goes about the selection and adaptation of what has worked elsewhere is…critical to the successful capture of what worked.

ence would ignore the effects of each system's unique educational context and the array of local conditions that govern change.

The extent to which the local context shapes and controls educational change has been documented in system-change efforts focused on improving student outcomes. How a P-16 system implements the work of improving mathematics and science education is as important as what it seeks to accomplish.

Three decades of large-scale system reform efforts suggest that effective system-improvement work, like all politics, is local. Policies, programs, or practices that have been effective in improving one system *may* work in other systems, but they are not easily transported to other systems.

Different types of successful intervention efforts exist. Among them is GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs), an effort that began in 1998, and was designed to help students of low-income middle schools and high schools prepare to successfully pursue a college education. Its partnerships of businesses, K-12 education groups, colleges, and civic organizations provide students with the career guidance and extra academic support so often unavailable in those schools.[16]

The goals and activities of the Louis Stokes Alliance for Minority Participation (LSAMP) program are a natural exten-

What Has Worked: Targeting Low-Income Middle School and High School Students

The GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs) is a U.S. Department of Education (DOE) initiative designed to increase the number of low-income students who are prepared to enter and succeed in postsecondary education. Initiated in 1998, GEAR UP supports states and partnerships that coordinate the efforts of 370 institutions of higher education, 800 school districts, and more than 1,000 business, community, and non-profit organizations in their efforts to assist low-income students to prepare academically and financially to enter into and succeed in college.

Although not specifically aimed at increasing the participation of disadvantaged students in the science, technology, mathematics, and engineering (STEM) fields, GEAR UP strives to increase the overall number of low-income students prepared to succeed at the undergraduate level. In doing so, it has the potential to improve enrollment rates in these fields.

Nationwide, the GEAR UP program provides:

- a continuous system of mentoring, advising, counseling, and tutoring;
- information about higher education options, required academic courses, and financial aid;
- student access to rigorous courses that help prepare them for college;
- staff development for teachers, tutors, guidance counselors, and other school staff;
- organization of activities to foster parental involvement in preparing students for college;
- administration of skills assessments and provision of tutoring and other services to improve student achievement; and
- services specially designed for students of limited English proficiency.

GEAR UP grantees work with a cohort of students for several years, beginning no later than the seventh grade and continuing through high school. GEAR UP funds also are used to provide college scholarships to low-income students.

GEAR UP success stories are reported on the DOE GEAR UP web site: http://www.ed.gov/programs/gearup/index.html

U.S. Department of Education
Gaining Early Awareness and Readiness for
Undergraduate Programs

sion of GEAR UP. LSAMP targets minority students enrolled in science, technology, engineering, and mathematics (STEM) college programs, providing services to ensure their successful completion of baccalaureate work and their preparation for the workplace or graduate study.

The NSF has funded eight Curriculum Implementation Sites that offer states and districts assistance in choosing and implementing K-12 mathematics and science curriculum. The Implementation Sites differ in their content focus and program offerings, but all provide assistance on curriculum-related issues. (see Sidebar p. 17)

These several successful interventions are models of potential value to systems seeking to make similar improvements. Modification of their tested materials and practices can be simpler and less costly than the creation of new ones. How a system goes about the selection and adaptation of what has worked elsewhere is, however, critical to the successful capture of what worked.

The implementation of new curricula is perhaps the most widespread type of intervention effort. The experiences of curriculum implementation groups provide insight into the difficulties of making what has worked work again. Clearly, standards-based mathematics curricula that have been used by some teachers in some systems to improve some student outcomes to some degree do exist.[17] Some "model" mathematics curricula have been successfully implemented in several systems.[18, 19]

But regardless of the number of previous successful introductions of a given curriculum, each new adoption or adaptation requires a significant upfront investment of time to assess and address the context of change of the system seeking improvement.

Prior to launching the implementation of a curriculum, the system must establish the why and what of change; conduct detailed assessments of the current status of the system; build widespread commitment to proposed changes; examine possible

What Has Worked: Increasing Minority Participation in Science, Technology, Engineering, and Mathematics (STEM)

The Louis Stokes Alliance for Minority Participation (LSAMP) is a National Science Foundation (NSF) program aimed at increasing the quality and quantity of students successfully completing STEM baccalaureate degree programs and the number of students prepared for either graduate study or professional practice in STEM fields.

LSAMP supports the establishment of alliances composed of representatives from school systems, community colleges, colleges and universities, federal, state, and local government agencies, national laboratories and centers, industry, private foundations, and STEM professional organizations. These alliances develop projects that focus on improving the undergraduate educational experience and the transition students experience at critical decision points during their educational life: the transitions between high school and college; two- and four-year colleges; undergraduate study and the workplace; undergraduate study and graduate study; graduate study and non-academic employment; and graduate study and academic employment.

LSAMP activities include: recruitment activities initiated as early as the seventh grade; "bridge" programs for middle and high school students; college orientation programs for freshmen; mentoring and peer-support programs; supplemental instruction opportunities; research experiences; and career development activities including Graduate Record Exam (GRE) workshops and summer employment opportunities in industry.

LSAMP projects have also addressed undergraduate curriculum reform as a strategy for increasing the enrollment in STEM disciplines. The restructuring of undergraduate gatekeeper courses in calculus, chemistry, and physics included increased emphasis on collaborative learning, a non-competitive approach to problem solving, and workshops conducted by trained peer tutors and faculty members.

National Science Foundation
Louis Stokes Alliance for Minority
Participation Program

resources for achieving proposed changes; adapt selected resources to local conditions; build system leadership capacity for implementing change; and establish benchmarks for, and appropriate measures of, progress.

All of this is necessary so that members of the system become advocates, rather than victims, of change. The system also must commit to the long-term costs of sustaining and, over time, changing what has been changed. The improvement of mathematics and science education is an ongoing process, not an event.

Organizing for System Change: Guidelines for Leadership Councils

In 2000, the ECS reported on efforts by 24 states using 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."[20]

A P-16 system has many desirable inherent strengths,[21] among them:

- aligning goals at all levels and creating a learning environment that expects everyone to master challenging material;
- establishing a logical progression of standards and assessments, clear expectations, aligned curricula, and strong support services that lead to better academic performance and reduced needs for remediation at all levels; and
- highlighting artificial barriers, such as a confusing mix of P-12 exit examinations and requirements, college entrance examinations and requirements, and college-placement assessments, and drawing leaders together to address them.

When fully functional, a P-16 system is both efficient and effective because it can be expected to produce: collaboration between education professionals at all levels; alignment of standards and curriculum across levels; widespread parent, community, and student understanding of goals and expectations; significant reduction in the amount of postsecondary remedial work required; and lower dropout rates in both secondary schools and colleges.

Apropos to the conclusion regarding SSIs that no one "best way" exists to improve a system, states are undertaking P-16 reform using several different structures and starting points. However, 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 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.

Sustaining System Change: The Necessity of Business Leadership

Contrary to the word "Initiative" in the title of NSF's Statewide Systemic Initiative or SSI program, the program's goal was to go beyond initiating change. That is, its long-term goal was to build state infrastructure that would sustain system change. In this regard, collaborative involvement of policy and business leaders emerged as a critical strategy in system reform.

While states are active in legislating the improvement in mathematics and science education, good ideas and good intentions fall victim to changes in political leadership; to lack of a clear implementation strategy; to absence of a body charged with guiding execution and evaluation of changes; and to emerging opposition from groups affected by the legislation.

Laws are passed, but implementation fades away for lack of political commitment. The hard lesson is that "even more than most other policy issues, the process of building a standards-led education system does not end for policymakers when the ink on the policy dries."[22]

A National Education Goals Panel study of two states, North Carolina and Texas, in which statewide gains in mathematics scores were both significant and continuing, concluded that business leadership was a key factor in sustaining the states' successful reform work.[23] Establishment of a lasting reform infrastructure was the most important aspect of the initiatives in the two states.

In both states, system reform was initiated by governors who made education a high priority. However, both states subsequently experienced changes in the party affiliation of key office holders (including the governors). To ensure that improvement of education would remain a focus of debate and that reform initiatives would not succumb to election cycles, the business community funded and led business-education-policymaker coalitions that provided stable, persistent, and long-term direction to implementation of the system-change agenda.

In each state, the business community remained constant in its advocacy for education reform, achieving compromises with education leaders and enabling passage of necessary legislation. Therefore, despite changes in political leadership, ongoing support remained for key reform policies, such as content standards, standards-aligned assessment, and system accountability.

Experiences in North Carolina and Texas underscore the importance of the deep and sustained involvement of a small number of business leaders.[24] This 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. The task of these few is to engage the many in productive reform.

In its prescription for effective collaboration with business in system reform, the first two practices recommended by BHEF are:

- Involve as many different parties as possible. Make certain that representatives from public schools, colleges and universities, and business are present. Seek involvement by elected officials, community organizations, and unions, where possible.
- Involve the highest level of leadership: company executives, school superintendents and principals, and chancellors and presidents of colleges and universities.

Securing Public Support for System Reform: The Need for Sustained Communication of Core Messages

A recent conference sponsored by the DOE addressed the nature of core messages that might help the public understand why mathematics and science education matters. The conference affirmed the need for a broad-based national public information campaign to develop that understanding. It was proposed that a campaign to draw attention to the need for better mathematics and science education in the nation's schools 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

Leaders from business and higher education must commit to unique, expanded, and long-term roles in the work of the P-16 council.

- develop a realization that U. S. competitiveness in the global economy is dependent upon all students learning more mathematics and science.[25]

Following the conference, the DOE proposed that such a public awareness initiative be launched in collaboration with the business community and professional organizations of mathematicians, scientists, and engineers. Businesses and federal departments and 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.[26]

Recommendations For Structures and Goals of a P-16 Council

1. Each state should establish a P-16 education council to guide and support the development of a statewide system of policies, programs, and practices in the long term. P-16 council membership should have balanced representation from business, all levels of education, and state government. In particular, it 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.

The council should be charged with defining, benchmarking, and initiating a statewide P-16 plan to ensure that *all* P-12 students successfully complete a high-quality mathematics and science education. It should build consensus for, promote, implement, and monitor the P-16 system of statewide policies, programs, and practices. To facilitate statewide implementation, council structure might include affiliated regional councils engaged in tailoring policy implementation to local conditions.

Leaders from business and higher education must commit to unique, expanded, and long-term roles in the work of the P-16 council. In those roles, they must provide more effective support to P-12 educators in achieving system change.

Business must increase its investment in high-impact activities that are focused on P-16 system change and must 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, must place teacher preparation at the center of its mission and must 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.

2. Each state P-16 council should develop a plan for the coordinated improvement of five key system components[27] affecting P-12 mathematics and science education:

- P-12 student content standards in mathematics and science;
- P-12 curricula in mathematics and science;
- P-12 assessment in mathematics and science;
- P-12 teacher quality; and
- 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 outcomes.

3. Each state P-16 council should regularly report on the progress of system reform efforts in the state. Based upon data from a centralized state or district evaluation system, the council should report regularly to the state's policymakers, employers, system members, students, and the public on system-coordination projects and progress. The council should document and report 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. Reporting should use both existing media channels and special publications addressed to specific audiences to describe and evaluate the nature, value, and system-wide coherence of evolving content standards, curricula, student assessments, system accountability, and teacher quality.

4. Each state P-16 council should initiate and guide a statewide, professionally designed public information campaign to make mathematics and science education a public priority. A five-year state public information campaign should be professionally designed around a small set of core messages. The core messages should be tailored to fit 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 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; 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 the advancement of, a state P-16 system of education.

Sharing Curriculum That Has Worked: National Science Foundation's Curriculum Implementation Sites

The National Science Foundation's (NSF) Curriculum Implementation sites provide assistance to schools, teachers, administrators, parent groups, and other community members and constituencies interested in improving mathematics and science opportunities and experiences for all students. The Implementation Sites include:

- Mathematics Curriculum Center for K-12 Mathematics Curriculum;
- Show Me Center for Middle School Mathematics Curriculum;
- The ARC Center for Elementary School Mathematics Curriculum;
- Compass for Secondary School Mathematics Curriculum;
- CESAME for K-12 Mathematics and Science Curriculum;
- EDC K-12 Science Curriculum Dissemination Center for K-12 Science Curriculum;
- Science Curriculum Implementation (SCI) Center at BSCS for High School Science Curricula; and
- LASER Center for K-8 Science Curriculum.

National Science Foundation
Curriculum Implementation Sites
http://www.ehr.nsf.gov/esie/resources/impsites.asp

Chapter 2.

P-12 Student Content Standards in Mathematics and Science

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National Models for State P-12 Content Standards

The setting of standards for what P-12 students should know and be able to do in mathematics and science began in earnest in 1989 with the release of the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics*[28] and the American Association for the Advancement of Science's (AAAS) release of *Science for All Americans*.[29]

The NCTM document set standards for what mathematics should be taught and how student performance should be measured. The AAAS document defined the meaning of scientific literacy for high school graduates.

During the next decade, the mathematics and science communities continued to refine, revise, and expand their standards-setting efforts.

In 1996, the National Research Council (NRC) published the

A Look at K-12 Science Standards

The National Science Education Standards (NSES), published by the National Research Council (NRC) in 1996, go beyond defining the knowledge and skills that students should acquire. The NSES encompass an array of issues that together define what it will take to create a scientifically literate population. Six related sets of standards address the requirements for delivering a system of science education.

1. Standards for Science Teaching: Outlines what teachers of science at all grade levels should know and be able to do.
2. Standards for Professional Development for Teachers of Science: Presents a vision for the development of professional knowledge and skill among teachers.
3. Standards for Assessment in Science Education: Provides criteria against which to judge the quality of assessment practices.
4. Standards for Science Content: Outlines what students should know, understand, and be able to do in the natural sciences during the course of K-12 education.
5. Standards for Science Education Programs: Describes the conditions necessary for quality school science programs.
6. Standards for Science Education Systems: Identifies criteria for judging the performance of the overall science education system.

National Research Council, 1996
National Science Education Standards
http://www.nap.edu/readingroom/books/nses/

A Look at K-12 Mathematics Standards

Principles and Standards for School Mathematics, published by the National Council of Teachers of Mathematics (NCTM) in 2000, describes six principles governing a high-quality mathematics education and details the mathematical content and processes that students should learn. The six principles for school mathematics that "reflect basic perspectives on which educators should base decisions that affect school mathematics" are:

1. The Equity Principle: Excellence in mathematics education requires equity — that is, high expectations and strong support for all students.
2. The Curriculum Principle: A curriculum is more than a collection of activities. It must be coherent, focused on important mathematics, and well articulated across the grades.
3. The Teaching Principle: Effective mathematics teaching requires understanding what students know and need to learn, and then challenging and supporting them to learn it well.
4. The Learning Principle: Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.
5. The Assessment Principle: Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.
6. The Technology Principle: Technology is essential in teaching and learning mathematics. It influences the mathematics that is taught and enhances students' learning.

The standards for school mathematics describe the mathematical understanding, knowledge, and skills that each student should acquire in each of four grade bands: P-2, 3-5, 6-8, and 9-12.The content standards — Number and Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability — are addressed in all grade bands, but the emphasis given to a particular standard varies across the grade bands.

National Council of Teachers of Mathematics, 2000
Principles and Standards for School Mathematics
http://standards.nctm.org/document/index.htm

National Science Education Standards (NSES)[30] which proposed sets of standards in six related areas of school science: P-12 science content; procedures for teaching that content; professional development of teachers; student assessment; P-12 science curricula; and science program and system strategies.

In 2000, the NCTM revisited its standards-setting efforts and published the *Principles and Standards for School Mathematics*[31] to address P-12 mathematics content, instruction, and assessment standards.

The NCTM and NSES standards are not a national curriculum. Rather, they represent the best thinking of what mathematics and science skills and knowledge students will need to function in the 21st century.

Standards Versus Standardization

Adoption of *standards* for mathematics and science education should not be confused with *standardization* of mathematics and science education. Standardization, the mandating of a single, rigorous set of national student-performance expectations at each grade level and use of a single set of curriculum materials in all schools, recently has been challenged by education leaders in countries that have a standardized national curriculum and that have consistently outscored the United States on international assessments of school mathematics and science.

In particular, the Japanese Ministry of Education has expressed concern that its curriculum in mathematics has suppressed independent thinking and creativity in problem solving, and has created student stress rooted in fear of failure. As a result, less than one in four older students reported that they enjoyed school.[32]

Such national standardization is not a concern in the United States, since the U.S. Constitution delegates primary responsibility for education to the states. It therefore disallows the imposition of a national curriculum for mathematics and science education.

The NCTM and NSES standards are not a national curriculum. Rather, they represent the best thinking of what mathematics and science skills and knowledge students will need to function in the 21st century. However, they have been widely accepted as starting points by states and districts as they have developed their standards and curricula.

The Status of Content Standards in the States

Adoption of Content Standards by the States

Passage of the No Child Left Behind (NCLB) Act of 2001[33] reinforced the need for state standards in the process of raising achievement levels of *all* students.

Because of the high mobility of American families, educators and policymakers charged with setting state-specific standards in mathematics and science voluntarily drew from the model standards developed by the NCTM and the NSES. While states have adapted those models to meet local expectations and resources, the resulting standards have considerable portability from state to state.

As of 2003, 49 states had adopted state-level standards in mathematics; 46 states had adopted state-level standards in science, and three others had science standards under development.[34] For each state, the development of content standards for students has been the first step in defining what has become known as the state's *intended curriculum* — the mathematics and science that the state wants all students to learn.

Content standards are the basis for describing what will be taught to all students year-by-year; how it will be taught; what materials will be used in instruction; how teachers will be prepared to teach it; professional development of teachers; student assessment; coherent P-12 science curricula; program and system strategies; and how student progress will be measured. Recognizing the need for standards to evolve in response both to research findings on teaching and learning and to the changing expectations of higher education and the workplace, most states have established five-year cycles for reviewing and updating their standards.

Variability in State Standards and in Their Implementation

Although establishment of content standards is widespread and strongly supported by educators, business leaders, and the public, estimates of the mathematics and science curricula intended by those standards varies from state to state. Evaluations of states' standards are conducted and reported on regularly by several institutions.

In 2003, evaluations showed that the majority of state mathematics and science standards are "clear, specific, and grounded in content."[35] However, a second 2003 evaluation revealed that although the clarity of state standards had risen during the preceding five years, and had become more measurable, specific, and precise, few states had made their standards significantly more challenging. The evaluation stated that "more disturbingly, they remain less rigorous than the expectation routinely set for students in the highest-performing nations."[36]

A 2004 study of 30 state education systems conducted by the Fordham Foundation included the evaluation of academic standards in mathematics and reading, assessments, and accountability policies.[37] State standards were rated on intelligibility and coverage against a set of "reference standards" developed by an independent contractor.[38] The reference standards defined and prioritized mathematics skills appropriate for students in late elementary, late middle school, and the middle of high school. The overall rating for mathematics standards for the 30 states is only fair.

In 1999, the Third International Mathematics and Science Study (TIMSS)[39] revealed a decline in U.S. student performance in mathematics from grade four to grade eight, a decline that continued through high school. In the same year, Achieve, Inc., initiated the Mathematics Achievement Partnership (MAP) which has developed a set of middle-school mathematics standards benchmarked to the best international and state standards available.

Fourteen states now are working with MAP to reverse the TIMSS performance slide by adopting and implementing middle school mathematics standards that are benchmarked to international standards.

The Trends in International Mathematics and Science Study (successor to the Third International Mathematics and Science Study and called TIMSS 2003) reported positive comparisons of the mathematics and science performances of U.S. fourth and eighth grade students from 1995 to 2003.

- **Mathematics.** U.S. students continued to score above the international average at grade four; the U.S. average score was higher than 13 of the 25 countries participating at grade four. Scores improved at grade eight, where only eight of the 48 countries participating at grade eight had scores higher than the United States. African-American students showed improvement at both grade levels; at

Two decades of rising expectations regarding what all students should know and be able to do in mathematics and science have resulted in changes in the course-taking patterns of high school students. Those changes have become public policy as states have legislated increased graduation requirements in mathematics and science.

grade eight, they closed the gap with white students by 20 points (from 97 to 77).[40]

- **Science.** U.S. student scored above the national average in science at both grades four and eight. Because U.S. average score in science for grade four did not improve since 1995, the U.S. slipped in the international ranking as the scores of the other countries did rise. The average score of students at grade eight did improve, and both African-American and Hispanic students closed the performance gap with whites at grade eight.[41]

Foundations for Success: Mathematics Expectations for the Middle Grades[42] articulates a set of content expectations for the end of eighth grade that incorporates the learning expectation and objectives of high-performing nations. In addition, MAP is developing professional development, curriculum, and assessment tools based on the skills and knowledge described in *Foundations for Success.*

Even where state or district standards clearly describe expectations for high-quality curricula in mathematics and science, implementation falls short of intent. The *implemented curriculum*, the mathematics and science that is *actually* taught in P-12 classrooms, often is uneven within a state. States and districts often have not translated the expectations of the standards into year-by-year specifications of what should be taught and how it should be taught. Effective implementation also lags because of the absence of coherent teacher preparation programs and professional development experiences that prepare teachers to help students achieve the higher standards.

Schools in areas with high poverty and with the highest concentrations of minority students are victims of even greater inequities in the implementation of high-quality standards. While studies suggest that students learn more from experienced teachers than from less experienced ones, students in areas of high poverty have higher rates of inexperienced teachers (double the proportion of inexperienced teachers compared to schools with lowest poverty and lowest concentrations of minority students).

Research also suggests that student learning is enhanced by computers when the computer is used to teach discrete skills. However, for schools with high concentrations of low-income families, only 39 percent of classrooms had Internet access compared with 62 percent to 74 percent in schools with a lower concentration of poverty.[43]

Standards and High School Course Taking

Two decades of rising expectations regarding what all students should know and be able to do in mathematics and science have resulted in changes in the course-taking patterns of high school students. Those changes have become public policy as states have legislated increased graduation requirements in mathematics and science.

As of 2000, 26 states required 2.5 to four courses (years) in high school mathematics, and 20 states required 2.5 to four courses (years) in high school science. During the decade from 1990 to 2000, the number of students nationwide taking three courses in high school mathematics increased from 49 percent to 62 percent, and the number taking three courses in high school science increased from 45 percent to 54 percent.[44]

The ACT publication, *Crisis at the Core: Preparing All Students for College and Work*, reported on the benefits of increasing both the number and the quality of the mathematics and science courses all high school students should take to ensure their successful transition to higher education or to the workplace.[45] At first glance, data gathered in 2004 appeared to undermine ACT claims of academic benefits. The data showed that the percent of ACT-tested high school students reaching the college algebra benchmark score was the same (13 percent) for two groups: those students who had completed the three courses of what has been the ACT-recommended core curriculum (Algebra 1, Algebra 2, geometry); and those students who had completed less than three mathematics courses.[46]

However, the data from 2004 also showed that when students take one or more advanced mathematics courses beyond Algebra 2 as well as Biology, Chemistry, and Physics, "they all benefit, regardless of achievement level, and are much better prepared for college and work."[47] ACT calls not only for a refinement of the core curriculum to include one or more advanced mathematics courses beyond Algebra 2 as well as Biology, Chemistry, and Physics, but also for a requirement that all students take this new core curriculum to better prepare for the rigors of postsecondary education or the high-level skill requirements of the workplace.

Other course-taking studies indicated that completion of advanced high school courses — in mathematics, at least — are positively related to future achievement and income. The federally conducted *High School & Beyond Survey* concluded that students finishing a course beyond the level of Algebra 2, and subsequently entering postsecondary education, were more than twice as likely to complete a bachelor's degree as were students who stopped short of Algebra 2.[48]

Data from the *National Educational Longitudinal Survey* relating course completion in mathematics to future income revealed that more than 50 percent of the workers earning more than $40,000 a year had two or more credits at or above the level of Algebra 2 level. By comparison, only 27 percent of workers earning $25,000 to $40,000 annually and 20 percent of those at the bottom of the earnings distribution had two or more credits at the level of Algebra 2 or above.[49]

Higher Standards Versus The *Same* Higher Standards for *All* Students

Higher Standards for *All* Students: The Achievement Disconnect Among Student Groups

According to the 2003 National Assessment of Educational Progress (NAEP), sometimes called the Nation's Report Card, the percentage of students performing at or above Proficient in mathematics, the level that all students should reach, was 32 percent at grade 4, and 29 percent at grade eight. Both percentages were increases over the year 2000 NAEP results. No significant difference exists between the average scores of male and female fourth and eighth graders. Significant increases in average mathematics scores were noted for white, African-American, and Hispanic subgroups at grade four and grade eight during the same time period.

…America must commit to an education system that sets high expectations for all of its students — African-American, Asian-American, Hispanic, Native American, and white.

However, while the score gaps between white and African-American students for both grades four and eight decreased significantly as did the score gap between white and Hispanic students for grade four, the differences remain large.[50]

A review of the percentage of student at or above the level of Proficient in mathematics by race and ethnicity unmasks the shocking disparity in the delivery and success of the American education system. In 2003, in grade four, the level of mathematical proficiently was attained by 43 percent of white students, 16 percent of Hispanic students, and 10 percent of African-American students. For grade eight, proficiency was attained by 37 percent of white students, 12 percent of Hispanic students, and only seven percent of African-American students.

These achievement gaps bode poorly for America's future, a future that depends on a highly skilled workforce drawn from a population that is increasingly non-white and historically underserved by the American education system. America's education system must meet the needs of *all* students, providing them with the skills and knowledge to become productive citizens.

Underlying the discussions and recommendations of this handbook is a core belief that America must commit to an education system that sets high expectations for all of its students — African-American, Asian-American, Hispanic, Native American, and white. That commitment must be coupled with a pledge to provide the education system with the resources and support necessary to bring *all* students to the high standards that have been set for them.

Higher Standards for *All* Students: The Disconnect Within Education

Unfortunately, a lack of understanding prevails about the importance of higher mathematics and science for *all* students. Many parents and students are ill-informed about the knowledge and skills needed to succeed at the postsecondary level and in today's workplace.

Widespread commitment to the notion that simple reading, writing, and calculating are still necessary and sufficient basic skills persists. However, the contemporary goal of having all students become self-sustaining, lifelong learners requires an education system that teaches all students to think and read critically; to communicate clearly and persuasively; and to apply knowledge to solve complex problems in mathematics and science.[51]

Part of the responsibility for parents' and students' confusion with respect to postsecondary education is a consequence of what the Consortium for Policy Research in Education (CPRE) refers to as "a profound disjuncture between K-12 and postsecondary education — two systems that often act independently and at cross-purposes from one another."[52]

In a 1999 survey of college presidents and corporate leaders,[53] higher education leaders reported that fewer than half of their institutions had changed curricula or admissions procedures to reflect new state K-12 standards and assessments.

But if higher education has failed to increase its involvement with statewide reform of K-12 content standards, neither has it been invited to do so. CPRE found that states develop K-12 standards and assessments aimed at improving K-12 education, but that work usually has been done without input from postsecondary faculty.

A dialogue between high school and postsecondary faculty on what students should know and be able to do must take place to align college admissions policies and placement exams with K-12 graduation standards and assessments. The Association of American Universities (AAU) in collaboration with The Pew Charitable Trusts has initiated this work with a project called Standards for Success (S4S).

A recent S4S report, *The Knowledge and Skills for University Success*, outlines what students must know and be able to do in mathematics and science to succeed in entry-level university courses.[54] An analysis of the content of 31 high school exit exams in mathematics from 20 state tests found no test that was well-aligned with AAU entry-level course expectations in any one of four skill areas: algebra, geometry, trigonometry, or statistics.

S4S is an effort to increase the alignment between what state K-12 systems are doing and what universities are expecting In addition to articulating specific content knowledge and skill standards required for university success, the project has compiled a library of work samples and syllabi that illustrate the quality of work that AAU-university professors expect of college freshmen.

The S4S study concluded: "States that have high-stakes high school tests should undertake more detailed content analyses to determine how well the state's academic content standards, particularly at the exit level, align with college success standards. *The Knowledge and Skills for University Success* produced by S4S offers a good starting point for such an investigation."[55]

In 2004, with its publication of *Ready or Not: Creating a High School Diploma That Counts*,[56] The American Diploma Project (ADP) called on state policymakers to revisit and update their state standards to ensure that high school graduates acquire the skills and knowledge necessary to succeed in postsecondary education or in high-performance, high-growth jobs.

To facilitate this effort, ADP worked with education and business leaders in five states to identify the mathematics and English skills and knowledge — the ADP Benchmarks — required for the real world beyond high school. These benchmarks are augmented with actual workplace tasks and postsecondary assignments that illustrate the practical application of the benchmarks beyond the high school classroom. States may use the Benchmarks to determine the degree of alignment between their standards and the requirements of postsecondary employment and education; to redefine their default curriculum to ensure that all students succeed in their postsecondary endeavors; and to review the content of the courses in the core curriculum.

Higher Standards for *All* Students: The Disconnect Between Education and Business

As worthy as the AAU effort is, it is limited to resolving the disconnect between graduation standards of K-12 education and entry-level expectations of postsecondary education (where "postsecondary education" is equated with "college education").

Indeed, most Americans believe that college entrance requirements are the highest standards to which a K-12 education can be directed. Properly viewed, however, the expectations of the postsecondary segment of a P-16 education system also include the entry-level expectations of the business community, and it has been argued that the academic skills required by many entry-level jobs are higher than those required for college.

ADP's *Ready or Not: Creating a High School Diploma That Counts* presents actual workplace tasks to illustrate the English and mathematics knowledge and skills necessary for success in a variety of fast-growing occupations. It maps these requirements back to the Benchmarks it has identified as essential to a core curriculum. A review of these Benchmarks reveals that they are more demanding than existing state graduation tests or core curriculum requirements.[57]

Workplace expectations go beyond technological skills to include workers' "ability to communicate effectively, access and apply work environments, and work across the organization in teams."[58] At present, "the majority of [college] students are severely lacking in flexible skills and attributes." Among them are problem solving, analytical thinking, and basic communications (speaking, listening, and writing).[59]

Anticipated educational demands of jobs in the future include integrated knowledge of mathematics and science and skill in applying knowledge to solve real-world problems, while at the same time, colleges persist in teaching science and mathematics as a collection of discrete subjects. It follows that teachers are not experiencing integrated, contextualized education in science and mathematics in their college programs and, therefore, are unprepared to provide such experiences for P-12 students.[60]

Giving Additional Meaning to "... and Be Able to Do"

The phrase "content standards" generally is equated with "statements of what all students should know and be able to do" at a particular grade level in particular subject area. In the case of mathematics and science, the "and be able to do" conditions has referred to the requirement that students perform very specific tasks such as multiplying two two-digit numbers.

Today, the "and be able to do" condition has acquired additional meaning. Students now are expected to demonstrate that they can apply what they have learned to new problems and in new settings.

According to a study of learning by the NRC, this requirement to flexibly transfer what has been learned to new situations is not a form of learning that is supported by rote memorizing of facts or performance of procedures in a single context.

Results of a comparison of mathematical literacy and problem solving performances of 15-year-olds in 39 countries conducted by the Program for International Student Assessment (PISA) were released in late 2004.[61] Mathematics literacy scores of U.S. students, 61 percent of whom were in grade 10, were significantly below those of students from 24 of the participating countries. In problem solving, U.S. students' scores were significantly lower than their peers in 25 countries.[62]

Performance in problem solving also was described in terms of proficiency levels from 6 to 1, with level 6 being the highest. The best U.S. students (12 percent) achieved level 3; 24 percent were at level 1, and 34 percent were below level 1.[63]

American newspapers that interpreted the PISA results as evidence of poor U.S. student "math skills" failed to identify and report the unique nature of PISA assessment. PISA uses the term "mathematics literacy" to denote a focus on the application of mathematical knowledge and skills.[64] Also, PISA defines "problem solving" as "an individual's capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution is not immediately obvious, and where the literacy domains or curricular areas that might be applicable are not within a single domain of mathematics, science, or reading."[65]

In short, the PISA emphasis is on what students are able to do with the mathematics and science that they have learned. Thus, the greater significance of the PISA results is that they reveal that American 15-year-olds are in an international cellar with respect to a demonstrated ability to draw upon mathematics knowledge and skills that have been learned in the context of textbook exercises and to apply them in new situations.

According to a study of learning by the NRC, this requirement to flexibly transfer what has been learned to new situations is not a form of learning that is supported by rote memorizing of facts or performance of procedures in a single context.[66] Rather, it requires a balance of specific examples and general principles.

Students must be challenged by similar, but different, cases of a problem; must engage in "what-if" problem solving; must generalize learnings; and must build the language needed to represent problems at increasingly higher levels of abstraction (pictures, tables, graphs, equations). Doing mathematics also takes the form of tasks in "document literacy" in which students are expected to extract information from such representations when they appear in the context of job applications, manuals, payroll forms, maps, operation diagrams, and survey results.[67]

However, a 1998 study of 14,000 Ohio high school seniors reveals evidence that this general "application" standard is not being met at the K-12 level.[68] Student performances on tests from the WorkKeys assessment package[69] indicated that seniors' preparation fell short on applied skills in mathematics, technology, and locating information expected in the workplace.

ACT test performances and the course-taking patterns of college-bound high school students aspiring to careers in the health sciences also serve as an indicator of the K-12/workplace standards mismatch.[70]

Recommendations For P-12 Student Content Standards in Mathematics and Science

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

Careers in the Health Sciences: Demand, Aspiration, and Preparation

The health sciences — medicine, nursing, dentistry, optometry, and pharmacy — are an expanding area of employment opportunity. U. S. Department of Labor projections for the year 2010 place registered nurses in the list of the 10 occupations with numerically largest job growth opportunities (an increase of 561,000 jobs or 26 percent growth), and lists medical assistants among the 10 occupations with the fastest job growth demand (an increase of 187,000 jobs or 57 percent growth).[71] Also, by 2020, the number of pharmacists needed will more than double to about 400,000.[72] In short, the *demand* is high.

Student *aspiration* to enter a health sciences career also is high. The health sciences area was the top choice of a college major among students taking the American College Test (ACT) in 2003. However, students' ACT scores in mathematics and science and their high school course-taking patterns were odds with their aspirations.

While the average composite ACT score for 2003 was the same as in 2002 — and is a score that would satisfy the general admissions standards of many institutions of higher education — only 25 percent of the 2003 test takers had ACT Science Test scores, and only 40 percent had ACT Mathematics Test scores, consistent with a high probability of achieving a grade of C or better in entry-level college mathematics and science courses (algebra and biology) required by health sciences programs. In addition, only 45 percent of the test takers had completed the ACT-recommended three or more years of high school science, and only 39 percent had completed the recommended four or more years of mathematics.

Therefore, although students' composite ACT test scores and course selections in high school may meet colleges' general admissions requirements, students' *preparation* in mathematics and science often falls short of program expectations of specific careers those students aspire to enter. The door to college is open, but the door to the desired career is not.

ACT, Inc., 2003
"College Bound Student's Academic
Skills at Odds with Career Plans"
http://www.act.org/news/releases/2003/8-20a-03.html

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.

Ohio's K-12/Workplace Skills Gap

A 1998 study conducted jointly by the Ohio Business Roundtable and the Ohio Department of Education tested more than 14,000 high school seniors in three skill areas (Applied Mathematics, Applied Technology, Locating Information) using the WorkKeys assessment package. The Applied Mathematics test provided a list of relevant formulas and permitted the use of calculators to solve multiple-step problems requiring the application of written and visual information.

Items of the Applied Technology test required students to apply basic principles of science and to interpret the interaction of complex physical systems. The Locating Information test called for interpreting and applying information from diagrams, tables, charts, graphs, forms, and instrument gauges, skills judged to be workplace reading competencies.

WorkKeys' student performances in these skill areas were matched with entry-level skill expectations of 80 percent of the jobs in a Technical Job Cluster (for example, auto mechanic, machinist, electrician, refrigeration mechanic, plastics fabricator, robotic machine operator) and a Science Job Cluster (for example, electrical or industrial engineer, OSHA inspector, nurse, avionics technician, surgical technician).

Of the students tested, 81 percent met the Applied Mathematics standard for 80 percent of the jobs in the Technical Cluster; 27 percent met that standard in the Science Cluster. In Applied Technology, four percent met the standard for the Technical Cluster, and zero percent met the standard for the Science Cluster. For Locating Information, the figures were 19 percent (Technical Cluster) and zero percent (Science Cluster).

Ohio Business Roundtable, 1998
Knowledge & Know-How: Meeting Ohio's Skill Gap Challenge

Chapter 3.

P-12 Curricula in

Mathematics and Science

Chapter 3.

P-12 Curricula in Mathematics and Science

High-Quality Coursework for *All* Students

Curricula and Standards: A Many-To-One Relationship

State and school district P-12 content standards describe the knowledge and skills that all students should acquire. They are the building blocks of an intended curriculum, of what should be taught, but they are not a curriculum.

The NSES define a K-12 science curriculum as "the way the content of the standards is organized and presented in the classroom."[73] The NCTM describes a P-12 mathematics curriculum in terms of grade-band structures of important mathematical ideas that are always "moving on," the goal being that "students will reach certain levels of conceptual understanding and procedural proficiency by certain points in the curriculum."[74]

High-quality default curricula in mathematics and science are not to be offered for election by some students. They are to be expected *of all students. Students may choose to do more, but they will not be permitted to do less.*

Because there are many possible variations in the organization, points of view, and relative importance given to the content, any given set of standards can be expressed as several very different curricula, each supported by a different array of instructional materials.

Expecting More of Students: A Better — and Fairer — Policy

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.[75] Conversely, students of all abilities are more likely to fail low-level courses.

The single best predictor of college success is "the quality and intensity of the student's high school courses," particularly in mathematics where the completion of courses beyond Algebra 2 can double the probability of earning a college degree.[76]

College graduation rates of minority students who pursue a strong high school curriculum rise dramatically, from 45 percent for all African-Americans entering college to 73 percent for those

…a college and workplace readiness curriculum should be a graduation requirement, not an option, for all high school students.

African-Americans who completed a strong secondary school curriculum. For Hispanics, the proportion jumps from 61 percent for all Hispanic freshmen to 79 percent for those who completed a rigorous high school curriculum.

Therefore, the evidence points to the appropriateness of state policies insisting on coursework that, beginning in elementary school, optimizes the learning opportunities of all students.

High-Quality "Default" Curricula for *All* Students

The current curricula in P-12 mathematics and science fall far short of what is needed to prepare students for entry into higher education on the workplace, the latter including the military, domestic security, and civil services. Preparation for both of these postsecondary endeavors requires learning high-level skills.

An achievement gap exists because of mismatched expectations of the P-12 and postsecondary worlds. Moreover, even those inadequate curricula are not accessible to or achieved by large segments of the American student population: women, African-Americans, Hispanics, and Native Americans. An achievement gap also exists between groups of students because of poor delivery of P-12 curricula in mathematics and science.

Achieving the vision set forth in the higher standards being set by states and districts requires the development and implementation of a "high-quality default curricula" in mathematics and science — coursework required of *all* students at every grade level, P-12. Completion of these high-quality default curricula should assure all students a smooth transition to postsecondary institutions or to employment.

The ADP focused on the mathematics and English skills required of all students saying: "No longer do students planning to go to work after high school need a different and less rigorous curriculum than those planning to go to college. In fact, nearly all students will require postsecondary education, including on-the-job training, after completing high school. Therefore, a college and workplace readiness curriculum should be a graduation requirement, not an option, for all high school students."[77]

In addition to implementing a high-quality default curricula to eliminate the preparation gap between P-12 and postsecondary expectation, access to and success in that high-quality default curricula must be extended to *all* students. Not only must high-quality default curricula be accessible to every student in every school, but all current achievement gaps between majority and minority groups must be eliminated.

High-quality default curricula in mathematics and science are not to be offered for election by some students. They are to be *expected* of all students. Students may choose to do more, but they will not be permitted to do less.

Characteristics of High-Quality Mathematics and Science Curricula

High-quality P-12 default curricula in mathematics and science require that every student study mathematics and science every year. They are defined in terms of grade-appropriate content and not in terms of courses.

For instance, the development of algebra in a high-quality mathematics curriculum begins in the primary grades. At present, it typically begins and ends with year-long courses in the middle school and high school years.

More specifically, a high-quality mathematics curriculum initiates the algebra concept of function in the primary grades with activities that require all students to recognize, extend, describe, and create physical patterns. By grades 9-12, tasks related to the concept of function require all students to describe physical phenomena using one- and two-variable relations and functions of several types (exponential, polynomial, logarithmic, periodic) and to create and analyze transformations of those functions.

In addition, a high-quality curriculum develops simultaneously several other algebra concepts, while relating them to P-12 concepts in geometry, measurement, data analysis, etc.

Similarly, a high-quality P-12 default curriculum in science is defined by concepts that are part of each year's study for every student. For example, the life science concept of organisms in a high-quality science curriculum begins in the primary grades by observation, recording, and discussing the physical needs (food and environment) of familiar plants and animals.

By grades 9-12, tasks related to the concept of organisms involve the study of systems of living things in terms of the physical and chemical principles that govern their development and interactions. Development of a science curriculum across the grades includes the introduction of other life science concepts and the building of connections between life science concepts and concepts in physical science and earth and space science.

The defining characteristic of a high-quality default P-12 science curriculum built on the NSES model is that it is inquiry-based. An inquiry-based science curriculum is one in which student activities are designed not only to develop knowledge and understanding of scientific ideas, but also to engage students in the kinds of activities and thinking by which scientists investigate the natural world.[78]

Inquiry-based learning in P-12 classrooms mirrors inquiry in the world of science. Both students and scientists learn by making observations, defining questions based upon what they already know, posing possible explanations, designing investigations, gathering and organizing data, developing explanations based on the data, considering other possible explanations, and communicating what they have learned.[79] To say that a science curriculum is of high quality is to say that it is inquiry-based in this sense. P-12 science curricula that meet the inquiry-based standard have been developed and their effectiveness evaluated. For example, the Curriculum Development Center of the National Science Resource Center has developed and successfully implemented inquiry-based science curriculum for grades K-8 in schools systems both large and small.[80]

High-quality P-12 default curricula in mathematics and science require that every student study mathematics and science every year. They are defined in terms of grade-appropriate content and not in terms of courses.

In a high-quality science curriculum, life science, physical science, and earth and space science are not conceptually isolated. Biology, chemistry, and physics, for example, evolve simultaneously, with appropriate connections, and are components of a science curriculum studied by every student throughout P-12.

By contrast, the typical current secondary school science curriculum does isolate concepts from these three fields of science in separate courses. It also then locks those courses into an arbitrary sequence (biology, chemistry, physics), with the consequence that physics concepts rarely are included in a student's science education because students opt out of the science curriculum before taking physics.

Implementing High-Quality Mathematics and Science Curricula

Implementing high-quality default curricula in mathematics and science likely will require adjustments — often major adjustments — in the initial preparation and professional development of P-12 teachers who will use new methods and new materials to deliver the new curricula to all students at every grade level.

Bringing about such fundamental changes in classroom instruction — that is, in successfully implementing high-quality default curricula — requires careful planning; appropriate teaching materials; universal and long-term delivery of support services to a diverse and ever-changing teaching force; and continuous evaluation of the implementation effort.

Curriculum Caveats

Caveat #1: The High Cost of Borrowing

Mathematics and science curricula are, by law, the responsibility of the states and school districts, with the power of districts being significant in many states. However, because curriculum development requires a large investment of human and fiscal resources, states have created model curricula and have shared those models both with districts in the state and with other states.

School districts, with widely varying effectiveness, have adopted and-or adapted those models, the result being district-to-district differences in curricular implementation that impact students' mathematics and science education even as they move within the state.

In practice, many school districts begin their curriculum development with a review of commercially produced textbooks. But

National Science Education Standards (NSES)[81] Focusing the K-12 Science Curriculum

Less Emphasis On:	More Emphasis On:
Knowing scientific facts and information	Understanding scientific concepts and developing abilities of inquiry
Studying subject matter disciplines (physical, life, earth sciences) for their own sake	Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science
Separating science knowledge and science process	Integrating all aspects of science content
Covering many science topics	Studying a few fundamental science concepts
Implementing inquiry as a set of processes	Implementing inquiry as instructional strategies, abilities, and ideas to be learned
Activities that demonstrate and verify science content	Activities that investigate and analyze science questions
Investigations confined to one class period	Investigations over extended periods of time
Getting an answer	Using evidence and strategies for developing or revising an explanation
Science as exploration and experiment	Science as argument and explanation
Providing answers to questions about science content	Communicating science explanations
Individuals and groups of students analyzing and synthesizing data without defending a conclusion	Groups of students often analyzing and synthesizing data after defending conclusions
Doing few investigations to leave time to cover large amounts of content	Doing more investigations to develop understanding, ability, values of inquiry, and knowledge of science content
Concluding inquiries with the result of the experiment	Applying the results of experiments to scientific arguments and explanations
Management of materials and equipment	Management of ideas and information
Private communication of student ideas and conclusions to teacher	Public communication of student ideas and work to classmates
Developing science programs at different grade levels independently of one another	Coordinating the development of the K-12 science program across grade levels
Using assessments unrelated to curriculum and teaching	Aligning curriculum, teaching, and assessment
Maintaining current resources allocations for books	Allocating resources necessary for hands-on inquiry teaching aligned with the NSES
Textbook- and lecture-driven curriculum	Curriculum that supports the NSES and includes field trips and laboratories emphasizing inquiry
Broad coverage of unconnected factual information	Curriculum that includes natural phenomena and science-related social issues that students encounter in everyday life
Treating science as a subject isolated from other school subjects	Connecting science to other school subjects, such as mathematics and social studies
Science learning opportunities that favor one group of students	Providing challenging opportunities for all students to learn science

American textbooks, often used as the "drivers" for curricula, are written to maximize their market appeal, which means they are designed to address as many topics as possible to meet the standards of as many states and districts as possible.

As a result, topics relevant to the standards of a given state can be set adrift in a sea of non-relevant topics, and the full development of key concepts suffer, shortchanging the potential impact on deep student learning.

TIMSS described such curricula as being "a mile wide and an inch deep."[82] Both the NCTM standards and the NSES, the starting points for most state mathematics and science curricula, call for curricula that focus on content and processes that are important and worth the students' time and attention.

Caveat #2: Mixed Signals from Higher Education

A state's effort to define and staff high-quality default curricula is not the sole responsibility of the P-12 sector. It also requires the collaboration and support of higher education and policy leaders.

Expectations of high school graduates often are expressed inconsistently by institutions of higher education in their entrance and placement examinations. Students may be admitted to higher education based upon their performances on entrance examinations such as the ACT and SAT only to find themselves assigned to remedial, non-credit courses. They are barred from enrollment in entry-level college courses based on a "higher set of standards generally hidden from public view"[83] — the college placement tests.

Like a state's P-12 assessments in mathematics and science, college entrance and placement tests must be matched with high-quality P-12 default curricula.

Caveat #3: The Floor-Becomes-Ceiling Danger

The purpose of high-quality default curricula is to provide a solid academic floor for all students. While it holds learning expectations constant, the time allowed for students to achieve those expectations is variable.

On the one hand, learning time must expand to help some students meet the expectations of a default curriculum. Additional teacher time needs to be allocated to work with those students. On the other hand, a default curriculum must not become an academic ceiling for those students who are capable of moving through it at a rapid pace.

At present, many schools offer the College Board's Advanced Placement (AP) courses and assign their best faculty as instructors. The efficacy of that procedure for serving talented students is challenged by the Education Trust. The Trust suggests that students who are moving rapidly though the secondary school curriculum might be better served by earlier entry into higher education:

> "Many states — and indeed the federal government — are rewarding schools for adding more and more AP courses. Indeed, the fastest growing part of the high school curriculum at the moment is AP — or college-level — courses. At the same time, the fastest growing part of the college curriculum is remedial — or high school-level courses. We wonder whether it makes sense for us to keep trying to do each other's work. Might some of those students in AP be better off in actual college courses taught by college professors? And wouldn't that free up some of our best-educated high school teachers to teach the students who *MOST* need their help?"[84]

Indeed, assigning a system's best teachers to the design, teaching, and assessment of courses in high-quality default curricula is consistent with the priority of ensuring that all students successfully complete those curricula. Higher education and business could be the primary education resources for talented students who are seeking to go beyond the core high-quality P-12 curricula.

For example, corporations have developed online courses in mathematics and science for employees. Some states and districts have well-developed P-12 distance-learning networks that could be used to deliver those courses to schools and individual students. Scientific personnel from corporations could supplement the online courses by volunteering to tutor either face-to-face or via the Internet.

Colleges and universities also could open their classrooms — on campus and through distance learning — to able secondary students. Distance-education courses already are available from about 90 percent of the nation's two-year and four-year public institutions of higher education, and 65 percent of institutions offering such courses indicate that gaining access to new audiences is very important.[85]

Graduates must have an integrated view of science and mathematics that cuts across specific fields in those subjects.

A BHEF report documents that the use of technology to deliver college-level courses has had several promising results that suggest it could be effective in serving P-12 by bringing college courses to the public schools.[86] Among these promising results are an increase in the number of students served; higher levels of performance by students; reduced dropout rates; and increased availability of courses to students previously not served. Working with schools, these courses might be delivered "as is" or might be modified for use with a pre-college audience.

Fading Disciplinary Boundaries Imply Fading Curricular Boundaries

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 merge their talents to tackle complex problems. For example, Systems Biology, an emerging field that aims at a system-level understanding of biological systems, requires a cross-disciplinary faculty of biologists, computer scientists, chemists, engineers, mathematicians, and physicists who speak and understand the languages of these different disciplines to facilitate the development of new global technologies.[87]

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. 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."[88]

Because of the fading disciplinary boundaries in mathematics and science, the defining of high-quality default P-12 curricula in mathematics and science will require more than designating a set of courses from among existing offerings. The default curricula must meet a new expectation placed on high school graduates both by entry-level courses in higher education and by entry-level positions in business and industry. Graduates must have an integrated view of science and mathematics that cuts across specific fields in those subjects.[89, 90]

Now, few American students experience curricula that integrate concepts within and across mathematics and science. While America's elementary school textbooks blend arithmetic, geometry, graphing, statistics, and probability under the general heading "mathematics," the blending is more a collating of topics than an integration of concepts. Blocks of textbook pages at a particular grade level are devoted to each topic, but the topics are treated as unrelated chunks of mathematics In the middle school, the concepts and procedures of something called Algebra I are cut off from their roots in number and geometry.

Elementary school science, if addressed at all, spends little time in developing important conceptual science ideas and skills that are crucial to achieving scientific literacy. Middle school science courses typically confine themselves to one area of science (physical, life, earth) at a time. In high schools, compartmentalization of science and mathematics into courses named Biology A, Chemistry 2, Algebra II, and Data Analysis effectively sustains and reinforces conceptual isolation within and between science and mathematics.

Removing Walls: The Mathematics Curriculum

America's secondary schools are unique in the world in that they (and the textbooks written for them) divide mathematics into separate courses: pre-algebra; algebra (I, II, III); geometry; trigonometry; discrete mathematics; data analysis; pre-calculus; calculus, etc. Field-tested secondary school course materials that provide an integrated view of mathematics and that engage students in solving real-world problems are available, but few mathematics teachers are prepared to use such an approach.

Moreover, the public generally is uncomfortable with the replacement of familiar, topic-specific course titles (for example, algebra, geometry) with non-topical titles (for example, connected mathematics, integrated mathematics).

One consequence of the current compartmentalization of mathematics in the secondary curriculum is that many students graduate from high school having studied one or two aspects of mathematics,

…many students graduate from high school having studied one or two aspects of mathematics, but not having made connections across courses, and not having made contact with topics confined to the courses they did not take.

but not having made connections across courses, and not having made contact with topics confined to the courses they did not take. A second consequence is that teachers certified to teach *mathematics* (the broad field) often become specialists in the teaching of only one or two topical courses of the secondary mathematics curriculum. The teachers' view of the larger picture of school mathematics fades, and updating their mathematical education becomes more difficult over time.

Under the current curriculum structure, both students and teachers are denied the opportunity to study and use mathematics. Instead, they study and use only bits and pieces of it. Yet, as both science teachers and employers will verify, effective use of mathematics requires the integrated application of all of many mathematical concepts. For this integration to happen, institutions that prepare teachers of mathematics must revisit their mathematics curriculum to ensure cross-course connections are made and that mathematics is "put back together again."

Movement toward making connections within the P-12 mathematics curriculum has begun. The mathematics community has united in proposing that secondary school teachers of mathematics be prepared to develop students' knowledge of the mathematics that they "are likely to encounter when they leave high school for collegiate study, vocational training, or employment."[91] It further proposed that core mathematics courses for all undergraduates be redesigned to reveal mathematical connections among them.

The movement has produced results. By 1999, school districts in at least 16 states responded by adopting secondary school mathematics courses that take the integrated "maths" approach typical of other industrialized countries.[92]

Removing Walls: The Science Curriculum

Progress toward an integrated view of science is proceeding by a less obvious route and is not well documented. While educators agree about the need for P-16 instruction that breaks down the walls between the physical, life, and earth sciences, states and school districts do not report having yet adopted an integrated science curriculum at the secondary school level.

One reason is that P-12 materials that integrate the sciences are uncommon.[93] In addition, although the preparation of elementary school teachers sometimes includes courses in natural science which bring together concepts from several branches of science, current college programs for secondary school teachers of science are designed to produce graduates whose content background and teaching certification is purposefully limited to biology *or* chemistry *or* physics *or* earth and space science.

The authors of the NSES explicitly addressed the need to connect the fields of science in the K-12 curriculum. While promoting in-depth, field-specific knowledge as a basic principle in the preparation of teachers of science, the authors viewed the K-12 science curriculum itself as a tapestry.

The warp of that tapestry comprised specific concepts and procedures from the physical, life, and earth sciences, and the woof comprised unifying concepts, processes, real-world applications, and inquiry.[94] Rather than proposing to connect science by collating topics from the three fields of science, NSES uses the unifying concepts to reveal how the fields interrelate. The envisioned curriculum was "to build student understanding of how we know what we know and what evidence supports what we know."[95]

The AAAS, in collaboration with the National Science Teachers of Association (NSTA), has published an *Atlas of Science Literacy*[96] that makes the kinds of connections among major fields of school science that are called for by NSES. The *Atlas* illustrates the inter-connectedness of approximately half of the specific learning goals articulated in AAAS' *Benchmarks for Science Literacy*[97] both within and between grade ranges. A subsequent edition is planned which will complete the mappings.

The current edition visually structures the content of the *Benchmarks* using "strand maps." Each K-12 strand map displays not only the sequence of ideas that lead to a science literacy goal, but also connections within a group of AAAS science education

Until recently, no widely accepted criteria and procedures existed with which to judge the appropriateness of materials for adoption or adaptation of a district's curriculum.

benchmarks. Each strand map also displays links to other strand maps.

For instance, elements of the strand map Atoms and Molecules (a strand typically associated with physical science) are explicitly linked to benchmarks in life science (cells and organisms; cell functions; flow of matter and energy in ecosystems; DNA and inherited characteristics; variations in inherited characteristics) and earth and space science (stars; changes in the Earth's surface; galaxies and the universe).

Through the S4S project,[98] members of the AAU have supported the NSES connected science approach. S4S promotes entry-level science standards that are broadly integrative. S4S expectations of entering freshman include ability in relating concepts both within and across the sciences; facility in applying concepts from mathematics and statistics; employing science concepts in evaluating scientific issues in daily life; and understanding how scientists know what they know.[99]

But while the science community has been explicit regarding the need for a P-12 curriculum that promotes an integrated understanding of the sciences, it has been tentative in its suggestions regarding how that integration might be reflected in higher education courses and programs.

Neither NSES nor S4S calls upon universities to design postsecondary courses that would equip graduates (including, but not limited to, teachers of science) with an integrated understanding of science that would support effective work across disciplines in schools or in the workplace. Without an overhaul of postsecondary science courses, integrated science teaching at the secondary level will remain an anomaly rather than becoming the standard.

Assessing P-12 Mathematics and Science Curricula

Until recently, no widely accepted criteria and procedures existed with which to judge the appropriateness of materials for adoption or adaptation of a district's curriculum.

However, the AAAS has developed a process for analyzing curriculum materials for alignment with content standards, and the Council of Chief State School Officers (CCSSO) has developed alignment-review materials and procedures that have been applied to both mathematics and science curricula. These processes can assist districts and states in the adoption of curricular materials; the development of new materials; the revision of existing materials; textbook selection; and professional development associated with the materials.

The result should be curriculum materials in mathematics and science that focus on "worthy" content that connects ideas within and across subjects; that de-emphasize or eliminate concepts and skills that have limited connection to the standards; that provide age-appropriate and consistent development of key ideas across the grades; that engage students of all ages in inquiry-based problem solving; and that provide students with the entry-level skills expected by higher education and employers.

The North Central Regional Educational Laboratory (NCREL) has undertaken a project that allows districts and schools to analyze and assess their mathematics and science curricula in relation to international mathematics and science curriculum frameworks adopted for TIMSS in 1995. An interactive web site allows districts and schools to compare their mathematics and science curriculum to those from top-achieving nations.

Recommendations For P-12 Curricula in Mathematics and Science

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 that are 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

Curriculum Mapping

The Curriculum Mapping Web Site, developed by the North Central Regional Education Laboratory (NCREL) in partnership with the U.S. TIMSS (Third International Mathematics and Science Study) Center at Michigan State University, offers assistance to schools and districts in their efforts to analyze curricula, textbooks, materials, and standards in relation to international curriculum frameworks developed for TIMSS in 1995.

Educators map out their mathematics and science curricula by indicating what topics are being taught at which grade levels across a framework of 44 mathematics and 79 science topics. They are guided through a series of analyses complete with a set of displays that superimpose their curricula against those of top-achieving TIMSS nations. They are able to diagnose their curricula's breadth and depth, flow and sequence, articulation, and rigor.

The TIMSS curriculum frameworks, which provide the basis for this curriculum mapping tool, were originally developed for the Survey of Mathematics and Science Opportunities Research Project, funded by the U.S. Department of Education (DOE) and the National Science Foundation (NSF).

NCREL and the U.S. TIMSS Center worked with the First in the World Consortium, a collection of suburban Chicago school districts, in developing this web site and ensuring that it is a practical and useful tool for use by districts engaged in curriculum reform.

North Central Regional Educational Laboratory
Curriculum Mapping Project
http://currmap.ncrel.org/default.htm

Evaluating Curriculum Materials

The American Association for the Advancement of Science (AAAS), through its long-term education initiative Project 2061, has developed a process which uses the learning goals of the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics, the National Science Education Standards* (NSES), state curriculum frameworks, and its own *Benchmarks*[100] document to judge the appropriateness of curriculum materials.

This process not only serves the textbook adoption needs of states, school districts, and schools, but also helps teachers revise existing curriculum materials to increase their effectiveness; guides developers in the creation of new curriculum materials; and contributes to the professional development of those who use the materials.

AAAS has used its process for evaluating curriculum materials to assess the effectiveness of selected textbooks in addressing the NCTM standards, NSES, and *Benchmarks*. They have conducted reviews of middle grade mathematics and science textbooks, algebra textbooks, and high school biology textbooks.

The analysis is intended to assist adoption committees, teachers, and others in making initial decisions about textbooks and narrowing the field to a more manageable number of candidates for closer review. AAAS summary reports are valuable to schools already using the reviewed materials because the reports highlight the materials' overall strengths or weaknesses; suggest the need for supplemental materials; and point to staff development required to help teachers use the materials effectively.

American Association for the Advancement of Science
Project 2061
http://www.project2061.org/research/curriculum.htm

students. In so doing, they should take responsibility for the overall mathematics and science education of all students in that cohort; maintain familiarity with an entire curriculum at that level; and continually assess and improve 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 — either face-to-face or via the Internet.

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 future teachers, in particular — to this connected view.

Chapter 4.

P-12 Student Assessment in Mathematics and Science

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National and State Assessment Initiatives

The United States has experienced waves of reform in P-12 state-level student assessment beginning almost a century ago in a few states. A report by the National Association of State Boards of Education (NASBE) traces the rising interest in assessment and its evolving purpose since World War II.[101]

The kind of assessment that grew in use and acceptance during the Sputnik era of the late 1950s was designed to compare students with national averages and to group students into categories: below average, average, and above average. In the 1960s and 1970s, comprehensive state assessment programs were introduced to meet federal requirements to identify students eligible for special education services.

Concerned by the lack of improved student achievement as measured by assessments that compared student performances to national averages (norm-referenced assessment), educators shifted assessment strategies to allow comparison of students' performances to preset learning expectations relative to specific content standards (criterion-referenced assessment).

By the mid-1970s, approximately 30 states had adopted some combination of norm-referenced and criterion-referenced assessments which were administered at selected grade levels. However, data from instruments used at different grade levels often were incompatible and, therefore, prohibited trend analysis across the grades.

National Assessment of Educational Progress: A Nationwide Assessment Program

Although the United States has no national curriculum in mathematics and science, it has conducted nationwide assessment of pre-college students' understanding of mathematics and science for three decades.

In the late 1960s, the federal government initiated the NAEP as a nationwide testing program designed to provide evidence regarding American students' progress in eight subjects: the arts; civics; geography; mathematics; reading; science; American history; and writing (NAEP assessments in economics, foreign language, and world history are under development).[102] Science was first tested by the NAEP in 1969; mathematics in 1973. Tests are administered periodically to a national sample of students in grades 4, 8, and 12. NAEP reports performances at the state and national levels, but it does not provide scores for individuals or for schools.

NAEP tests include two kinds of items. Items constituting what is called the Main NAEP reflect current thinking about what students should know and be able to do. Items constituting what is called the Trend NAEP are items that have been used repeatedly during the past 30-plus years to monitor changes in performance levels of selected subjects over time.

While American students' performance in mathematics and science has steadily improved since 1990, their achievement falls

Under the NCLB, states must document student achievement of their standards by implementing programs of standards-based testing of reading, mathematics, and science across P-12.

far short of the level that represents solid academic performance — the level termed "Proficient."[103] In 2003, roughly 30 percent of fourth and eighth grade students participating in the NAEP reached or exceeded the Proficient level in mathematics,[104] while the year 2000 mathematics scores for 12th graders indicate that only 20 percent reached or exceeded it.[105] NAEP science scores in 2000 reveal similar lackluster performance patterns for all three grade levels: fourth, eighth, and 12th.[106]

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 grade 4, 43 percent of whites were Proficient; the rates for African-American and Hispanic students were 10 percent and 16 percent, respectively. For grade 8, the Proficient rate for whites was 37 percent; for African-American and Hispanic students it was seven percent and 16 percent, respectively.[107]

Nationally, student mathematics scores in grades 4 and 8 grew steadily from 1990 to 2003. Grade 12 scores grew from 1990 to 1996, but declined in 2000.[108] Between 1996 and 2000, national science scores showed no statistically significant difference for fourth and eighth graders; 12th grade science scores declined during this period.[109]

State Student Assessment Responsibilities Under Federal Education Mandates

The Improving America's Schools Act (IASA) of 1994[110] required states to adopt challenging content and performance standards in mathematics and reading and to develop or adopt a set of high-quality yearly student assessments. These assessments, to be administered once in each of the grade bands 3-5, 6-9, and 10-12, were to monitor the yearly performance of each local education agency.

IASA also required the establishment of Adequate Yearly Progress standards. Schools whose students fell short of these standards were to be provided with interventions to improve their performance. Some states did meet the 1997 deadline of IASA, but overall, because of a lack of political will at both the federal and state levels, requirements were not always enforced.

Congress replaced IASA with the NCLB in 2001. The new law places greater responsibility on states to implement student assessment systems aligned with state content standards.[111]

Under the NCLB, states must document student achievement of their standards by implementing programs of standards-based testing of reading, mathematics, and science across P-12. To allow cross-state comparisons of achievement and to verify the results of state tests, all states also must administer NAEP tests in reading and mathematics every two years to statewide samples of students in grades 4 and 8.

To comply with NCLB, states must administer high-quality tests in mathematics and reading in each of grades 3-8 and at one grade between the 10th and 12th grades by the beginning of the 2004-2005 school year. Beginning with the 2007-2008 school year, states must add science tests for at least one grade in each of three grade groupings: 3-5, 6-8, and 10-12. The tests must be aligned closely with state standards and must permit school-by-school comparisons across school districts.

Prior to NCLB, most state assessment systems required statewide student evaluations only three times during students' K-12 experience. To meet requirements of NCLB, many states are now faced with the need to expand their assessment systems. Some states must more than double the number of tests now being administered and to develop programs of data analysis and compensatory instruction.[112] Funding of this additional testing, analysis, and instruction falls upon states at a time when they are facing budget pressures caused by the national economic downturn.

State-, district-, and school-level data must be disaggregated for each of six major demographic categories: major racial and ethnic groups; gender; limited English proficiency status; migrant status; disabled versus non-disabled; and low-income versus higher income. Disaggregated state data must be available to districts, schools, and teachers prior to the next school year, and the data must be used by districts, schools, and teachers to improve the achievement of individual students.[113]

A 2002 summary of state assessments in mathematics found that only 16 states and the District of Columbia had annual mathematics tests in grades 3-8 required by NCLB, and while many states had demographic breakdowns of their student enrollment, far fewer reported achievement results this way. Of the states that did, more disaggregated the data at the state level than the school level. Only one state disaggregated data on all six demographic subgroups at the school level.[114]

...implementation of high-quality standards and student assessments based on those standards may result in increased failure rates for schools and districts in the short term. The public must be prepared for this possibility.

Public Understanding of Federal Education Mandates

Beginning with the 2002-2003 school year, NCLB required that school districts provide parents with school-by-school reports related to student performance. The information must be "to the extent practical, provided in languages parents can understand."[115] Information must be publicly distributed through the media and via the Internet. However, published results of student assessments generally are not well understood by parents, employers, and policymakers.

There is, however, evidence that both the title and the intent of NCLB are misunderstood by parents and the general public. Asked about the meaning of the law, parents in Hartford, Connecticut responded that it:

- prohibits leaving children alone on the street;
- means that parents should not leave a child behind after school;
- requires that students who are not doing well must go to summer school, because schools are not allowed to hold them back (in grade); and
- ensures that every student will be promoted each year regardless of attendance record or academic performance.[116]

The 2004 Phi Delta Kappa/Gallup poll on public attitudes toward public schools gives further evidence that the public: knows little about the intent of NCLB; misinterprets the meaning of the title of NCLB; is divided regarding the use of standardized tests as the basis for awarding diplomas (51 percent in favor versus 47 percent opposed); and is not in agreement with major strategies of NCLB. Moreover, the public is not happy with what it is learning as its awareness of NCLB is being brought about through the imposition of sanctions.[117]

The public is not aware (nor does it accept) that a significant time lag is likely between a state's adoption of higher expectations for student learning and the implementation of programs that are effective in delivering that content to all students. Consequently, efforts must be made to ensure that the public understands that improved student achievement will not be instantaneous.

In fact, implementation of high-quality standards and student assessments based on those standards may result in increased failure rates for schools and districts in the short term. The public must be prepared for this possibility.

Materials and methods of instruction must be changed throughout the system, and a student must pass through the entire revised system to have had the opportunity to learn what is assessed at each level. Specifically, improved performance in grade 12 depends on what the student experienced in P-11.

In addition, assessment results can be dramatically affected by refinement or replacement of the tests being used. To improve public understanding of the student performance reports, a need exists to relate change in those performances to changes in other elements of the education system (for example, standards-assessment alignment; test selection; curriculum reform; teacher professional development; and equitable distribution of resources among schools).

Evolving Purposes of P-12 Assessment Programs

While the assessments of the 1950s and 1960s compared students' performances to those of other students using national averages, standards-based assessments measure the extent to which students have achieved preset learning goals.

The assessments also are meant to do more than simply sort students into "knows" and "know-nots" with respect to state stan-

[Assessments'] threefold purpose is to measure student progress; to diagnose academic needs of students; and to inform decisions on the use of resources…

dards. Rather, their threefold purpose is to measure student progress; to diagnose academic needs of students; and to inform decisions on the use of resources to ensure that all students reach high standards.

The diagnostic use of assessment to track progress toward a particular goal and to provide feedback to teachers and students on that progress is called *formative* assessment. In contrast, *summative* assessments report whether or not a particular goal has been reached. Formative assessments, which can include teacher observation, classroom discussion, and analysis of student work, including homework and tests, are used to alter instruction for the purpose of improving teaching and learning. They provide an understanding of what students know or don't know, and guide teachers in initiating appropriate actions to assist students in achieving the desired learning goal.

Feedback to students based on formative assessment "may be particularly helpful to lower-achieving students because it emphasizes that students can improve as a result of effort rather than be doomed to low achievement due to some presumed lack of innate ability."[118]

In an effort to improve students' mathematical competencies and to give all students access to algebra, the Los Angeles Unified School District (LAUSD) has launched a new Mathematics Plan that uses formative assessments as the key instrument for guiding instruction to meet individual student needs. The LAUSD mathematics curriculum is organized into four quarters of work. To gather quarterly progress information, the district has partnered with the Educational Testing Service (ETS) to develop quarterly mathematics assessments that are aligned with the curriculum.

Within 24 hours of the completion of student testing, the ETS software provides LAUSD teachers with information about the level of each student's understanding of the mathematics that has been taught. These reports not only inform instruction about individual students, but also provide targeted activities for those students who need additional assistance.

The Status of State Assessment Programs

As of the 1998-1999 school year, 49 states used a state assessment as the principal indicator of school performance in mathematics, and 36 states did so in science. State assessment programs reported use of a mix of tests that compare student performances with national and state averages (norm-referenced tests) and tests that measure progress on specified content standards (criterion-referenced tests).

State testing programs employed 46 different norm-referenced and 67 different criterion-referenced tests in mathematics. In science, states use 27 different norm-referenced tests and 34 different criterion-referenced tests. Measurement of student progress toward achieving state standards was based solely on criterion-referenced tests in only nine states.[119]

The independent state-by-state development of assessment programs has raised questions about the comparability of assessment results, both across states and across grade levels within states. Assessments appear to differ widely in the types of test items employed, the technical quality of the test items, and the alignment of test items with state content standards. A disconnect also seems to exist between P-12 assessments and the entry-level assessments employed by colleges, universities, and employers.

Type and Quality of State Assessment Items

The growth of state assessment programs has been accompanied by major changes in the types of questions appearing on the tests. Early tests contained multiple-choice items only. A multiple-choice item, in effect, requires only that students *recognize* a correct response. Students have learned to increase their probability of finding the correct response by eliminating clearly unlikely choices and by performing certain "checking" procedures on promising choices.

A notable change in state student assessment programs since 1990 was the incorporation of open-ended exercises in addition to multiple-choice items. Newer tests have short-answer (fill-in-the-blank) items or use a response format that makes use of grids of letters or numbers to construct short answers. Other items call for essay-like responses in which the student is expected to use text and graphics to display the solution to a problem.

As of 2000, 35 states included some combination of multiple-choice, short-answer, gridded, and essay-response items in their mathematics assessments; while 15 states used a combination of item types in their science assessments.[120] While the inclusion of "hand-scored" items is consistent with the need to assess higher-level learning in mathematics and science, the cost of scoring the resulting tests can be up to five times that of a multiple-choice test. Since most states must expand their present testing schedule to meet the requirements of NCLB, the cost of developing and scoring tests that include hand-scored items is being reviewed. Some states are considering a revamping of their tests to eliminate these costly items[121] or are switching to off-the-shelf norm-referenced tests.

In addition, the time required to score the more complex test items for large numbers of students adversely affects testing schedules and works against the timely reporting of results to states, districts, and schools so that appropriate interventions can be planned and implemented. For example, to meet reporting deadlines, states and school districts may have to administer the eighth-grade examination several months before the end of the school year. Therefore, the eighth-grade students may be tested on concepts not yet taught in that grade.

Alignment of State Assessments and Content Standards

Because assessment requirements have built up during years of local, state, and federal policy making, many state assessment programs lack internal consistency and comprehensive planning. According to the National Association of State Boards of Education (NASBE), "accumulated assessment programs often: assess some grades of students disproportionately and others not at all; reflect outdated education standards or curricula; utilize teaching and learning methods that no longer reflect classroom practice; and send conflicting messages about what knowledge is valuable to teachers and students."[122]

The problem of alignment between state standards and state assessments varies dramatically from state to state. Specific deficiencies in state assessment programs include: the measuring of skills and knowledge that are not among the state's learning standards; failure to measure learning standards that are listed by the state; and use of poor measures for the standards that are assessed.[123]

Models for Aligning State Assessments and Content Standards

As a result of NCLB, states have a greater responsibility to ensure alignment between their academic standards and their assessments, where alignment is judged on the following dimensions:

- "Comprehensiveness: Does the assessment reflect the full range of the standards?
- Content and Performance Match: Does the assessment measure what the standards say students should both know and be able to do?
- Emphasis: Does the assessment reflect the same degree of emphasis on the different content standards as is reflected in the standards?
- Depth: Does the assessment reflect the cognitive demand and depth of the standards? Is the assessment as cognitively demanding as are the standards?
- Consistency with Achievement Standards: Does the assessment provide results that reflect the meaning of the different levels of achievement standards?
- Clarity for Users: Is the alignment between the standards and assessment clear to all members of the school community?"[124]

To assist states in strengthening the alignment between their standards and the statewide assessment instruments used to measure achievement, the CCSSO has promoted the development and implementation of models for standards-assessment alignment analysis. CCSSO has worked with two organizations in developing, testing, and applying two models of alignment analyses. In addition, it has provided a comprehensive comparison of four models of alignment analysis to assist states in determining the appropriateness of one of the models for their alignment-analysis needs.

Alignment of P-12 and Postsecondary Assessment Programs

A major shortcoming of efforts to develop state assessment programs has been the failure to align the exit-level standards and assessments of P-12 with the entry-level standards and postsecondary assessments employed by businesses, colleges, and universities. Consequently, state assessments used with students through grade 12 often are not well matched with those used by postsecondary institutions and employers in the same state.

As states have moved to criterion-based testing related to specific learning standards, postsecondary institutions have continued to

The Council of Chief State School Officers (CCSSO) has worked with two organizations on the development, testing, and implementation of two alignment-analysis models.

The SEC Model

The Survey of Enacted Curriculum (SEC) alignment methodology was developed by Andrew Porter and John Smithson from the Wisconsin Center for Education Research. The SEC model uses a common content matrix that produces alignment analyses of standards, assessments, and instruction.The two-dimensional matrix permits three types of comparison: alignment between pairs of states; alignment between state and national assessments and standards; and alignment between state and local assessments and standards.

State standards and assessments are categorized by content topics and by "cognitive demand" which, for mathematics, is broken down into five categories: memorize; perform procedures; communicate understanding; generalize and prove; and solve non-routine problems. Content maps and graphs, written evaluations, and statistics are used to portray the differences and similarities in the content of the standards and of the assessments. The SEC model, which has focused on mathematics and science alignment studies, has been field tested and demonstrated with 11 states and four large urban districts.

The Webb Model

Developed by Norman Webb from the University of Wisconsin, the Webb Model methodology codes each benchmark of the content standards using one of four levels of knowledge: recall; skill and concept; strategic thinking; and extended thinking. For each item on the state assessment, the benchmarks of the content standards related to the item are identified. Using the same four-level scale, the level of knowledge necessary to successfully complete the assessment item is determined and then compared to the level of knowledge of the corresponding benchmarks of the content standards. A determination is made as to whether the assessment item is below, at, or above the level of knowledge of the corresponding benchmarks.

Further analysis produces statistics and tabular reports on four criteria of alignment for each standard: categorical concurrence; depth-of-knowledge consistency; range of knowledge correspondence; and balance of representation. The Webb Model has been used for language arts, mathematics, science, and social studies alignment analyses in 10 states.

A Four-Model Comparison

To further assist states with the challenges of alignment, CCSSO has highlighted the work of two additional alignment projects that are operational and have been used by several states: The Achieve Inc. Model and the Council for Basic Education (CBE) Model. In an effort to inform states of the alignment models available to them, the CCSSO has summarized and compared the key features of the SEC, Webb, Achieve, and CBE alignment models.

Council of Chief State School Officers
Alignment Analysis Project
http://www.ccsso.org/projects/alignment_analysis/

rely on admissions and placement tests that are norm-referenced and are not related to the standards of a particular state. State assessments increasingly require that students present written or graphic arguments in support of their responses, while tests used by postsecondary institutions and employers rely on multiple-choice items. This mismatch of expectations as expressed by assessments can lead to denial of admission or employment or can necessitate student enrollment in postsecondary remedial courses. Such results discourage postsecondary study and add to the time and expense required for the initiation of productive postsecondary work.

Admissions and placement tests administered by institutions of higher education should be viewed as elements of P-12 assessment…

Recommendations For P-12 Student Assessment in Mathematics and Science

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 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.

Chapter 5.

P-12 Teacher Quality

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P-12 Teacher Quality

Highly Qualified Teachers of Mathematics and Science: Scarce and Becoming Scarcer

Every student deserves highly skilled, committed, and professionally 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 what they teach; a commitment to lifelong professional improvement; the desire and skill to share knowledge; and the resources necessary to do their work.

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Calling Teachers: Finding Almost No One at Home

Increasing the number of students prepared for successful entry into higher education or the workplace will not happen unless the United States addresses the problem of developing and sustaining a highly qualified mathematics and science teacher workforce. 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 solely depressing; they are also alarming.

By 2020, the school-age population will increase by 20 percent.[125] All of those students will be required to take more — and more advanced — mathematics and science. At the same time, trend data from the period 1990-2000 indicates that the percentage of high school mathematics and science teachers age 50 and older is steadily increasing and will result in a high retirement rate in the immediate future.[126] Before the end of this decade, it will be necessary to find replacements for 75 percent of the current teaching force.[127]

Urban schools are finding it especially difficult to recruit and retain teachers of mathematics and science. In particular, the supply of minority teachers is insufficient to meet the hiring needs of schools with large populations of minority students. In most states, the percentage of minority teachers is one-third that of minority students. During the last decade, the total percentage of minority teachers of high school mathematics and science courses has increased slightly, but, as of 2000, minority teachers remain vastly under-represented in comparison to the minority student enrollment.[128]

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.[129] 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.

Because U. S. immigration law classifies teachers as "skilled workers," it is not surprising that states and school districts, like corporations, have tried to solve their critical shortage problem with long distance calls to recruit talent from other countries (for example, England, Germany, and India). Nationwide, American school districts employed more than 10,000 foreign-born teachers with H1B visas in public and private schools during the 2002-2003 school year — with the Houston Independent School District leading the nation with 915 teachers on H1B visas.[130]

But this off-shore supply now is threatened by a decrease in the overall number of available visas and by 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.[131] 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.

In seeking highly qualified foreign-born K-12 teachers, some districts now face an additional recruitment problem resulting from the federally mandated cap on H1B visas in 2004 that will decrease the number of visas available to teachers. These teachers, many of whom meet the NCLB requirements for a highly qualified teacher in subject areas experiencing shortages, have been willing to take positions in hard-to-staff schools.

Both Pulled and Pushed, Teachers Are Leaving the Profession

Few U.S. students are drawn to teaching mathematics and science. It is hardly surprising that America's "brightest and best" are not attracted by a profession that offers a lifetime of low pay, lock-step advancement opportunities, poor working conditions, and public distain. The teacher pool in mathematics and science education continues to shrink as prospects interested in those subject fields are being pulled away from a teaching career by broadening employment opportunities, jobs with higher salaries, career growth potential, and greater independence in work-related decision making.

Even those states and districts with incentive programs for teaching candidates are unable to avoid employing persons who hold emergency teaching credentials. Increased salaries and improved working conditions, seen as essential for expanding the teacher workforce, require an infusion of money much larger than current legislation provides.

While teaching appears to be unable to develop much pull among college students, it clearly is developing strong push among those already in P-12 classrooms. In 1999-2000, nearly 50,000 more teachers left the profession than entered it.[132] A study of DOE data concluded that 49 percent of teachers who leave the profession every year are either dissatisfied or switching careers. In contrast, only about 27 percent are retiring.[133]

Four out of 10 mathematics and science teachers leave the profession because of job dissatisfaction.[134] While about 66 percent of those leaving cite salary as the deciding factor, many quit because of working conditions, such as poor student motivation (32 percent), poor administrative support (22 percent), student discipline problems (21 percent), and lack of faculty autonomy (15 percent).[135]

Teachers leaving the profession often point to the lack of resources with which to do their work as the primary reason for their departure. Many schools — especially those where teachers are most needed — simply are unattractive places to work. According to the American Council on Education (ACE):

> "In stark contrast to workplaces in most public and virtually all private professional enterprises, many school facilities are outdated, poorly maintained, and technologically obsolete; few

school teachers have offices or access to private telephones, private computers, or administrative support; supplies, up-to-date textbooks, computer software, and other necessary teaching materials often are inadequate; and the social environment for new teachers within the schools, among parents of school children in the community, and in relation to their colleges and universities, often is unsupportive."[136]

Additionally worrisome is the fact that the attrition problem among younger teachers is so acute that it outweighs retirement as a cause of teacher shortages. Data for the school year 1994-1995 shows that 30 percent of all teachers leave the profession within the first three years and 39 percent leave within the first five years. Figures for mathematics and science teachers are estimated to be slightly higher. Teachers are being pushed away from P-12 classrooms by little or no mentoring during the initial years in the classroom; by the heavy teaching assignments given to new teachers; by assignment to out-of-field courses; and by the absence of parental and public support and respect.

Mathematics and Science Faculty Shortages Extend to Higher Education

The shortage of P-12 mathematics and science teachers is, in part, a function of a shortage of teacher educators in institutions of higher education. As in the case of P-12 education, good ideas and intentions to improve the quality and quantity of P-12 teachers have run up against declining higher education budgets and staff size.

College and university mathematics and science departments are experiencing a wave of retirements, but the shrinking budgets of higher education are making it necessary to postpone the hiring of replacements. Based upon data collected by the American Mathematical Society (AMS) during the two-year period beginning in 2000, it is predicted that an 8-10 percent drop in hiring of mathematics faculty will take place at the same time that the mathematics faculty will be retiring at a rate of three percent per year.[137]

College officials testifying before a Congressional subcommittee considering reauthorization of the Higher Education Act argued that the higher education faculty shortage affecting the preparation of P-12 teachers includes a shortage of college education faculty with graduate degrees in mathematics and science education.[138] Until recently, data on which to base such a recommendation has been scant.

For instance, although the AMS publishes the results of an annual survey regarding doctorates awarded, job opportunities, and salaries in mathematics, there is no organization that annually surveys openings and placements in mathematics education at the university level.[139] However, an NRC survey of doctorates conferred by almost 400 institutions during the period 1995-98 found that those institutions granted an average of 1,130 doctorates in mathematics per year, but only 100 doctorates in mathematics education.[140, 141, 142]

During the past decade, studies have documented that a low rate of production of doctorates in mathematics education persists at a time when the employment opportunities for those graduates is diversifying, and when there is about to be a dramatic increase in the pending retirements of current degree holders.

On the diversification side, traditional teacher-preparation positions in institutions of higher education have been augmented by openings to conduct research in the teaching and learning of undergraduate mathematics, and by positions with state departments of education, publishing companies, testing agencies, and school districts.[143]

On the pending retirements side, the 1999 report of the NRC included survey data indicating that 51 percent of the mathematics education faculty in 48 institutions would be eligible for retirement by the year 2000, and 80 percent would be eligible for retirement by 2008.

This combination of low production of doctorates in mathematics education and large percentages of pending retirements has produced a supply-demand mismatch. According to a recent University of Missouri survey of the results of searches by 119 institutions to fill 134 positions for persons with doctorates in mathematics education, the typical number of applicants ranged from two to 10 and that 49 percent of the positions went unfilled.[144]

A recent study of the production of science education doctorates awarded at 10 institutions — including seven large-to-moderate producers of such graduates — concluded that doctoral-level programs in science education in the United States "appear unable to supply an adequate number of graduates to fill vacant positions in universities and other agencies."[145] The study found that, during the decade 1990-1999, the 10 institutions graduated a total of only 183 persons prepared to enter regular work in the field of science education: teaching methods courses; supervising master's and doctoral students; and contributing to curriculum or policy development in the field.[146] Yet, in the year 2001-2002, there were 168 job postings for a doctoral-level position in only science education and another 60 job postings for a position that combined science education with mathematics education.[147]

The NCLB requires that, by the end of the 2005-2006 school year, states must verify that all teachers in core subjects are highly qualified.

Raising the Certification Bar: Every Teacher of Mathematics and Science Must Be Highly Qualified

Meeting the "Highly Qualified Teachers" Requirement of NCLB

The NCLB requires that, by the end of the 2005-2006 school year, states must verify that all teachers in core subjects are highly qualified. In the case of new teachers, highly qualified means a bachelor's degree and a passing score on state tests in the subjects to be taught. For experienced teachers, it means a bachelor's degree and a passing score on a state evaluation demonstrating proficiency in the subjects taught.

State-mandated assessment of the knowledge and skills of new teachers is increasing. In 2002, 44 states reported having a written test policy. Of these 44 states, 30 assess subject matter knowledge in the field in which the teaching license is issued.[148] Also in 2002, 35 states reported having a policy requiring either a major or minor in the subject content field of teaching. In most states, the requirement applies to all teachers applying for secondary certification, which usually covers grades 7-12.[149]

The magnitude of the challenge of having a highly qualified teacher in every classroom by 2006 is made clear by national statistics on teacher qualifications gathered during the 1999-2000 school year (see Figure 5.1). In that year, the percentages of students who were taught by teachers who did not have the two credentials that were most likely to help their students excel — a college major and state certification in the subject taught — were alarmingly high.[150]

Inequitable Access to Highly Qualified Teachers

Studies published in 2002 report that students enrolled in mathematics or science classes with high-minority and high-poverty are less likely to be taught by a teacher who is well prepared in the subject area. In the case of middle school mathematics, 72 percent of high-minority classes were taught by teachers with no major or minor in mathematics as compared with 55 percent of low-minority classes. In high schools, the pattern is maintained with a 33 percent to 23 percent differential between high- and low-minority mathematics classes.[151]

In low-poverty secondary schools (grades 7-12), 27 percent of mathematics teachers did not have a major or minor in the subject, while 43 percent of teachers in high-poverty schools did not have a mathematics major or minor. Eighteen percent of secondary school science teachers in low-poverty schools did not have a major or minor in a science (or in science education), while 28 percent of teachers of science in high-poverty schools were judged to be poorly prepared.[152]

Questionable Applications of "Highly Qualified"

By October 2003, 39 states and the District of Columbia reported baseline data on the extent to which their experienced teachers met the three criteria of the NCLB definition of highly qualified teacher: a bachelor's degree; state certification; and demonstrated mastery of every subject taught.

While most of those states reported that at least 80 percent of the current teaching force was highly qualified, percentages across the

Figure 5.1

Percentage of Students Taught By Teachers with No Major and Certification

	Middle Grades	High School Grades
Mathematics	69	31
Science	57	27
Biology/life science	64	45
Physical Science	93	63
Chemistry	*	61
Geology/earth/space science	*	79
Physics	*	67

**No data available. Courses in these subjects are not offered in the middle grades.*

nation ranged from a low of 16 percent to a high of 99 percent. Such wide variation among state counts of highly qualified teachers suggests that "national comparisons are imperfect because states set their own standards for licensing [certification] and subject mastery by veteran teachers."[153]

A 2003 study by the Education Trust rates the quality of this baseline data on highly qualified teachers that states reported for NCLB purposes. The report concludes that the reporting methods of many states resulted in a distorted picture of where states stand now, and what progress needs to be made.[154]

The Education Trust study judged that no state satisfied all criteria for defining "highly qualified teacher;" only eight states were judged to have definitions focused on ensuring that every child has access to teachers with the depth and breadth of knowledge required for them to be effective. Moreover, three of those eight states failed to apply their definitions when reporting to NCLB.

Defining the Performance of a High-Quality Teacher

In 1999, the National Commission on Mathematics and Science Teaching for the 21st Century, also known as the Glenn Commission after its chairman, retired Senator John Glenn of Ohio, was tasked to "investigate and report on the quality of mathematics and science teaching in the nation, directing [it] to consider ways of improving recruitment, preparation, retention, and professional growth for mathematics and sciences teachers in K-12 classrooms nationwide."

Although the Glenn Commission report, *Before It's Too Late*[155], was received enthusiastically when it was issued in the fall of 2000, implementation of its recommendations languishes. The Commission based its recommendations on a vision of mathematics and science instruction that was defined as high-quality teaching.[156] It was a core premise that the ability to teach is not something one is born with but, rather, something that is learned and refined over time.

Defining Quality Preparation for Teachers: Quality = Content Knowledge + Teaching Skills

A study of human learning by the NRC concluded that being deeply educated in a discipline such as mathematics or science does not guarantee the ability to teach others but, rather, that "expertise can sometimes hurt teaching because many experts forget what is easy and what is difficult for students."[157] In fact, studies of K-12 teaching effectiveness have shown positive relationships to the number of education courses taken by teachers.[158]

Mathematics students do learn more from certified teachers who have taken mathematics education courses.[159] Effective teaching of mathematics requires not only in-depth content knowledge of the subject, but also teaching skills and knowledge with which to apply that content knowledge in problem-solving classroom situations through "useful representations, unifying ideas, clarifying examples and counterexamples, helpful analogies, important relationships, and connections among ideas."[160]

In an effort to solve mathematics and science teacher shortages by tapping mathematicians, scientists, and engineers who are retiring or seeking a career change, states and districts are implementing alternative teacher certification programs. These programs are designed to help non-traditional candidates — that is, those who have the content knowledge in mathematics and science — acquire the teaching skills and knowledge needed for the new, high-quality default curricula while meeting requirements for state teaching licenses.

The National Commission on Mathematics and Science Teaching for the 21st Century: *Before It's Too Late*, 2000

In the view of the Commission, a practitioner of high-quality teaching:

- has a deep knowledge of subject matter;
- places the process of *inquiry*, not merely "giving instruction," at the center of instruction;
- *insists* that all students learn;
- develops a student skill set that includes observation, information gathering, sorting, classifying, predicting, testing, and skeptical review;
- recognizes and builds on differences in students' abilities and learning styles;
- aligns high standards for student learning with curriculum and assessment;
- is continually refined and encouraged by professional development, use of technology, and recognition and rewards; and
- can be evaluated by the achievement of the students.

Preparing a New Generation of Mathematics Teachers

In 2001, leaders in mathematics and in mathematics education addressed departments of mathematics and education at community colleges, colleges, and universities on the issue of the preparation of K-12 teachers. Their report, *The Mathematical Education of Teachers*, takes the position that teaching K-12 mathematics requires in-depth knowledge of the mathematics specific to the level taught.

In addition, it asserts that content knowledge, although *necessary*, is *not sufficient* to the preparation of K-12 teachers. Effective preparation of mathematics teachers requires that content be studied in relation to subject-matter teaching methods. As stated in the report: "What effective teachers need is mathematical knowledge that is organized for teaching — deep understanding of the subject they will teach; awareness of persistent conceptual barriers to learning; and knowledge of the historical, cultural, and scientific roots of mathematical ideas and techniques."

The report further describes broad concepts and procedures that constitute required "mathematical knowledge for teaching" at grade levels K-4, 5-8, and 9-12. It then details topics that should comprise the content focus of each concept and relates the topics to the school mathematics taught at each level. Content recommendations are not aligned with a particular school mathematics curriculum, but they are consistent with National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics*.

The authors call for increased collaboration in preparing K-12 teachers of mathematics. University courses and programs should be designed jointly by mathematics and mathematics education faculty and with input from K-12 teachers. Furthermore, program development should involve faculty of two-year colleges, since a large number of future teachers begin their postsecondary study in two-year colleges.

Conference Board of the Mathematical Sciences, 2001
The Mathematical Education of Teachers
http://www.cbmsweb.org/MET_Document/

In 2003, 46 states and the District of Columbia report having some type of alternative teacher certification program.[161] Most of these programs are collaborative efforts among state departments of education, colleges and universities, and school districts.

Proposals to Improve Teacher Education Programs

Many teacher education programs are not aligned with the standards proposed by the Glenn Commission or the learning principles reported by the NRC. To encourage, guide, and improve such alignment, professional groups in the mathematics and science communities have made recommendations for the development of undergraduate programs that link teachers' preparation to the content, program, and process standards for K-12 mathematics and science, and to the teaching methods most effective in grades K-12.

The Conference Board of the Mathematical Sciences (CBMS) has defined programs for the preparation of K-12 teachers of mathematics that seek to merge relevant content related to the learning expectations now placed on pre-college students with effective methods of teaching mathematics. It recommends that the mathematical education of teachers be carried out as a partnership between mathematics and mathematics education faculty.[162]

This collaboration is critical, since research on learning and teaching runs contrary to widely held beliefs that "anyone can teach" and that "teacher preparation programs contribute little to the production of quality teachers."

Paralleling the CBMS work in mathematics, the College Committee of the NSTA has translated the NSES into recommendations for college instruction in science and, in particular, for the preparation of P-12 science teachers.[163] Both sets of recommendations call not only for widespread revision of undergraduate courses in mathematics and science for all students — courses that also serve as the foundation of teacher preparation programs — but also for the design and staffing of additional courses specific to the needs of future teachers (especially elementary and middle school teachers).

To ensure that mathematics, science, and education faculties are encouraged to collaborate in the development of cohesive teacher preparation programs such as those called for by CBMS and NSTA, the ACE has "urge[d] college and university presidents to put the education of teachers at the center of the institutional agenda and to accept the challenge and responsibility to lead constructive change."[164]

In fact, cross-college collaboration in efforts to improve teacher education has been underway in some universities for more than a decade through their participation in the Holmes Group or the National Network for Educational Renewal (NNER).[165]

Those participating in the Holmes Group often developed five-year teacher education programs that required an undergraduate degree in the liberal arts followed by post-baccalaureate work directed toward applying content knowledge and teaching skills in school settings.

Members of NNER sought to restructure teacher education to address problems identified by John Goodlad, author of *Education Renewal: Better Teachers, Better Schools.* These problems include the disconnections among schools of education, university liberal arts programs, and K-12 schools, and the low status of teacher education programs and schools of education on university campuses.[166]

In 2004, the president of the Carnegie Corporation of New York challenged presidents of America's colleges and universities to "make it clear that teaching institutions must prepare teachers who are proficient in the fields they will be teaching, well-versed in the latest theories and practices of pedagogy, skilled in technology, and professionally mentored with solid classroom experience."[167] Relative to that challenge, the Corporation announced the initiation of a five-year effort designed to strengthen K-12 teaching through the creation of a new model of teacher education. The model, titled Teachers for a New Era, has obtained the commitment of the leaders of 11 institutions of higher education to redesign their teacher education programs around three principles:

- generating research evidence of learning gains in students taught by graduates of the program;

National Network for Educational Renewal

In 1986, the Center for Educational Renewal at the University of Washington established the National Network for Educational Renewal (NNER), a network of partnerships composed of schools of education, arts and sciences colleges, and P-12 schools.

NNER is the implementation arm of a research-based agenda which has as its base four moral dimensions for teaching in a democracy:

- provide access to knowledge for all children;
- educate the young for citizenship in a social and political democracy;
- base teaching on knowledge of the subjects taught, established principles of learning, and sensitivity to the unique potential of learners; and
- take responsibility for improving the conditions for learning in the entire school and university community.

This four-part mission is supported by 20 postulates that outline the conditions necessary for a robust teacher education program, and define specific responsibilities for individual institutions and agencies as well as necessary collaborations. The first three postulates address the commitment to teacher preparation programs within higher education institutions. They require that such programs:

- be viewed by institutions offering them as a major responsibility to society and be supported and promoted vigorously by the institution's top leadership;
- enjoy parity with other professional education programs, full legitimacy and institutional commitment, and rewards for faculty geared to the nature of the field; and
- be autonomous and secure in their borders with clear organization identity, constancy of budget and personnel, and decision-making authority similar to that enjoyed by the major professional schools.

The 20th postulate addresses the necessary conditions for supporting and sustaining teachers once in the field.

It raises questions concerning potentially new roles and responsibilities for colleges and universities, schools districts, unions and others related to the issues of induction, mentoring, professional development, teacher support services, and compensation issues.

Center for Educational Renewal, 2003
National Network for Educational Renewal
http://depts.Washington.edu/cedren/nner.htm

- ongoing collaboration of the institution's faculties of education and arts and sciences; and
- viewing teaching as an academically taught clinical practice requiring the engagement of master teachers as clinical faculty in college of education and requiring two-year residencies for beginning teachers.[168]

To ensure a supply of teachers large enough to guarantee that every student will have high-quality instruction in mathematics and science, explicit and continuing attention must be given to increasing the attractiveness of the profession; improving working conditions of teachers; evaluating and overhauling teacher preparation in these fields; and providing relevant, high-quality professional development…

Improving the Quality of Professional Development

To ensure a supply of teachers large enough to guarantee that every student will have high-quality instruction in mathematics and science, explicit and continuing attention must be given to increasing the attractiveness of the profession; improving working conditions of teachers; evaluating and overhauling teacher preparation in these fields; and providing relevant, high-quality professional development that is aligned with the new high standards that states and districts have set.

However, the process of learning to teach well does not end when a teacher enters the profession. It is a career-long endeavor that requires a lifelong plan for professional development.

Implementation of high standards in mathematics and science education will require that current and future teachers receive ongoing professional development in subject content and methods of teaching that are related to state learning standards of the students they teach.

Forty-seven states have policies requiring documented professional development as a condition for renewing a teaching license, and most of those states require a minimum of six semester hours of work during a five-year period.[169] The most recent data (2000) from the NAEP indicates that 81 percent of mathematics teachers at grade four, and 48 percent of the mathematics teachers at grade 8, participate in fewer than 16 clock-hours of professional development per year. For science, the figures are 88 percent at grade 4 and 54 percent at grade eight.[170]

In addition, although 24 states have adopted policies requiring that professional development activities be aligned with the state content standards,[171] national studies do not report on the actions taken to achieve that alignment or on the effectiveness of the professional development activity completed on classroom instruction.

Principles of Effective Professional Development

The systemic reform movement has greatly increased the understanding of what constitutes effective professional development.[172] It must be viewed as a component of the broader system reform effort — that is, it must be tied to the system's goals for students, student assessment, curricula, instructional materials, and school staffing.

Successful programs of professional development do not have a standard format and cannot simply be transplanted from one system to another. Rather, planners of professional development activities must consider an array of local conditions: specific needs of students and teachers; organization of the schools; past history of professional development; and existing policies and resources.

Research on professional development of mathematics and science teachers has identified seven governing principles.[173] Effective professional development experiences:

- are driven by a clear vision of effective classroom learning and teaching such as inquiry-based instruction or in-depth understanding of core concepts;
- allow teachers to build both subject knowledge and teaching skills (for example, posing and responding to questions, recognizing misconceptions);

- model instructional strategies that teachers are intended to use with their students;
- build a community of learners that will continue to grow in teaching effectiveness through experimentation and sharing;
- support the development of teachers who will lead other teachers to embrace change;
- link professional development to other elements of the education system; and
- include continuous evaluation of the effectiveness of the professional development program.

Professional Development: Leave No Teacher Behind

Three decades ago, NSF encouraged and aided universities in their efforts to enhance the education of mathematics and science teachers by funding summer and academic-year institutes for teachers. As the result of the procedures used in selecting participants for those institutes, the NSF-funded programs mainly benefited those teachers in secondary classrooms who already were the best-educated and most highly motivated.

In effect, the institutes served to make the best even better, but they did not impact the large mass of teachers with weak preparation. In a renewed commitment to institutes for mathematics and science teachers, NSF is funding programs designed to increase the content knowledge and teaching effectiveness of that larger group. The University of Wyoming, for example, is designing and testing a program of new courses in mathematics and mathematics education that targets middle school teachers who have little or no previous preparation in the subject.[174]

Wyoming Middle-Level Mathematics Initiative (WMMI)

Under a grant from the National Science Foundation, Wyoming educators are collaborating in the design and piloting of eight new courses that integrate mathematics and pedagogy. When completed, the courses of the Wyoming Middle-Level Mathematics Initiative will be the foundation of a teacher licensure program in middle school (grades 5-8) mathematics.

The Initiative has several unique features.

- **It is broadly collaborative.** Program development is a joint venture of university, community college, and secondary school faculty. Postsecondary faculty members are drawn from mathematics, statistics, and mathematics education. Secondary school faculty include teachers who have received the Presidential Award for Excellence in Mathematics and Science Teaching.
- **It provides in-service for its university staff.** Postsecondary faculty participate in seminars and teleconferences to increase their understanding of grades 5-8 content, materials, and students and to ensure that the eight courses come together as a coherent program.
- **It builds course content on national and state content standards.** Course content is selected with the goal of amplifying participants' understanding of the mathematics behind the standards that middle school mathematics students are expected to achieve.
- **It places middle school teaching tasks at the center of course design.** Activities are focused on increasing participant's ability to communicate the core ideas of middle school mathematics and to resolve unanticipated questions raised by students.
- **It models what it proposes.** Instructors tackle middle school mathematics with middle school student-tested problem-solving methods. They employ the investigative tools (physical and electronic) and instructional strategies that they propose be used in middle school classrooms.

The eight courses of the program are bound together by instructors' focus on in-depth exploration of fundamental mathematical ideas and by program strands that weave through all courses: the state's middle school content standards; problem-solving strategies; questioning skills; in-depth assessments; and appropriate uses of technology.

Science & Mathematics Center
University of Wyoming, 2003
Wyoming Middle-level Mathematics Initiative
http://smtc/uwyo.edu

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.

RECOMMENDATIONS FOR P-12 TEACHER QUALITY

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 following 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; for increasing the number of teachers of mathematics and science (especially teachers drawn from under-represented minorities); and for 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 not only with subject-content knowledge and with knowledge of teaching materials and techniques, but also with the effective use of that knowledge in teaching then is learned 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 field, 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. School 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.

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.

Chapter 6.

System Accountability

Chapter 6.

System Accountability

Accountability: Going Beyond Assessment

Assessment is not synonymous with accountability. The word assessment, when employed as an abbreviation for *student* assessment, refers to a set of criteria and instruments for measuring student learning. In a broader sense, it also is applied to sets of criteria and procedures from measuring the effectiveness of teachers, school administrators, and school boards.

Accountability, on the other hand, is a system of interrelated elements that include public policies, P-12 content standards and student assessment, performances of P-16 institutions and governing boards, public reporting of performance, rewards, sanctions, and continuous improvement. While assessment is applied to students, teachers, schools, and boards to provide information for data-based decision making, accountability is applied to all aspects of an education system in order to improve outcomes.

Most existing education accountability policies and practices focus on the P-12 segments of P-16 systems. However, the term *system accountability* as used here is meant to imply that it is the entire P-16 education system, not only parts of it, that must be held accountable for student achievement. The system comprises government officials, college and university administrators, 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.

If data on poor test performances is to be used to sanction schools through such things as public embarrassment, forced re-staffing, loss of funds, reduced budgetary control, or voluntary student transfers, then documentation of empty rhetoric, poorly designed and implemented policies, and allocation of inadequate resources certainly should be grounds for comparable sanction of public officials. No key group of education stakeholders should escape scrutiny.

Growth of the System Accountability Concept in Education

State Mandates:The Origin of P-12 System Accountability

State-level education accountability programs were initiated decades ago to measure the kinds and quantity of resources that states and districts provided as "inputs" to the P-12 level of their education systems. Those inputs — the number of certified teachers, the length of the school day and year, and the number of library books — were reviewed as part of a school accreditation process performed by an independent accreditation association or by the state as a means of determining the quality of the education system.

But by the mid-1980s, it became clear that focusing solely on inputs to an education system did not result in increased student achievement. Student achievement remained poor because no one in the education system was held responsible (accountable) for student performance. Education needed to broaden its evaluation focus from inputs to outputs, from the quantity and quality of the system's resources to the quantity and quality of the system's graduates, and from P-12 to P-16.

Federal Mandates: Raising the Stakes of P-12 System Accountability

The 1994 IASA focused national attention on the nature of state and district education accountability programs. IASA required states to establish challenging P-12 content and performance standards; to implement assessments that measured student performance against those standards; and *to hold schools and school systems accountable for the achievement of all students.*

IASA mandated that each state or district develop a single P-12 accountability program applicable to all students. The state was to use that single system statewide to determine if schools and districts were achieving targeted goals for helping all students meet state standards; to identify schools that did not reach the adequate yearly progress goals for all students during two consecutive years; to target appropriate resources to these schools; and, if necessary, to take strong corrective actions such as replacing staff or closing the school.

But implementation of IASA nationwide was uneven. Six years after the law took effect, only 22 states had single-system accountability programs in place. More than half of the states had dual accountability programs. In the dual-system states, one set of measures of adequate yearly progress were applied to "most" schools. However, a different set of measures were applied to those schools that qualified for federal funds intended to improve the performance of disadvantaged children (Title I schools).

In addition, benchmarks for judging the successful implementation of IASA varied from state to state. States differed both in

Figure 6.1

State-Adopted Accountability Policies

Policy	No. of States with that Policy
State requires school-level "report cards" relative to NCLB criteria	48
School report cards include disaggregated student performance data by	
Race/ethnicity	20
Poverty	19
Limited English proficiency	20
Special education/disabled students	25
High school report cards include disaggregated graduation/dropout rates	1
State assigns rating to all schools or identifies low-performing schools	30
State provides assistance to low-performing schools	28
State accountability program includes sanctions	23
School closure	11
Reconstitution	19
Reconstituting schools as charter schools	4
Permitting student transfers	12
Turning over schools to private management	6
Withholding funds	3
State provides rewards to high-performing and improved schools	17

the percentage of students required to reach the state-defined level of proficiency and in the timeline given for reaching proficiency.

Only one-third of the states focused on closing the gap between low- and high-achieving students in their Title I schools, and few states required schools to close the documented achievement gaps for students of color, students from low-income families, and students with disabilities and limited English proficiency.[175] Simply put, the federal government did not enforce measures of IASA that were intended to hold states accountable for its implementation.

In passing NCLB in 2002, Congress strengthened the educational accountability provisions of IASA. For instance, NCLB:

- sets specific starting dates and schedules for testing all pre-college students in reading, mathematics, and science;
- requires that a single measure be used in reporting the annual yearly progress of all students, schools, and school districts;
- delineates the types of corrective action that states and districts should take when schools fail to make adequate progress;
- establishes a target date (12 years) by which all students must score at a state-defined Proficient level;
- holds states, school districts, and schools accountable for the adequate yearly progress of subgroups of students; and
- sets a date by which states must have a highly qualified teacher in every elementary and secondary school classroom.

A state's failure to comply with NCLB's accountability provisions can result in the loss of federal education funds. Also, students in low-performing schools must be given the option of transferring (along with their state funding) to a school that is not low-performing.

Nationwide Variation in States' P-12 Accountability Programs

Despite increased state attention to education accountability in response to NCLB, the details of accountability programs relative to P-12 differ greatly from state to state. This widespread variation in state-legislated accountability policies is illustrated (see Figure 6.1) in data from a 2003 *Education Week* report.[176]

States also differ with respect to the combination of criteria that determine whether a district or school qualifies for a reward or for some form of state intervention to help improve student performance. The criteria listed in Figure 6.2 were gathered from state statutes and regulations and from state departments of education documents by the ECS.[177]

Figure 6.2

Criteria Used to Trigger Rewards & Interventions

Criteria	No. of States
Student achievement/ assessment scores	32
Improvement in achievement/ assessment scores ("value added")	21
Student attendance rate	17
Dropout rate	13
Graduation rate	8
Student behavior	6
Transition (education or employment after high school)	4
Expenditure and use of resources	3

States also vary in the details of the performance goals of their accountability programs. While most states have established standards of proficiency for some or all students, those standards are not comparable across states because states use different assessment instruments and set different minimal "cut scores" for different performance levels. A study of states' cut-score definitions for Proficient performance in mathematics in grades four and eight found that:[178]

- proficiency standards among states differ enough to cause substantial differences in the percentage of students categorized as proficient from one state to another, even if the students measure exactly the same skills; and
- proficiency standards within individual states differ enough across grades that they may provide teachers with inconsistent proficiency indications for a large percentage of students.

States also differ with respect to the percentages of students that are expected to meet Basic or Proficient scores and with respect to the length of the timelines under which students are expected to reach proposed performance benchmarks.[179]

Design Requirements for a Value-Added Accountability System

NCLB gives high priority to the annual assessment of student performance as an element of a state accountability program. A closely associated feature of some accountability programs is a value-added design that tracks the incremental value that the system of education adds to the performance of each student as the student moves through the system. Ohio's Project SOAR (Schools' Online Achievement Reports) is one example of an accountability program that supports the application of value-added assessment both to individual students and to groups of students.

At the foundation of a value-added accountability system are detailed data on each student. Collecting data on each student is the primary requirement of a statewide student data collection system proposed by the National Center for Educational Accountability (NCEA).[180] NCEA's nine data system requirements are:

- assignment of a statewide student identifier to each student in the system;
- individual student-level information on enrollment, demographics (for example, race, economic status), and program information;
- individual student scores on state exams;
- information on students not taking state exams, including why each student did not take a particular exam;
- high school course-completion data on individual students;
- individual student results on ACT, SAT, and College Board's AP exams;
- individual student high school completion and dropout data;
- auditing of the state data-collection process; and
- ability to match K-12 student data with postsecondary performance data.

Finally, designers of education accountability programs should note that such recommendations on data-gathering need to be embraced as carefully as a porcupine. Lacking plans for the careful analysis, thoughtful use, and security of the data gathered and stored, the educational progress of both individual students and the system as a whole can be badly injured. Accountability systems themselves must be held accountable.

States' Challenges in Implementing P-12 Accountability

States exhibit considerably commonality with regard to the challenges they face in implementing effective accountability programs that satisfy NCLB.[181] While educators, business leaders, policymakers, and the public are generally supportive of higher standards for all students and of annual assessment of student progress, there has been widespread distress as NCLB accountability criteria have come into play.

Communities have responded with shock and anger when schools they considered to be good or excellent were designated "low-performing" under NCLB. Classification as a low-performing school resulted when disaggregated performance data revealed that particular student groups in the school (low-income or limited English proficiency students, for example) were not making adequately yearly progress.

In reaction to public outcry, some states have redefined (lowered) expectations and extended implementation schedules by several years. Some states have opted to lower the "cut scores" of their proficiency ratings, thus ensuring a higher student passage rate and avoiding the loss of federal education funds. Also in reaction to the consequences of high-stakes assessments and accountability measures, students, parents, and the general public are challenging systems' promotion and graduation requirements.

The federal government's accountability expectations call for major expansion of testing programs. Because this costly expansion comes at a time when state and local education budgets are badly strained, it has led some states and districts to abandon the development and use of customized, criterion-based tests that are closely matched to their standards. They are turning instead to the use of machine-scored, off-the-shelf tests that, while less expensive, often are poorly aligned with the systems' content standards and, hence, are less valuable as a diagnostic tool.

The finance challenge is further complicated by the federal mandate that states and districts provide tutors and supplementary programs to assist students who are not making adequate yearly progress. They also are required to provide intervention services to improve low-performing schools. States are anticipating that from 30 percent to 80 percent of their schools will qualify for and request such intervention services.[182]

NCLB requires that every teacher of mathematics must be highly qualified by 2004, and that every teacher of science must be highly qualified by 2006.The challenge of complying with these teacher quality provisions is twofold. On the one hand, budgetary issues present a challenge. Highly qualified teachers cost more than uncertified teachers or teacher aides. Some states and districts find that their current and anticipated budgets do not even permit them to continue to employ the existing teacher force.

A second and far greater challenge to satisfying the highly qualified teacher mandate is posed by a national shortage of teachers of mathematics and science at a time when state and district policies are requiring all students to take more mathematics and science. The demand for teachers of mathematics and science is steadily increasing, but the supply is decreasing. The shortage is especially acute in areas with concentrations of high-poverty schools.

Focusing System Accountability on Improving Student Performance

The accountability provisions of NCLB call for a holistic approach to the design and implementation of state accountability programs. States are rethinking the structure, purpose, and emphasis of their accountability systems. Their thinking draws upon organizations such as ECS, which has summarized the key policy issues state leaders face in overhauling an accountability system.

Prior to the enactment of NCLB, ECS initiated a project to develop "next-generation" improvement-focused accountability models designed to help states expand the use of their accountability systems from only reporting how well schools and students are doing to actually designing and using their accountability systems to bring about system-wide improvement.

Five ECS accountability models represent a shift from "keeping score" to focusing on improving student learning. All five models assume application within a standards-based system, but each uses different theories of change and improvement to address different needs and situations and is designed to work under various conditions.[183]

Expanding System Accountability from P-12 to P-16

In 1999, the ACE argued the need for direct involvement of college and university presidents in improving teacher quality. ACE recommendations regarding that involvement recognized teacher education as a P-16 endeavor and included teacher education accountability responsibilities for institutions of higher education.

Specifically, college and university presidents were called upon to "mandate a campus-wide review of the quality of their institutions' teacher education programs" and to "commission [in cooperation with their governing boards] independent appraisals of

Value-Added Analysis in Ohio: Project SOAR

Project SOAR (Schools' Online Achievement Reports) is a Battelle for Kids initiative designed to help Ohio school districts improve student performance. The centerpiece of the project is a secure web site educators can use to view district, building, grade, and student-level performance data.Project SOAR produces reports at the school and grade levels — not at the classroom or teacher levels. Project SOAR's value-added analysis of student performance data assists districts in their efforts to focus on instruction to improve performance and raise achievement levels.

Value-added analysis adds an important new dimension to an education accountability program by measuring whether schools and districts are making progress toward reaching the state's standards. The value-added methodology offers a way to gauge district, school, and program effectiveness. It provides critical data with which to analyze the impact of various educational, instructional, and program practices on student achievement levels.

Project SOAR methodology has the potential to create a more comprehensive accountability program. For instance, Ohio now measures only how students perform against its standards proficiency "bar." This annual report presents a "snapshot" of school building achievement. It is based on a single assessment of a group of students at a single point in time. The procedure does not track the progress of that group of students over time.

In contrast, value-added analysis provides a "big picture" overview that tracks both individual student progress and students in groups during multiple years.

Project SOAR is being piloted in 42 volunteer school districts across the state. Project staff meets with each district individually to train district staff on the use of the value-added reports. A year-long training program has been developed to build the internal capacity of district teams to use the data to focus on instruction to improve student achievement.

Battelle for Kids
Project SOAR
http://www.battelleforkids.com/b4k/rt/initiatives/SOAR

10 Steps to a Standards-based Accountability Program

State policymakers should consider 10 key policy issues when designing and implementing accountability programs:

1. **Define Purposes and Goals.** Identify desired purposes and design an accountability program to serve all of those purposes effectively. One way to do this is with a coordinated accountability program that satisfies different purposes at different levels of the education system.

2. **Establish a Design and Implementation Process.** Appoint a working group or create an independent panel charged with the design, implementation, and maintenance of the accountability program.

3. **Decide Who Will Be Held Accountable and How Performance and Progress Will Be Measured.** Design an accountability program that articulates expectations for all education system participants — students, schools, legislature, state and local school boards, state departments of education, higher education, district administrators, teachers, parents, and community and business leaders.

4. **Decide How Performance and Progress Will Be Compared.** The performances of students, schools, or districts might be compared by using an absolute performance standard, a value-added standard (gain scores), or percentile rankings on standardized tests.

5. **Decide What Levels of Data to Collect and Report.** Data can be collected and reported to allow comparisons at the international, national, state, district, school, or individual student level. The appropriate levels of comparison are determined both by the purposes of the accountability program and by cost considerations.

6. **Weigh the Costs.** Features that increase accountability program costs include: custom-developed tests; annual development of new tests; "hand-scored" tasks or test items; assessing several grades or subject areas; testing all students rather than a sample; refining tests' technical quality to ensure legal defensibility; and rewarding high-performing schools.

7. **Create Rewards, Sanctions, and Other Incentives.** Select rewards and sanctions that have high potential for focusing teachers' work, motivating school improvement efforts, and improving teaching and learning. Implement sanctions on a continuum, starting with assistance and possibly ending with a "state takeover."

8. **Help the Public Understand Results.** Help the public understand what leads to the specific rewards and sanctions and why such actions are likely to be productive. Educators and policymakers must explain new reporting formats and how a standards-based accountability program differs from previous accountability programs.

9. **Support Teachers, Schools, and Districts.** Give equal attention to creating the conditions for effective teaching and to holding schools accountable for results. Support effective teaching by revising licensing, certification, and professional development standards, by organizing professional development centers, by allocating additional teaching resources, by developing reform networks, or by providing direct assistance to schools and districts.

10. **Fine-Tune the Program.** Demonstrate commitment to the accountability program with a plan to evaluate, refine, and sustain it over time. Without such visible commitment, accountability may be perceived as just another state-imposed program.

Education Commission of the States, 1998
Designing and Implementing Standards-based Accountability Systems
http://www.ecs.org/clearinghouse/33/44/3344.htm

Next-Generation Models of Education Accountability

"Next-generation" accountability models offer states a variety of approaches to bring about improvement in schools and student performance across a standards-based education system. The models' development was guided by seven principles drafted by the National Forum on Accountability, a 23-member panel of educators, teachers, business leaders, and policymakers:

- The purpose of accountability systems should be to improve teaching and learning so that all students reach challenging standards.
- Accountability should be expanded to include all levels of the education system — state, district, school, and classroom.
- Adults in the system should be held accountable for student performance.
- Better — and multiple — measures should be used to hold the system accountable.
- Accountability results need to be more timely and useful.
- System capacity should be built to support better data use.
- Accountability systems should be evaluated on an ongoing basis.

The principles were used to develop five different next-generation accountability models:

1. *The Regulated Market Model* combines a market system of choice with standards-based reform. Some regulations are included to ensure the public interest and investments in education capacity. Market forces — choices by families, educators, and school operators — ensure accountability.

2. *The Teacher Professionalism Model* uses a career-development system based on standards for teacher preparation, teacher licensing, induction, career progression, and teacher performance. Meeting high professional standards and improving student achievement ensure accountability.

3. *The Quality Improvement Model* rests on the belief that improving product quality (student achievement) relies on the improvement of process quality (teaching and learning). Accountability is based on student gains in achievement and on a performance review of quality processes.

4. *The K-16 Model* uses standards to align high school graduation requirements to college admission requirements. System indicators, coupled with incentives and consequences, seek to keep the system aligned and create multiple pathways to postsecondary education.

5. *The Community Involvement Model* recognizes that student achievement reflects the contribution of parents and a variety of community-based organizations, in addition to schools. A community-wide strategic planning process, coupled with the allocation of resources to those organizations contributing to the community's goals, is the backbone of this accountability mechanism.

For each model, various "supporting conditions" are identified. These conditions often include significant policy changes; a more deregulated system to allow increased decision-making at the school level; and capacity-building to help educators and others learn the "how" of improvement while holding multiple stakeholders accountable.

Education Commission of the States, 2003
Next-Generation Models of Education Accountability
http://www.ecs.org/html/issue.asp?issueid=206

…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.

the quality of their institutions' teacher education programs."[184] Education is a P-16 system endeavor. Education accountability is a P-16 system responsibility.

Recommendations for System Accountability

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 for 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 difficulties 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 when students enter middle school.

Chapter 7.

Roles for Business and Higher Education

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Roles for Business and Higher Education

Sharpening the Focus of Business and Higher Education

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.

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.

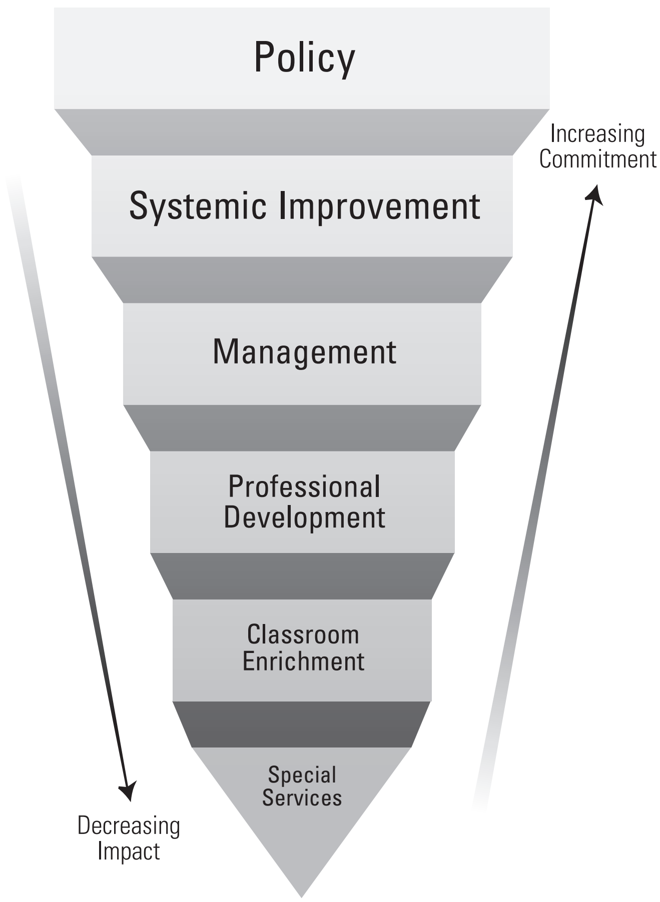
About 15 years ago, the National Alliance of Business (NAB) analyzed the business community's education investment portfolio in terms of the types of partnerships through which businesses were supporting improved student learning.[185] It identified six types of partnerships in that portfolio. While 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 Service Partnerships (lowest impact). (see Figure 7.1)

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

Figure 7.1

Multilevel Partnerships:
Levels of Impact on Educational System



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

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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.

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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."[186]

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 continuing underscored the importance of the deep and sustained involvement of a core group of business leaders.[187] 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.[188]

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 improvement of the entire system.

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 state policymakers — governors, legislators, and 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's 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 enrichment, and special services 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 both 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:

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 NCTM and the 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.[189] Rising enrollments have been attributed to open admissions policies, proximity to jobs and family, primary institu-

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 — …

tional 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.[190] Approximately 20 percent of teachers currently begin their work in community colleges.[191] 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.[192] 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.[193] A survey conducted by the CBMS 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.[194]

In the year 2000, those community college enrollments included 18,000 students who were taking Mathematics for Elementary School Teachers.[195] 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.[196] In 2000, about 35 percent of community college freshmen were enrolled in a remedial course in mathematics.[197]

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.[198]

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:

Support P-16 Council Work

Directly Support the Mathematics and Science Education System Reform Work of the State's P-16 Council

- 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 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.

Evaluate Admissions Policies and Courses of Study

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 Teacher Education

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 just 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.

Chapter 8.

Coordinated National and State Public Information Programs

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The Public's Role in System Change

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.

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.

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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 same quality as 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; 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 the advancement of, a state P-16 system of education.

The campaigns should be designed and executed in collaboration with the business community and professional organizations of mathematicians, scientists, and engineers.

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 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.[199]

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.[200]

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.

Sample Core Messages for a Public Information Campaign

The following are offered as examples of potential core messages. They require 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 key to 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 American 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.** Partic-

All students should have access to mathematics and science coursework that will prepare them for successful post-secondary study in higher education or the workplace. Failure to complete high-quality curricula closes doors now and in the future.

ular 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

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 the 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 NCLB; and
- national media campaign information transmitted to the states to assist in state-level media campaigns.

References and Acknowledgments

Glossary of Abbreviations

AAAS	American Association for the Advancement of Science
AAU	Association of American Universities
ACE	American Council on Education
ACT	American College Test
ADP	The American Diploma Project
AMS	American Mathematical Society
AP	Advanced Placement
ARC	Alternatives for Rebuilding Curricula
BHEF	Business-Higher Education Forum
BSCS	Biological Sciences Curriculum Study
CBE	Council for Basic Education
CBMS	Conference Board of the Mathematical Sciences
CCSSO	Council of Chief State School Officers
CEEB	College Entrance Examination Board (now The College Board)
CESAME	Center for the Enhancement of Science and Mathematics Education
CPRE	Consortium for Policy Research in Education
DOE	U.S. Department of Education
ECS	Education Commission of the States
EDC	Education Development Center, Inc.
ETS	Educational Testing Service
GEAR UP	Gaining Early Awareness and Readiness for Undergraduate Programs
IASA	Improving America's Schools Act of 1994
LASER	Leadership and Assistance for Science Education Reform
LAUSD	Los Angeles Unified School District
LSAMP	Louis Stokes Alliance for Minority Participation
MAP	Mathematics Achievement Partnership
NAB	National Alliance of Business
NAEP	National Assessment of Educational Progress
NASBE	National Association of State Boards of Education
NASH	National Association of System Heads
NCEA	National Center for Education Accountability
NCLB	No Child Left Behind Act of 2001
NCREL	North Central Regional Educational Laboratory
NCTM	National Council of Teachers of Mathematics
NNER	National Network for Educational Renewal
NRC	National Research Council
NSES	National Science Education Standards
NSF	National Science Foundation
NSTA	National Science Teachers Association
OECD	Organisation for Economic Co-operation and Development
OSHA	Occupational Safety and Health Administration
P-12	Pre-kindergarten through high school
P-16	Pre-kindergarten through higher education
PISA	Program for International Student Assessment
S4S	Standards for Success
SAT	Scholastic Aptitude Test
SCI	Science Curriculum Implementation Center
SEC	Survey of Enacted Curriculum
SOAR	Schools' Online Achievement Reports
SSI	Statewide Systemic Initiative
STEM	Science, Technology, Engineering, and Mathematics
TIMSS	Third International Mathematics and Science Study (also, Trends in International Mathematics and Science Study)
WWC	What Works Clearinghouse

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