Preparing Our Children

Math and Science Education in the National Interest

National Science Foundation

MARCH 1999

National Science Board

NSB

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Acknowledgments

TASK FORCE ON MATHEMATICS AND SCIENCE ACHIEVEMENT

The Task Force on Mathematics and Science Achievement, or "TIMSS Task Force," was created in March 1998 by then-NSB Chairman Richard N. Zare in the wake of the Third International Mathematics and Science Study. The Task Force reported to the NSB Committee on Education and Human Resources (EHR).

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This report may be accessed at the NSB website <www.nsf.gov/nsb/documents/>. The NSB also welcomes your comments by telephone (703/306-2000; TDD: 703/306-0090) or mail:

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Executive Summary

". . . as American schools fail more youngsters, this nation's capability to innovate, solve problems, and produce—to sustain world leadership—*is in jeopardy.*"

In a culture dedicated to opportunity for all, nothing is more important than preparing our children for the future workplace. For a mobile population, local schools are *de facto* national resources for learning.

The National Science Board (NSB), charged with advising the President and the Congress on national science policy, urges a nation-wide consensus on a core of knowledge and competency in mathematics and science. The Board believes it is both possible and imperative to develop national strategies that serve the national interest while respecting local responsibility for K-12 teaching and learning.*

In this report, the NSB draws on research and analysis that show how stakeholders working in their home communities can converge on what matters most in promoting student achievement. The Board further suggests that the science and engineering communities—both individually and through their institutions—represent a special resource for local schools, teachers, and students.

Math and Science Standards in the National Interest

The future of the Nation depends on a strong, competitive workforce and a citizenry equipped to function in a complex world. That interest encompasses what every student in a grade should know and be able to do in mathematics and science. The connection of K-12 content standards to college admissions criteria is vital for conveying a national expectation: educational excellence improves not just the health of science, but everyone's life chances through productive employment, active citizenship, and continuous learning.

According to the National Center for Education Statistics, one in three students changes schools more than once between grades 1 and 8. Thus, the needs of our mobile student population beg for some coordination of content and resources. This is a systemic problem that demands systemic solutions. For U.S. student achievement to rise, no one can be left behind.

The Board believes that stakeholders must develop a much-needed consensus on a common core of mathematics and science knowledge and skills to be embedded consistently in classroom teaching and learning.

NSB

Imparting core competencies neither defines an entire curriculum nor precludes locally-held prerogatives about the content of curricula. For example, NSF, NASA, and other agencies have funded instructional materials development that reflects professional consensus on what constitutes teachable and rigorous content in mathematics and science. The evaluation and distribution of such materials help districts, teachers, and administrators make informed choices among resources.

*The National Science Board first articulated this belief in *Failing Our Children: Implications of the Third International Mathematics and Science Study*, July 31, 1998, NSB-98-154.

Areas for Action

Implementing standards creates opportunities to change both the conditions for learning and the performance of U.S. students. The recommendations that follow suggest strategies for implementing the Board's core belief. Of special emphasis are areas of action in which the science community can collaborate to advance the consensus on core competencies. The NSB proposes three areas for consensual national action to improve mathematics and science teaching and learning: instructional materials, teacher preparation, and college admissions.

According to the Third International Mathematics and Science Study (TIMSS), U.S. students are not taught what they need to know. Most U.S. high school students take no advanced science, with only one-quarter enrolling in physics, one-half in chemistry. From the TIMSS analysis we also learned that mathematics and science curricula in U.S. high schools lack coherence, depth, and continuity, and cover too many topics in a superficial way.

Without some degree of consensus on content for each grade level, textbooks will continue to be all-inclusive and superficial. They will fail to challenge and motivate students to be curious and use mathematics and science as ways of knowing.

RECOMMENDATION 1

Instructional Materials

To implement its principal recommendation through instructional materials, the NSB urges (a) broad adoption of the principle of citizen review; (b) active participation on citizen advisory boards by educators and practicing mathematicians and scientists, as well as parents and employers from knowledge-based industries; and (c) use of public forums to foster dialogue between textbook publishers and advisory boards in the review process. Accompanying this process should be a national dialogue on appropriate measures for evaluation of textbooks and instructional materials for use in the classroom.

Student achievement should reflect the value *added* by schooling. Asserting that "all children can learn" reflects the power of standards and accountability. Through district-level policy changes in course and graduation requirements, all students can be held to the same high standard of performance. At the same time, teachers and schools must be held accountable so that race, ethnicity, gender, physical disability, and economic disadvantage can diminish as excuses for subpar student performance.

Amidst education experimentation across the U.S., the *Washington Post* noted last Fall that "class size, physical resources, local administration—can help. But good teaching is the vein of gold. To mine it, we'll have to pay more to attract and keep the best. And we'll need to be sure we get our money's worth by requiring strong preparation, and performance up to measurable standards."

According to the National Commission on Teaching and America's Future, as many as one in four teachers is teaching "out of field." The National Association of State Directors of Teacher Education and Certification reports that only 28 states require

RECOMMENDATION 2

Teacher Preparation

To implement the principal recommendation through teacher preparation and professional development, the NSB urges formation of three-pronged partnerships: institutions that graduate new teachers working in concert with national and state certification bodies, and local school districts. These partnerships should form around the highest possible standards of subject content knowledge for new teachers, and aim at aligning teacher education, certification requirements and processes, and hiring practices. Mechanisms for the support of teachers, such as pay supplements for certification, should be implemented through partnerships.

prospective teachers to pass examinations in the subject areas they plan to teach, and only 13 states test them on their teaching skills.

Widely shared goals and standards in teacher preparation, licensure, and professional development provide mechanisms to ensure teacher quality. We cannot expect world-class learning of mathematics and science if U.S. teachers lack the confidence, enthusiasm, and knowledge to deliver world-class instruction. While updating current teacher knowledge is essential, improving future teacher preparation is even more crucial.

Providing the best possible teachers for our schools requires juggling the competing pressures faced by besieged districts, schools, and classroom teachers. The community partners of schools—higher education, business, and industry—share the obligation to heighten student achievement.

Content standards, clusters of courses, and graduation requirements bestow advantages on students. They illuminate the path to college and the workplace by forming a foundation for later learning, and draw students' career aspirations within reach. How high schools assess student progress, however, has consequences for deciding who gains access to higher education.

RECOMMENDATION 3

College Admissions

To implement the principal recommendation through the college admissions process, the NSB urges institutions of higher education to form partnerships with local districts/schools that create a more seamless K-16 system, increasing the congruence between high school graduation requirements in math and science and undergraduate performance demands; and offer faculty and student incentives that motivate interactions to reveal linkages between classroom-based skills and experiences and the demands on thinking and learning in the workplace.

Longitudinal data on 1982 high school graduates point to course-taking or "academic intensity," as opposed to high school grade point average or SAT/ACT scores, as predictors of completion of baccalaureate degrees. Nevertheless, short-term, quantifiable measures such as standardized test scores tend to dominate admissions decisions. Such decisions promote the participation of some students in mathematics and science, and discourage others.

Data suggest, too, that the cumulative disadvantages of family income will be compounded by admissions criteria that apply the wrong filters and restrict opportunities. State efforts to create a "seamless" education system—K-12 schools and colleges working together to set standards and curricula—and hold colleges accountable (much as schools already do) are laudable for tying state resources to performance.

Acting as "all one system" means that the strengths and deficiencies of one educational level are not just inherited by the next. Instead, they become spurs to better preparation and opportunity for higher learning. Partnering by an institution of higher education demands adjusting the reward system to recognize service to local schools, teachers, and students as instrumental to the mission of the institution.

RECOMMENDATION 4

Research

To implement the principal recommendation through research, the National Science Foundation and the Department of Education must spearhead the Federal contribution to science, mathematics, engineering, and technology education research and evaluation. Overall, the investment should increase—by the Federal government, private foundations, and other sponsors—in research on schooling, educational systems more generally, and teaching and learning of mathematics and science in particular.

Research Informing Practice

Policymakers, business leaders, and parents are increasingly vexed over the academic achievement of U.S. students. Clearly, the issues raised in this report shape a research agenda: What do we need to know and how best can we engender reliable and usable knowledge about, for example, *which* tests should be used for gauging progress in teaching and learning, and *how* children learn in both formal and informal settings? What would attract the participation of the requisite communities? How can an interagency portfolio of research be devised?

The National Science Board sees research, supported at a national level and in a global context, as a necessary condition for improved student achievement in math and science. Research on "what works" should inform those seeking a change in practice and learning outcomes, especially teachers. Like other professionals, teachers need support networks that deliver information, helping to refine and renew their knowledge and skills.

Conclusions: A Shared Responsibility

A generation ago, the NSB Commission on Precollege Education in Mathematics, Science and Technology advised: "Our children are the most important asset of our country; they deserve at least the heritage that was passed to us . . . a level of mathematics, science and technology education that is the finest in the world, without sacrificing the American birthright of personal choice, equity and opportunity."

The health of science and engineering tomorrow depends on improved mathematics and science preparation of our students today. But we cannot delegate the responsibility of teaching and learning mathematics and science solely to teachers and schools. And we cannot expect instant results.

Improved student performance in mathematics and science will be short-lived if the conditions for schooling do not change and our strategies are uninformed by research. These needs transform the national interest into a national imperative. Educational excellence K-16 is a shared responsibility and, above all, a tractable challenge to us all.

Student Achievement as a Shared Responsibility

"Without a standard, tests become mere comparisons among students . . . they measure what children bring to *school, not what they* learn in *school."*

Almost 10 years ago, President Bush and the state governors "set goals aimed at preparing all the Nation's children to improve their achievement in core subjects and outpace the world in at least math and science by 2000."[1] The urgency of the ensuing national debate on how to improve academic achievement by U.S. elementary, middle, and high school students—and the consequences of failing to do so—remains undiminished today. At issue is who ostensibly defines the content to be learned, and who ensures the opportunity to teach and learn it well. While resolutions will be local, the dialogue that precedes them should reflect experiences from across the Nation, as well as research and evaluation of processes and outcomes, including international comparisons.

The National Science Board (NSB), the governing body for the National Science Foundation, is charged with advising the President and the Congress on matters of national science policy.* Last July, the NSB issued *Failing Our Children*, a statement urging "all stakeholders in our vast grass-roots system of K-12 education to develop a nation-wide consensus for a common core of knowledge and competency in mathematics and science."† "In the new global context," the statement continues, "a scientifically literate population is vital to the democratic process, a healthy economy, and our quality of life."

Just as the inability to read puts a child at risk of truancy and becoming a school dropout, deficiencies in mathematics and science have become a barrier to higher education and the 21st century workplace. Preparation of new generations for entry to both of these worlds is a community responsibility; it cannot be delegated solely to teachers and schools. Thus, the articulation of K-12 content standards with college admissions criteria is vital for conveying the national expectation that educational excellence improves not just the health of science, but everyone's life chances through productive employment, active citizenship, and continuous learning.

Moreover, the future of the science enterprise is renewed through a continuous flow of talent into the Nation's science and engineering workforce—talent that embodies certain core skills and competencies derived from education and training shaped by the highest standards of quality.‡ The NSB believes that nothing is more essential to the health of the science enterprise than human resources—the *people* who are prepared for

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*As stipulated in the National Science Foundation Act of 1950, as amended, 42.U.S.C. Sec. 1861.*et seq.*

†National Science Board, *Failing Our Children: Implications of the Third International Mathematics and Science Study*, July 31, 1998, NSB-98-154 (hereafter referred to as the "July statement").

‡In its 1980 reauthorization in the Science and Engineering Equal Opportunities Act (42 U.S.C. 1885) and subsequently in Title I of the Education for Economic Security Act (20 U.S.C 3911 to 3922), NSF was given additional authority to increase participation by groups historically underrepresented in science.

careers that produce the next generation of knowledge, products, and processes in all sectors of the economy.

It is imperative to raise the voice of the science and engineering communities,* as the chief practitioners of research and education, in the national dialogue on improving the teaching and learning of mathematics and science. Together with elected officials, school administrators, classroom teachers, parents, and employers (especially those from knowledge-based industries), scientists and engineers bring a valuable perspective on mathematics and science as a way of knowing, a transferable skill, and a citizenship tool as we enter a new millennium.

In a culture dedicated to opportunity for all, nothing is more important than preparing our children for the future workplace. In the science, mathematics, engineering, and technology (SMET) education of all students, K-12 through post-graduate, the NSB believes that rigor and depth of content are keys to preparation.† Education reform is a long-term proposition. In this report, the Board sets forth what it considers the necessary conditions for academic achievement, including concurrence on what constitutes "basic skills" for the 21st century.

Science education in the U.S. has received several national wake-up calls since the launching of Sputnik in 1957, including the publication of *A Nation at Risk* in 1983. More recently, the Third International Mathematics and Science Study (TIMSS)[2] warned that America's children ages 13–17 are, on average, not leading, but *lagging* the world in mathematics and science achievement. Every parent—not just scientists, educators, and employers—should be alarmed by these results.

The school systems of high-performing countries share characteristics that can be gleaned from the TIMSS data. These data range from content analysis of textbooks, curricula, and classroom videotapes, to ethnographic case studies and surveys of teachers' attitudes and students' coursetaking.[3] The characteristics that emerge include:

- a coherent vision of what all students in each successive grade should learn, with a focus on a few topics in depth both in their textbooks and classroom instruction;
- instruction delivered by teachers well-prepared in the subject, who benefit from out-of-class opportunities to develop lessons, and consult regularly with teachers and other resource persons; and
- alignment between what is expected, taught, tested, and rewarded for students, teachers, and schools.

All high-performing countries show student gains between grades 3 and 4, and again between grades 7 and 8. The U.S. does not. Even in 4th grade, where U.S. students do well relative to those in other countries, their performance in physical science areas is

*The words "science" and "scientists" sometimes appear in this report as a shorthand for the principal participants in the community of "scientists, mathematicians, engineers, and technologists," as well as math and science educators at grades K-16. They are all central to what is sometimes called "SMET education."

†One of NSF's three overarching goals is to "Achieve excellence in U.S. science, mathematics, engineering, and technology education at all levels." This "requires attention to needs at every level of schooling and access to . . . educational opportunities for every member of society" *NSF in a Changing World: Executive Summary of The National Science Foundation's Strategic Plan* (1995, NSF 95-142): 3.

weak, foreshadowing their average performance at 8th grade and their unacceptably poor showing at 12th grade. When we compare our K-12 schools and curricula in light of the TIMSS results, we find many teachers lacking good content preparation and, in the aggregate, a muddled and superficial curriculum. Even excellent pedagogy cannot inspire learning what the world's best-performing children are expected to know in these circumstances. Amidst the diversity of students and systems—large and small, wealthy and disadvantaged, urban and suburban and rural—there is an overarching reality: in too many American schools there is too little quality science and mathematics being taught and learned.

"In the science, mathematics, engineering, and technology (SMET) education of all students, K-12 through post-graduate, the NSB believes that rigor and depth of content are keys to preparation."

In addition, while U.S. graduate education remains the envy of the world, the declining interest and participation of domestic students in science and engineering must be taken as a disturbing sign that K-12 mathematics and science education is failing to renew, expand, and prepare our talent pool.[4] This decline clearly suggests that the performance of U.S. students signals uneven preparation for college-level study, a lack of readiness for the world of work, an accumulating disadvantage in the global economic competition to come. A further implication, more subtle and harder to demonstrate, is that as American schools fail more youngsters, this nation's capability to innovate, solve problems, and produce—*to sustain world leadership*—is in jeopardy.

With such a prospect in mind, the National Science Board asks how to address the national interest through local strategies that promote academic achievement in mathematics and science. Drawing on research and analysis, this report asserts that stakeholders working in their home communities can converge on what matters most for mathematics and science achievement—rigorous content standards, high expectations for teaching and learning, teachers well-prepared in the subjects they are teaching, and meaningful measures of accountability. Such convergence can help clarify shared responsibility, identify where contention resides, and suggest how research can illuminate both what is known and what needs to be known. The Federal role in elevating education practice and student performance is catalytic and analytical—one resource among many helping to foster the conditions under which all students, schools, parents, and communities can together boost academic achievement.

Content Standards for All Schools

No topic in education has stirred more emotion than "standards." As communities debate the essence and intended influence of standards on what teachers teach and *their* children learn, the *national* interest often recedes from view. The national interest is grounded in the importance of a strong, competitive workforce for the future of the Nation and a citizenry equipped to function in a complex world. That interest encompasses what every student in a grade should know and be able to do in mathematics and science (among other core subjects). Today's mobile society means that local schools have become a *de facto* national resource for learning.

The NSB believes that stakeholders must develop a much-needed consensus on a common core of mathematics and science knowledge and skills to be embedded consistently in classroom teaching and learning.

In the remainder of this section, we address two issues that underpin this core recommendation: the need for standards in a mobile population, and the role of nation-wide standards in the context of local school governance.

Student Mobility

In the July statement, the NSB notes that "Students often move several times during their K-12 education, encountering varying curricula and instructional materials that cover an increasing number of topics while sacrificing depth and rigor." National data show that 31 percent of the 8th grade class of 1988 changed schools two or more times between grades 1 and 8.* Ten percent changed schools two or more times during high school, i.e., between 1988 and 1992. White students were less likely to move than ethnic minorities; students who lived with their mother and father during the 8th grade were less likely to have changed schools than students in single-parent or other family situations. And students in low-income families were more likely to change schools than students with family incomes exceeding $20,000. According to the U.S. Department of Education, "students change schools for academic, personal, and family-related reasons. Those who make frequent school changes can experience inappropriate placement in a new school, lack of continuity of lesson content, disruptions in social ties, and feelings of alienation. Teachers may also find it difficult to identify and meet the academic needs of the highly mobile student."[5] This "mobile student" segment of the school population also has implications for other phenomena that affect the Nation's workforce—high school dropouts and completions.†

" . . . mobility becomes another disadvantage that accumulates, leaving some children further behind or labeling them inappropriately."

*U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988, Base Year (1988) and Second Follow-up (1992) Surveys. Data that extend this time series will not be available until 2000. Also, mobility rates in urban districts are probably higher than this national average. The Houston Independent School District, for instance, reports a 38 percent mobility rate in 1998 (C. Lanius, personal communication, Sept. 18, 1998).

†Most strikingly, Hispanics—the fastest growing segment of the school-age population—drop out of high school at higher rates and attain lower levels of education than other groups. U.S. Department of Education, National Center for Education Statistics, *The Condition of Education—1998*, Indicator 24 <//nces.ed.gov/pubs98/condition98/c9824a01.html>.

Special local programs alone will not compensate for the learning deficiencies created by the movement of children between school districts. A sounder approach is student access to exemplary teachers and support that begins with agreement on the "minimum requirements" of what, say, all 5th graders should know and be able to do in mathematics and science. Without defining these requirements, mobility becomes another disadvantage that accumulates, leaving some children further behind or labeling them inappropriately.

If the content of instruction encountered by students in 5th grade math classes in Missoula is unlike its counterpart in Cincinnati, then every transfer student—regardless of what she has been taught and is prepared to learn—will have little opportunity (exacerbated by the lack of continuity) for making academic progress. This situation is all too common across the U.S.*

" . . . TIMSS demonstrated that content matters*—and students must have the opportunity to learn it."*

A remedy is *content*—instructional materials, teaching, and testing aligned to something beyond, or in addition to, a local standard that gauges learning by every old and new kid on the block. The needs of the mobile student population beg for some coordination of content and resources. Structures and practices must help to prevent mobile students—who tend to be ethnic minorities, poor, or come from one-parent families—from slipping through the cracks of a school or district. Better record-keeping is only a start. To help recognize learning needs, classroom teachers must be better informed about the content preparation of newly-arrived students.†

Student mobility illustrates a systemic problem that demands systemic solutions. Unless the needs of the mobile student population are addressed, other bigger problems loom. If school imparts too few skills, the teenager is at greater risk of dropping out and becoming dependent on another set of social services. If transience and mobility between schools reduces students' access to quality teachers, instruction, and materials because of content that lacks consistency across districts and grades, then guidelines that transcend statewide practices and help to minimize the disruptions of change should be welcome.

*Content standards need not encroach on teachers' creativity in presenting material. As Finn et al. ("Four Reasons Why Most [State Standards] 'Don't Cut the Mustard,'" *Education Week*, Nov. 25, 1998: 56, 39) put it: "Standards, if done right, should not standardize what happens within schools. Rather, they should free the schools from top-down dictates while obliging them to focus on results. This will enable various school models to emerge, from 'progressive' to 'traditional,' and everything in between—a range of choices that can better serve the needs and learning styles of children and the passions and talents of teachers" (quote from 39).

†For example, the IEP (Individualized Education Program) is a locally administered but nationally standard tool used to guide and monitor services specifically designed to meet the needs of special education students. Depending on the disability, a statement of goals, setting, and supports necessary for the student to perform academically must be completed, with parents' consent, before services can be provided, as stipulated in the Individuals with Disabilities Education Act (IDEA). One idea is to encapsulate a version of the IEP in a "digital portfolio," e.g. a CD-ROM, containing each student's academic history—what courses s/he has taken and learned at what level of proficiency. This would travel with the student, so that "receiving" districts would not have to rely on the records and responsiveness of "sending" districts. A version of this innovation was a prize-winner in the 1998 Bayer/NSF Award for Community Innovation competition that challenged student teams to use science and technology in developing solutions to real-life community problems. A team from Atlanta proposed T.A.S.K.—Tracking and Saving Kids Force, creating a clearinghouse to assist parents in locating, retrieving, and storing the school and immunization information of homeless and transient students. See <//www.nsf.gov/od/lpa/events/bayernsf/winrelea.htm>.

Standards and Accountability

A decade ago, national standards in mathematics and science began to be designed by the American Association for the Advancement of Science (AAAS), the National Council of Teachers of Mathematics (NCTM), and the National Academy of Sciences (NAS), in close consultation with all stakeholders in education—preschool to graduate school. These standards, while evolving, have been endorsed—generically if not specifically—by organizations as diverse as the American Federation of Teachers, The Business Roundtable, the Education Commission of the States, and the CEOs of over 200 Silicon Valley high-tech companies.[6]

"There is a threshold of preparation and competence that all future teachers of mathematics and science must initially reach, and then augment, as their careers unfold."

The reality today is that virtually all states have curriculum frameworks that use the NCTM, AAAS, and the NAS documents as points of reference for teaching challenging mathematics and science.[7] These independently-generated frameworks signify an emerging consensus that offers a national resource on which local districts across the U.S. can draw as they define "basic skills" and formulate guides to classroom practice.

The existence of frameworks has not translated content standards into widespread classroom practice.[8] "Translation," of course, requires change—teacher by teacher, textbook by textbook, classroom by classroom. There is no "one size fits all" implementation plan. In this sense, the Federal role in the national movement toward standards is at best supportive. "National" standards do not mean "federal," "federally mandated," "standardized," or "homogeneous." Indeed, the relation of "nation-wide" standards to state frameworks and to what is actually taught in classrooms remains murky at best.* Imparting core competencies neither defines an entire curriculum nor precludes locally-held beliefs and prerogatives about the content of that curriculum.

Rather, math and science competencies must try to anticipate future national needs as convergence on the definition, content, and use of standards continues to grow.[9] For example, NSF, NASA, and other agencies have funded instructional materials development, yielding models that reflect professional consensus on what constitutes teachable content standards in mathematics and science.† The evaluation and distribution of such materials help districts, teachers, and administrators make informed choices among innovative resources.‡

In a recent review of the status of standards, the President of the National Center on Education and the Economy identified what will reinforce high academic performance.[10] Attaining such performance, by pursuing the following, is consistent with the states' role as chief accountability agent:

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*In the words of a recent commentary, "Standards should not prescribe teaching methods, devise classroom strategies, or substitute for lesson plans. Standards are about ends, not means. Yet many states either do not understand this distinction or do not agree with it. Too often, pedagogy and ideology have seeped into their standards." See C.E. Finn, Jr., et al., *op.cit.*, 1998.

†NSF programs, for instance, support a range of projects. In its NSF oversight role, the NSB would apply the national policy analysis of this report to NSF programs designed to address the myriad needs of school systems. In its 1999 Government Performance and Results Act performance report, NSF will evaluate the outcomes of its investments in Education and Training. With this NSF report is in hand, the NSB could better address NSF portfolio questions.

‡For example, see AAAS' Project 2061 at <http://project2061.aaas.org>. This "Guidebook to Examine School Curricula" is part of the *TIMSS Resource Kit* at <//timss.enc.org/TIMSS/timss/curicula> and features a "curriculum analysis procedure" for evaluating existing classroom materials. It is part of the *TIMSS Resource Kit* found at <//timss.enc.org/TIMSS/timss/curicula>.

- assessments set to the standards (if you cannot accurately measure progress toward the standards, they are unlikely to influence behavior);
- curriculum set to the standards (what is taught is what is learned);
- incentives for the students to meet the standards (students presently have incentives to stay in high school to get the diploma, but little incentive to take tough courses or work hard);
- a relentless focus on results (develop a strong rewards-and-consequences system tied to the standards and directed to the staff of schools; making progress would be rewarded, repeatedly dismal performance would put jobs at risk);
- a modern accountability system (put performance standards in place, institute appropriate measures of progress, and decide how to raise the students to the standards); and
- accurate, detailed, up-to-date data on student performance (readily available to parents and policymakers).*

"But school districts should not be left to shoulder the burden of training that undergraduate education failed to deliver. This becomes an expensive form of compensatory teacher education . . ."

The reality of educational accountability lags these attainable prerequisites for student achievement. As *Quality Counts '99*, a survey of state policies on accountability, concludes, "most have a long way to go in making their accountability systems clear, fair, and complete." The survey finds, for example, that 49 states (all but Iowa) have or are drafting standards in core subjects, 48 now test their students, and 36 publish annual report cards on individual schools. Fewer than half publicly rate the performance of all schools or identify low-performing ones. Only 16 states have the power to close, take over, or overhaul chronically failing schools. While 19 require students to pass tests to graduate from high school, only two have attempted to tie teacher evaluations to student performance. Finally, while most states rely on test scores to help determine "rewards and sanctions," the focus is primarily on schools rather than individual educators, penalties are threatened but not imposed, and there is no agreed-upon strategy for fixing failing schools.[11]

Accountability may begin with standards. But because content standards are mere abstractions until melded with instructional and student performance standards, teaching and assessment are intimately (and perhaps inevitably) bound up in discussions of standards.[12] Bound up as well are expectations—not just of students but also of teachers, parents, and the Nation. Test performance, too, must be interpreted relative to something, be it expectations or course offerings, and coursetaking (i.e., curriculum and the opportunity to learn it). Without a standard, tests become mere comparisons among students—norm-referenced tests—uncalibrated by content. They also risk missing or mismeasuring complex cognitive and performance proficiencies. In the very worst case, they measure what children *bring to* school, not what they *learn in* school. Student achievement, in short, should reflect the value *added* by schooling, not the distribution of class or home (dis)advantages that characterize the U.S. student population. Stan-

*"What standards should do, among other things, is tell teachers what the experts think [based on research] is most worth teaching . . . Looked at that way, the changes that have taken place since the start of the standards movement are impressive, but not nearly enough. That is hardly cause for despair. It is cause for redoubled effort." M.S. Tucker, "The State of Standards: Powerful Tool or Symbolic Gesture?" *Expecting More* (Newsletter on Standards-Based Reform), 1 (Spring 1998): 2. Also see D. French, "The State's Role in Shaping a Progressive Vision of Public Education," *Phi Delta Kappan*, November 1998: 185–194.

dards should help us think about the relation of science literacy to basic skills. What those skills are fuels the ability to apply knowledge to new contexts and problems. Controversy over *how* students acquire them seems to distract communities from achieving what most avow is in the national interest.

Teachers' cognitive expectations, or what they believe the child can learn, set the stage for performance. Additionally, the child must be convinced of his/her own capability. Asserting that "all children can learn" reflects the power of standards and accountability: increasing mathematics and science graduation requirements (to at least three and preferably four years of each); eliminating remedial courses (and the tracking and ability grouping they denote); and holding principals, guidance counselors, and teachers—along with students themselves—accountable for academic improvement. All students can be held to the same high standard of performance, so that race, ethnicity, gender, physical disability, and economic disadvantage can diminish as excuses for subpar performance.*

Likewise, parents' expectations influence achievement. The research literature indicates that parents decide to become involved in the education of their children due to three principal factors: what they believe is important, necessary, and permissible for them to do with and on behalf of their children; the extent to which they believe they can exert positive influence on their children's education; and their perceptions that the child and the school want them to be involved. Various factors, but particularly change of residence, inhibit parental involvement.[13]

Of course, adoption of curricula with challenging content and parental involvement will not willy-nilly boost American students' academic achievement. Curriculum innovations have historically failed to influence teaching and learning practices due, in part, to teachers' scarce opportunities to learn new content and improve their practice. Although teachers are instrumental in student learning, no *one* component can transform the quality of schooling, improve student achievement, and communicate to all stakeholders (especially parents) why changes should be tried, indeed supported, before positive results will be observed (much less measured). That is why a systemic vision—the U.S. as a "common market" for knowledge workers with transferable skills—is needed to integrate all components of teaching and learning.

For U.S. student achievement to rise, a consensus on standards, from classroom to statehouse, must be forged. The recommendations discussed below all contribute to effective implementation of the Board's core recommendation. Implementation is addressed to areas of action for which stakeholders share responsibility. Of special emphasis are NSB proposals for how the science community can collaborate to advance the consensus on core competencies, and how national and international experience should inform decisions about mathematics and science teaching and learning.

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*Such changes are examples of "policy drivers" that are central to the program design of NSF's Urban Systemic Initiatives (USI). While each USI may follow a different reform trajectory for achieving the goal of system-wide, challenging mathematics instruction for all students, progress toward this goal—as reflected in student achievement data—is the chief outcome for which the districts are held accountable. "Such improvements are called 'systemic' because they fundamentally alter the school systems in which they occur." See L.S. Williams, *The Urban Systemic Initiatives (USI) Program of the National Science Foundation: Summary Update*, March 17, July 1998, quote from 3; and *The National Science Foundation's Urban Systemic Inititiatives (USI) Program: Models of Reform of K-12 Science and Mathematics Education* (Westat*McKenzie Consortium, October 1998).

Building a Seamless Education System, K-16

"Most innovative science curricula . . . stress inquiry, a connectivity among disciplines, a concern for societal implications, and a scientific 'way of knowing.'"

Content standards that nurture a science-literate population serve the national interest. Implementing standards creates opportunities to change both the conditions for learning and the performance of U.S. students. This is a call to transcend a dangerously balkanized system and assist local communities to support teachers and learners of mathematics and science, K-16. To reiterate the NSB July statement, "No nation can afford to tolerate what prevails in American schooling: generally low expectations and low performance, with only pockets of excellence at a world-class level of achievement."

The NSB proposes three areas for consensual national action to improve mathematics and science teaching and learning: instructional materials, teacher preparation, and college admission. We address each in turn.

Instructional Materials

U.S. students, TIMSS showed us, are not taught what they need to know. Most U.S. high school students don't take advanced science; they opt out, with only one-quarter enrolling in physics, one-half in chemistry. Instructional materials are not the only culprit, but surely contribute to this science-aversion. As the president of the American Physical Society puts it, "Both common sense and modern educational theory tell us that students, when asked to memorize disconnected facts without truly understanding them, quickly lose interest in the subject."*

From the TIMSS analysis we also learned that mathematics and science curricula in U.S. high schools lack coherence, depth, and continuity; they cover too many topics in a superficial way. In short, TIMSS demonstrated that *content matters*—and students must have the opportunity to learn it. While most countries introduce algebra and geometry in the middle grades, only one in four U.S. students take algebra before high school. Topics on the general knowledge 12^{th} grade mathematics assessment were covered by the 9^{th} grade in the U.S., but by 7^{th} in most other countries. In the general science assessment, topics in the U.S. were covered by 11^{th} grade, but by 9^{th} grade in other countries.

Students' exposure to challenging mathematics and science content is limited, it seems, by what is offered them and the coursetaking choices they make. According to TIMSS, 90 percent of U.S. high school students stop taking math before getting to calculus. Among college-bound students, half had not taken physics or trigonometry; three in four had not taken calculus, while one in three had taken less than four years of mathematics.

The TIMSS analysis also disclosed that most general science textbooks in the U.S. touch on many topics rather than probe any one in depth. The five most emphasized topics in

*Content is closely monitored due to its potential impact on the kinds of instructional materials that textbook publishers produce for students nation-wide. For example, see J. Basinger, "Coalition Lashes Out at California's Proposed Science-Education Standards for Schools," *The Chronicle of Higher Education*, Sept. 3, 1998 <//chronicle.com/daily/98/09/98090301n.htm>.

4th grade science texts accounted for 25 percent of total pages compared with an international average in the 70–75 percent range. General mathematics textbooks in the U.S. contain an average of 36 different topics; texts in Japan cover 8 topics, in Germany, 4-5. In middle school (grades 5-8), while the world proceeds to teach algebra and geometry, the U.S. continues to teach arithmetic. All high-performing countries show student gains between grades 3 and 4, and again between grades 7 and 8. The U.S. does not. Like others, the NSB believes this reflects a muddled, unfocused, repetitious, and superficial curriculum.

Without some degree of consensus on content for each grade level, textbooks will continue to be all-inclusive and superficial. If used as the foundation for instruction, these textbooks will fail to challenge and motivate students to exercise their curiosity and experience mathematics and science as ways of knowing.

At their best, curriculum materials energize learning. But we learn in different ways. Curriculum developers therefore offer alternative formats for their textbooks.* Some emphasize rote learning, others coherent knowledge of science content and process, sometimes with the concurrent use of mathematics.[14] Few introduce real-world interdisciplinary problems and serve as the foundation for Advanced Placement courses, school-to-work transition courses, or the challenges of a liberal arts college education.† Most innovative science curricula, for instance, seek coherence, integration, and movement from concrete ideas to abstract concepts. Furthermore, they stress inquiry, a connectivity among disciplines, a concern for societal implications, and a scientific "way of knowing." Taken together, they would foster in the high school graduate what we would term "science literacy."

Teaching and learning to high standards cannot be the province only of *some* schools, teachers, and students. To be systemic, 15,000 school districts should not engage in the same curriculum-based experiments and repeat all-too-familiar mistakes. They should reap the benefit of what other districts have tried. Since most decisions on textbooks and related instructional materials are made at state or local district levels, they frequently incorporate some mechanism for citizen review and advice.

RECOMMENDATION 1

To implement its core recommendation (above) through instructional materials:

1. The NSB urges (a) broad adoption of the principle of citizen review; (b) active participation on citizen advisory boards by educators and practicing mathematicians and scientists, as well as parents and employers from knowledge-based industries; and (c) use of public forums to foster dialogue between textbook publishers and advisory boards in the review process.
2. Accompanying this process should be an ongoing national dialogue on appropriate measures for evaluation of textbooks and instructional materials for use in the classroom. The NSB urges professional associations in the science community to take a lead in stimulating this dialogue and in formulating checklists or content inventories that could be valuable to their members, and all stakeholders, in the evaluation process.

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*Middle school math textbooks, for example, offer few excellent choices. Separate reviews by AAAS' Project 2061 and a parent group called "Mathematically Correct" found little agreement on which texts to recommend. They differ over learning strategies, with the Project 2061 review team of 24 teachers and mathematicians giving *Connected Mathematics* consistently high marks on the content criteria or "benchmarks" used to rate a dozen textbooks. See D.J. Hoff, "Reviews of Math Text Parallel Pedagogy Rifts, *Education Week*, Jan. 27, 1999 <www.edweek.org/ew/current/20math.h18>. Also see M.T. Battista, "The Mathematical Miseducation of America's Youth," *Phi Delta Kappan*, February 1999: 425–433.

†M.G. Bardeen and L.M. Lederman, "Coherence in Science Education," *Science*, vol. 281, July 10, 1998, pp. 178-179. By reconceptualizing the traditional sequence of biology, chemistry, and physics, for instance, science curricula face serious barriers to implementation. Materials and tests would have to change. Teachers would require professional

Teacher Preparation

Public opinion overwhelming favors "ensuring a well-qualified teacher in every classroom" as the top education priority. Indeed, teachers—once viewed as central to the problem of student underachievement—are now being recognized as the solution.[‡] In teacher preparation there is a "multiplier effect" that can span generations. While a sound undergraduate science education is essential for producing the next generation of scientists, it is equally critical for future teachers of science. The refrain, "you can't teach what you don't know,"[15] surely applies.

There are many signs that teachers in the classroom cannot rely on their undergraduate education when teaching mathematics or science. According to the National Commission on Teaching and America's Future, as many as one in four teachers is teaching "out of field." The National Association of State Directors of Teacher Education and Certification reports that only 28 states require prospective teachers to pass examinations in the subject areas they plan to teach, and only 13 states test them on their teaching skills.[16] Many students who turned away from mathematics and science in college become elementary school teachers.

The NSB thus believes that improving future teacher preparation is crucial for improving their performance in the classroom and the achievement of their students. One commentator has noted that all the experimentation in full bloom across the U.S.—"class size, physical resources, local administration—can help. But good teaching is the vein of gold. To mine it, we'll have to pay more to attract and keep the best. And we'll need to be sure we get our money's worth by requiring strong preparation, and performance up to measurable standards."[17] There is a threshold of preparation and competence that all future teachers of mathematics and science must initially reach, and then augment, as their careers unfold.

The distributed character of our education system and the diversity of higher education institutions illuminate the problem. Over 1250 colleges and universities prepare future teachers, and 700 are regularly audited by the National Council for the Accreditation of Teacher Education (NCATE), which has contractual relations with 36 States. But NCATE accredits programs, while the 50 States credential teachers,[18] and the teachers are employed by 15,000 independent school districts. This recipe for distributed responsibility has resulted in much variance in course requirements for budding teachers and uneven quality in teacher education. Maintaining, enhancing, and "scaling up" or spreading quality in a distributed system are difficult at best. Codified, widely shared goals and standards in teacher preparation, licensure, and professional development provide mechanisms to overcome these difficulties.

What we have learned about mathematics and science teachers already in the classroom is dismaying. While most teachers embrace a vision of high standards for all students, coop-

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development to compensate for *their* lack of command of content. Teamwork among teachers with the requisite expertise would be essential. Nothing short of a restructured school day and calendar would need to be instituted—in all, systemic change.

[‡]Teaching was recently hailed as "the essential profession." See J. Archer, "Public Prefers Competent Teachers to Other Reforms, Survey Finds," *Education Week*, Nov. 25, 1998: 6. The survey results for *The Essential Profession* can be seen at <www.rnt.org/tep.html>.

erative learning (in small groups), and the use of technology (computers and calculators), their instructional strategies fall short of the vision.* Many teachers lack support to plan and deliver quality instruction: 1 in 2 teachers feel inadequately prepared to integrate computers into instruction, and 2 in 5 feel inadequately prepared to use math or science textbooks as a resource rather than as the primary instructional tool, or to use performance-based assessments. Fewer than 1 in 3 teachers feel prepared to teach life science, and only 1 in 10 feel prepared for the physical science course they are teaching. In addition, more than a third of elementary teachers, and more than half of high school mathematics and science teachers in 1993, felt unprepared to involve parents in the education of their children!

Thus, in addition to teacher preparation, we have the continuing challenge of professional development, where school districts update the knowledge, skills, and strategies that teachers bring into the classroom. No professional is equipped to practice for all time, i.e., be an inexhaustible "vein of gold." We cannot expect world-class student learning of mathematics and science if U.S. teachers lack the confidence, enthusiasm, and knowledge to deliver world-class instruction.

"Acting as 'all one system' means that the strengths and deficiencies of one educational level are not just inherited by the next."

As a body of scientists and engineers, the NSB believes that content background matters for classroom performance. For example, the proportion of Presidential awardee teachers in mathematics and science with degrees in the fields they teach is much higher than in the total teacher population.†

Likewise, professional development—intensive and rigorous, with follow-up—can overcome flaws in content and pedagogical training. Recently, a decade-long study clearly established the links among professional development, changes in teaching practice, and improved student achievement in California.[19] But school districts should not be left to shoulder the burden of training that undergraduate education failed to deliver. This becomes an expensive form of compensatory teacher education—and a diversion of scarce resources that could be put toward much-needed merit-based salary increases for teachers, the purchase of new materials and classroom equipment, and ongoing professional development.‡

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*The most recent national study, based on a probability sample of 1250 schools and 6000 teachers in grades 1–12, is the 1993 National Survey of Science and Mathematics Education. See I. Weiss, "The Status of Science and Mathematics Teaching in the United States: Comparing Teacher Views and Classroom Practice to National Standards," *NISE Brief* (University of Wisconsin–Madison), 1 (June 1997): 1–8. A new U.S. Department of Education report, "Teacher Quality: A Report on the Preparation and Qualifications of Public School Teachers," based on a national survey of 4000 veteran and new teachers of all subjects (not just math and science) confirms these results. See J. Basinger, "Most New Schoolteachers Feel Unprepared for Recent Demands of the Classroom, Survey Finds," *The Chronicle of Higher Education*, Jan. 29, 1999, and <www.nces.ed.gov/pubsearch/pubsinfo.asp?pubid=1999080>.

†In 1996, a sample of 930 recipients of Presidential Awards for Excellence in Mathematics and Science Teaching, bestowed annually since 1982 on a mathematics teacher and a science teacher at the secondary level from every State and U.S. territory, was surveyed for the first time. The findings showed that over 70 percent of the high school Awardees had majored in a science discipline, compared to 54 percent nationally. Awardees in mathematics similarly majored in math in a proportion well beyond the national average (55 v. 39 percent). This survey was sent to 1390 Awardees with at least 15 years of teaching experience, yielding an 82 percent response rate. See I. Weiss and J. Raphael, *Characteristics of Presidential Awardees: How Do They Compare with Science and Mathematics Teachers Nationally?* (Chapel Hill, NC: Horizon Research, Inc., 1996).

‡For example, testimony at the NSB field hearing May 29, 1998, in Los Angeles on informal science learning indicated that museums and science centers are deeply involved in professional development of science teachers employed by districts in their proximity. This connection of the formal and informal systems is neither well-recognized nor systematically exploited. See especially the keynote address of the Executive Director and CEO of the L.A. Natural History Museum, James L. Powell, <www.nsf.gov/nsb/meetings>.

As another commentator notes, it is important to connect professional development to the evaluation of teachers and to student performance:

> The disconnect between professional development and growth-oriented performance appraisal is hard-wired into prevailing practice, if not into collective bargaining agreements. Few principals align their evaluations of teachers with expected competencies addressed through professional development. . . . What's good for students should be good for our teachers. In schools, professional development must be viewed as part of a comprehensive system . . . that supports teachers and administrators in continually improving their proficiency with respect to specific competencies linked to student-learning outcomes.[20]

"The NSB urges formation of three-pronged partnerships: Institutions that graduate new teachers working in concert with national and state certification bodies, and local school districts."

Without instructional quality control, motivating students to learn to world-class standards is futile. But teacher-strapped districts are apt to sacrifice quality for quantity—more experience for less salary—in hiring. State agencies routinely issue temporary, emergency, and provisional licenses.* The challenge of recruiting and retaining well-prepared teachers bumps up against other considerations, including reduced class size, which requires more teachers, straining the already limited supply of those with significant content background in mathematics and science.† A simultaneous increase in student enrollment levels and teacher retirements will increase the pressure to hire unqualified teachers.[21]

Only the resolve of all partners who contribute to the training, certification, hiring, evaluating, and professional development of math and science teachers will reduce "out of field" teaching.‡ Then those with solid grounding in these subjects will have to confront the quandary of career choice—alternative sources of attractive employment opportunities. For districts to compete with these opportunities, as the NSB stated in July, communities must build "a system of rewards and incentives, including appropriate salaries, for well-trained teachers who are knowledgeable about content and pedagogically skillful."

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*Some governors favor incentives to attract and retain qualified teachers. See, for example, "Taft Targets Math, Science Testing," *Columbus Dispatch,* Sept. 3, 1998. Voluntary certification through the National Board for Professional Teaching Standards is expected to grow as the districts coalesce on the implementation of content standards for students in core subjects (see <//www.nbpts.org>). It is germane here as well that references to the command of modern technology as a teaching necessity are barely visible in the education literature, with computer-aided instruction hardly seen as a mainstream tool in teacher preparation (see below).

†There has been much "political caterwauling about class size" (see L. Monteagudo, "MORE Teachers? What About the Ones We Have Now?" *Education Week*, Jan. 13, 1999: 72). Indeed, most new funding—over $1 billion—for education in the FY 1999 budget was designated for hiring new teachers to reduce class size. But any gain in individual student attention derived from reducing class enrollment from 22 to 17 will be nullified by that teacher's lack of content knowledge. As Monteagudo notes, "Especially in rural and inner-city areas, it is already hard enough to attract strong applicants. By earmarking Federal funds for hiring additional teachers as opposed to investing in the ones we have in place now, we are placing an even greater burden on those districts."

‡L. Pearlstein, "Schools Cautioned on Hasty Hiring," *Washington Post*, Sept. 16, 1998, p. A12. Education Secretary Riley is quoted as saying, "Too many school districts, I am afraid, are sacrificing quality for quantity in order to meet the immediate demand of putting a warm body in front of a classroom." More recently, the Secretary has been more blunt in challenging higher education institutions to make teacher preparation a priority, stating "Our colleges of education can no longer be the sleepy backwaters that many of them have been. There must be greater collaboration from all parts of the university community, including the arts and sciences." Quoted in J. Basinger, "College Presidents Must Lead Effort to Improve Teacher Training, Education Chief Says, " *The Chronicle of Higher Education*, Feb. 17, 1999. Related to this are the National Council for Accreditation of Teacher Education draft standards that would hold education programs responsible for the quality of their graduates' teaching. See "Draft Standards Issued for Teacher Education, " *The Chronicle of Higher Education*, Feb. 5, 1999: A38.

Ideas worth pursuing include: forgivable student loans and state income tax credits for new teachers with content certification, creation of a national job bank to assist school districts in locating teachers with the desired mathematics or science and grade level credentials, and awarding merit raises for the acquisition by teachers of specific skills and content concentrations.*

These factors create contradictory pressures for states and local districts. Convergence on what a science or mathematics teacher at the elementary, middle, and secondary level must know and be able to do in the classroom will be a key factor in resolving some of these contradictions.†

RECOMMENDATION 2

To implement the core recommendation through teacher preparation and professional development:

1. The NSB urges formation of three-pronged partnerships: institutions that graduate new teachers working in concert with national and state certification bodies, and local school districts. These partnerships should form around the highest possible standards of subject content knowledge for new teachers, and aim at aligning teacher education, certification requirements and processes, and hiring patterns.
2. Mechanisms for the support of teachers, such as sustained mentoring by individual university mathematics, science, and education faculty, as well as other teacher support mechanisms such as pay supplements for board certification, should be implemented through the three-pronged partnerships.

Ensuring the best possible teachers for our schools poses a formidable policy dilemma: how to juggle competing pressures on besieged districts, schools, and classroom teachers?[22] The community partners of schools—higher education, business, and industry—share the obligation to heighten student achievement. A combination of support for strong content and pedagogical preparation of teachers, continuing professional development linked to classroom performance and improved student achievement, and incentives that keep good teachers in the classroom provides an avenue for acting—in the name of accountability—upon that obligation.

Another avenue, using categorical Federal education programs such as Title I for poor children, would increase incentives for educators or students to do well.[23] One option, for example, would make improved performance part of the standard for payment under Title I, a provision that could be built into the Elementary and Secondary Education Act that is subject to reauthorization in 1999.

*Monetary incentives are endorsed not only by the president of the National Education Association, but also by the Committee on Science of the U.S. House of Representatives. See B. Chase, "Why Not the Best Teacher?" *Washington Post*, Sept. 20, 1998, p. C5; *Unlocking Our Future: Toward A New National Science Policy*. A Report to Congress by the House Committee on Science, Sept. 24, 1998 <www.house. gov/science/science_policy_report.htm.>; and summarizing the work of Linda Darling-Hammond, director of the National Commission on Teaching and America's Future, A.C. Lewis, "Just Say 'No' to Unqualified Teachers," *Phi Delta Kappan*, November 1998: 179–180. The President of the Council for Basic Education reminds us that the reauthorized Higher Education Act offers loan forgiveness to teachers willing to work in inner-city schools for five years. He proposes, as part of strengthening Social Security, waiving the cap on "retirement earnings for anyone involved in teaching or school administration." An incentive could be provided for states to do so as well. See C.T. Cross, "Retirees in the Classroom," *Washington Post*, Dec. 31, 1998: A27.

†For example, the U.S. Department of Education's Lighthouse Models of Excellence and NSF's Collaboratives for Excellence in Teacher Preparation program unite mathematics and science departments with colleges of education and local school districts in preparing content-based teachers. These programs, the Department's Eisenhower Professional Development Program, NSF's Local Systemic Change Initiatives, and other tools for teacher training are described in U.S. Department of Education and National Science Foundation, *An Action Strategy for Improving Achievement in Mathematics and Science*, Report of an Interagency Working Group, February 1998 (Arlington, VA: NSF 98-79), appendix 4.

College Admissions

Quality teaching and learning of mathematics and science bestows advantages on students. Content standards, clusters of appropriate courses, and graduation requirements illuminate the path to future advantages. They smooth the transition to college and the workplace by forming a foundation for later learning and drawing students' career aspirations within reach. But how high schools assess student progress has consequences for deciding who gains access to higher education and, moreover, who is prepared to succeed at the baccalaureate level and beyond. Congruence between what is needed to *exit* secondary education and *enter* higher education would be ideal. Because the metrics for each leave much to chance, how to define and predict student "success" remains a matter of contention.

Longitudinal data on 1982 high school graduates point to the role of course-taking or "academic intensity," as opposed to high school grade point average or SAT/ACT scores, in predicting completion of baccalaureate degrees. (Academic intensity refers to trigonometry, precalculus, and calculus, as well as laboratory science, especially chemistry and physics). By 1993, only 42 percent of black students who had gone directly into four-year colleges and universities had received the baccalaureate as compared to 72 percent of white students in the cohort.*

An education researcher recently observed,

> Grades are a crapshoot, varying wildly from teacher to teacher and from school to school; a single standardized-test score is merely a snapshot of a student's performance on a Saturday morning. But a student invests years in a course of study, which provides momentum into higher education and beyond. The effects of grades and tests diminish in time, but the substance of learning does not go away. . . . [So] which of these indicators—grades, scores, or courses—would you rather rely on in admissions decisions? In which area does achievement seem to be most meaningful for students' success? And which can educators change most easily? The student's course of study wins, hands down.[24]

Nevertheless, short-term and readily quantifiable measures such as standardized test scores tend to dominate admissions decisions. Such decisions promote the participation of some students in mathematics and science, and discourage others.†

*"Controlling for socioeconomic status, high school curriculum is 48 percent more accurate than test scores and 72 percent more accurate than class rank or grade-point average in predicting whether a student will get a bachelor's degree." C. Adelman, "Forget What Color You Are, It's Where You Went to School," *Washington Post*, Nov. 2, 1998: A19.

†The NSB Committee on Education and Human Resources has defined for further examination in 1999 the issue of standardized tests, especially the SAT and the GRE, in the college and graduate school admissions processes. The NSB study will build on W.G. Bowen and D. Bok, *The Shape of the River: Long-Term Consequences of Considering Race in College and University Admissions* (Princeton, NJ: Princeton U. Press, 1998); commentary such as "Elite Colleges' Race-Sensitive Policies Opened Doors to Black Success, Says Broad New Study, *The Chronicle of Higher Education*, Sept. 9, 1998 <//chronicle.com/daily/98/09/98090901n.htm>; E. Bonner, "Study Strongly Supports Affirmative Action in Admissions to Elite Colleges," *New York Times*, Sept. 9, 1998: B10; W.G. Bowen and D. Bok, "Get In, Get Ahead: Here's Why," *Washington Post*, Sept. 20, 1998: C1; and S.M. Malcom et al., *Losing Ground: Science and Engineering Graduate Education of Black and Hispanic Americans* (Washington, DC: American Association for the Advancement of Science, 1998).

Data suggest that the cumulative disadvantages of family income will be compounded by admissions criteria that apply the wrong filters and restrict opportunities.[*] For example, nearly 60 percent of low-income nonattending students cite an inability to afford college as the reason.[†] If preparation is the key to college access and enrollment, then we must find ways of reducing the achievement gap in high school performance between majority and minority students. There is new evidence that, even in suburban schools where family income and per pupil spending is high, peer pressure may suppress minority student performance.[25] This would suggest that out-of-class influences, which are less amenable to policy intervention, have pernicious effects on achievement.

Students simply face different classroom experiences due to factors unrelated to interest or ability. Recent studies suggest that "successful theories will probably have to look more carefully at the way black and white children respond to the same classroom experiences, such as being in a smaller classroom, having a more competent teacher, having a teacher of their own race, or [one] . . . with high expectations for those who perform below the norm for their age group."[26] The President of the National Education Associate writes: "Until large numbers of students in the *same* school and the *same* neighborhood value academic achievement, success will continue to be the exception . . . If universities and urban public schools could become 'sister cities,' our most troubled schools might be saved from *within*."[27]

For university faculty to embrace collaboration with schools and K-12 educators, there must be some incentive for spending professional time in support of a community partner.[59] A Southern Education Foundation report lauds some state efforts to create a "seamless" education system: K-12 schools and colleges work together to set standards and curricula, and to hold colleges accountable—much as schools already are—by tying state resources to performance on a set of indicators, including the status of minority students.[29] In this spirit, it has been hypothesized that:

> States and school districts are reluctant to pursue reforms more aggressively until they are sure higher education admissions and placement processes will accommodate their students. The result is stasis: Both sides are waiting for the other to pull the "trigger." We must adjust, and even overhaul, the current melange of K-16 education policies that sends confusing signals to students and schools about what knowledge is worth knowing. Universities must collaborate with K-12 leaders and policymakers to improve policies that will enhance academic preparation, elevate education standards, and let prospective college students know what lies ahead.[30]

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*The National Education Longitudinal Survey of 1988 shows that among those who scored in the top third of a standardized test, low-income students were five times more likely to skip college than were high-income students. Students who took advanced mathematics and science courses were more likely to attend college than those who didn't, but low-income students lagged their high-income peers. "Money, More Than Brains, Governs Whether Students Will Attend College, Study Finds," *The Chronicle of Higher Education*, Aug. 10, 1998 <//chronicle.com/daily/98/08/98081003n.shtml>.

†A quarter of these students' parents claim an inability to get financial aid information when their child was in 8th grade and they were deciding whether college would be affordable. A quarter also reports that they did not apply for financial aid because they did not know how to do so. Information on the financial aid process must reach families early; the end of high school may be too late. Institutions of higher education are also revising their financial aid policies to attract more students from low- and middle-income families. See "Change in Aid Policy Nets Princeton More Students From Low- and Middle-Income Families," *The Chronicle of Higher Education*, Aug. 14, 1998 <//chronicle.com/daily/98/08/98081402n.htm>.

RECOMMENDATION 3

To implement the core recommendation through the college admissions process, the NSB urges:

1. institutions of higher education to form partnerships with local districts/schools that create a more seamless K-16 system, increasing the congruence between high school graduation requirements in math and science and undergraduate performance demands; and,
2. faculty and student incentives that motivate interactions to reveal linkages between classroom-based skills and experiences and the demands on thinking and learning in the workplace.

In the July statement, the NSB exhorted stakeholders to establish "college admissions criteria that reinforce high standards in K-12 education and bolster participation of all students in mathematics and science." Acting as "all one system" means that the strengths and deficiencies of one educational level are not just inherited by the next. Instead, they become spurs to better preparation and the opportunity for higher learning.

By committing university resources to offering programs for middle and high school students, supplying mentors for teachers, etc., higher education provides glimpses at what preparation for college and advanced learning means.* Partnering demands adjusting the institutional reward system to recognize such service as instrumental to the mission of the university.

*Recently, the NSB Committee on Education and Human Resources held a field hearing to explore models for creating such a seamless system. See All One System: *Developing Human Capital and Infrastructure for Science and Engineering*, San Juan, Puerto Rico, Oct. 7, 1998 <www.nsf.gov/nsb/meetings/1998/fieldoct/fieldoct.htm>. For appraisals of the "statewide systemic" approach, see J. Mervis, "Mixed Grades for NSF's Bold Reform of Statewide Education," Science, 282, Dec. 4. 1998: 1800–1805.

How Research Can Better Inform Practice

The role of research and evaluation in informing—and changing—education practice has itself become a policy issue.* Making research reliable, timely, and relevant to classroom teaching and learning has long been a concern of policymakers, educators, and researchers alike. Public awareness of this need has grown as "high standards" are translated from a concept into high-visibility efforts to challenge students, teachers, parents, and communities—and hold all accountable for academic achievement.

"The National Science Board sees research as a necessary condition for improved student achievement in mathematics and science . . . [A]nalysis based on national and international data sources can help to explain the conditions that affect performance."

The U.S. Department of Education's National Center for Education Statistics (NCES) has sought to develop a moving picture of how well American schools and their students are faring.[31] The National Assessment of Educational Progress (NAEP) compares the performance of today's students with performance by their age peers in the past. Policymakers, business leaders, and parents increasingly ask if American students are achieving academically as much as they can. International comparisons such as TIMSS provide a "world" benchmark for gauging achievements.[32] The NSB's own *Science and Engineering Indicators—1998* report summarizes, in addition to TIMSS and NAEP, robust time series since the 1970s on the performance of 9-, 13-, and 17-year-olds in mathematics, science, and other subjects.[33]

The need for research on practice relates, too, to differing expectations of stakeholders. What do they seek to learn and how best can data be used to refine system-, school-, and classroom-level practice? Some caution that education interventions alone will not suffice.[34] Others seek education investments different in magnitude and kind.† A topic for continuing debate within professional communities, among parents, and by policymakers, for example, remains *which* tests should be used for gauging progress in teaching and learning—and for other purposes of teacher and school accountability. A broader topic is ways and styles of learning in both formal and informal settings—how do children learn with understanding and refine the quality of their thinking?[35] No research area than cognitive development is more multidisciplinary or longitudinal in approach.‡ Finally, studies of systemic change are needed: ". . . as efforts to reform the elementary and secondary system expand, new indicators of governance, partnerships, and

*For example, see N. Lane, Assistant to the President for Science and Technology, "Educational Technologies: How Will We Know They're Working?" 1998 Educational Technology Leadership Conference, Council of Chief State School Officers, Washington, DC, Nov. 12, 1998 (typescript).

†Two reports are noteworthy: National Science and Technology Council, Committees on Fundamental Science and on Health, Safety, and Food, *Investing in Our Future: A National Research Initiative for America's Children for the 21st Century* (Washington, DC: OSTP, April 1997), which recommends research focused on, among other topics, learning, influence of families and communities on development, longitudinal studies, and policy; and *Report to the President on the Use of Technology to Strengthen K-12 Education in the United States*, March 1997 <www.whitehouse.gov/WH/EOP/OSTP/NSTC/PCAST/k-12ed.html>, which calls for at least 5 percent of all public K-12 education spending in the U.S. (or approximately $13 billion annually in constant 1996 dollars) to be designated for research—a significant increase over the current level of 1.3 percent. (Note: *The* FY 1999 *Federal investment in K-12 education exceeds $15 billion.*)

‡A massive Federal initiative to track children's learning and development from birth, and again from the start of school, was launched in Fall, 1998. One NCES study will test 21,000 kindergartners in 1000 public and private schools

alignment among various parts need to be developed, and research on the measurement of learning of science and mathematics must be extended into undergraduate education."[36]

Clearly, an agenda such as the one examined in this report is a cogent justification for research: what do we need to know and how best can we engender reliable and usable knowledge?[§] What organizational arrangement would attract the participation of the requisite research communities? How can an interagency portfolio of basic and applied research that goes beyond extant programs be devised?[37]

The National Science Board sees research as a necessary condition for improved student achievement in mathematics and science. Further, research is best supported at a national level and in a global context. While student achievement is the "bottom line" for parents, teachers, schools, communities, and policymakers, analysis based on national and international data sources can help to explain the conditions that affect performance.

RECOMMENDATION 4

To implement the core recommendation through research:

1. The National Science Foundation and the Department of Education must spearhead the Federal contribution to SMET education research and evaluation.
2. Overall, the investment should increase—by the Federal government, private foundations, and other sponsors—in research on schooling, educational systems more generally, and teaching and learning of mathematics and science in particular.
3. To focus and deepen the knowledge base, an interagency Education Research Initiative, led by NSF and the Department of Education, should be implemented. It should be distinguishable as a joint venture within the agencies' respective research missions, and cooperatively funded.

In 1999, NCES and NSF will revisit the 4th grade population that performed so well on TIMSS in international competition. TIMSS-R will sample 8th graders who were in the 4th grade in 1995. Through an analysis of teacher and school questionnaires and the administration of a new achievement test linked to TIMSS, TIMSS-R will test the robustness of the TIMSS 4th grade results and allow examination of schooling in the middle grades. Comparative research is a prerequisite for suggesting appropriate responses by systems at any or all—State, district, school, subject, and classroom—levels.[‖]

In 1997, both NSTC and PCAST recommended not only a larger investment, but also a larger-scale program of rigorous, systematic research on education to demonstrate the effi-

and interview their parents and teachers. Another interagency effort called the Early Childhood Longitudinal Study will begin in 2000 by following 12,000 newborns through their 6th birthdays. Both studies will help to distinguish empirically the large learning gaps among children when they enter school and how and why those gaps often persist through high school. See D. Viadero, "NCES Launches Broad Study on Early Childhood," *Education Week*, Dec. 16, 1998 <//www.edweek.org/ew/current/16nces.h18>.

[§]In 1991, the independent National Academy of Education outlined a national research agenda for sparking positive changes in schools. The agenda encompassed the main challenges that persist today: active learning over the lifespan; assessment; bolstering achievement of historically underserved, minority, and impoverished groups; school organization; and connection to teachers and teaching. National Academy of Education, *Research and the Renewal of Education*. Project on Funding Priorities for Educational Research (Stanford, CA: Stanford University, 1991), pp. 5–6.

[‖]Study designs such as TIMSS-R hold great potential for specifying teaching and learning linkages among curriculum materials, school organization, classroom practices, and student achievement among a sample of 8th grade U.S. students. Such research includes efforts like the First in the World Consortium in northwest suburban Illinois that paid to participate in TIMSS to gauge its students' progress against that of other "countries" of the world. See OERI, U.S. Department of Education, "Seminar on The First in the World Consortium," Aug. 20, 1998, unpublished notes, and <www.ncrel.org/fitw>.

cacy of transferring exemplary practices among our nation's schools.* The National Science Board endorses research that can generalize to a diversity of classrooms, student populations, and school districts.†

An experimental program of research is particularly needed on *how* information and computer technologies influence the processes of teaching and learning of science and mathematics by children of various ages and in different classroom settings.‡ Harnessing the creativity and power of innovative tools and pedagogy should be a priority.

Research on "what works" should thus inform those seeking a change in practice and learning outcomes. The dissemination and adaptation of research results, however, pose other problems. The knowledge base is thin; gaps abound and what is known from empirical study is *not*—even in this age of electronic communication and information retrieval—conveniently catalogued, updated, advertised, and/or accessible to the so-called end-users in schools. Research simply remains outside the purview of most classroom teachers.§

Like other professionals, teachers need support networks in various forms—Internet bulletin boards, websites, in-person professional development experiences, university faculty mentors, etc.—to refine their knowledge and skills. Technical assistance by those who understand classroom settings and have the confidence of teachers is essential. In short, "getting the word out" only begins a process of using knowledge to inform ongoing teacher preparation and education practice.

Above all, we should remain mindful that "schools reflect society far more than they shape it, and that test scores tell us much more about what schools are facing than how they're failing. Surely, we must challenge teachers and administrators to do their utmost, but not to work miracles. And not by themselves."[38]

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*Through workshops with researchers from various communities held in September 1998, advice on a research agenda for teaching and early learning of mathematics, science, and reading (the latter with the participation of the NIH's National Institute of Mental Health) was solicited on developing a Request for Proposals in FY 1999. OSTP and OMB are spearheading this collaboration for a 5-year initiative that will produce measurable outcomes of progress through various research and evaluation designs.

†More generally, results of competitively funded research can only inform future investments by districts and local schools, and guide policymakers' decisions about "what works," if they are evaluated to determine the cost and learning effectiveness of scaling up to serve more students. "Randomized field trials," a staple of medical research but seldom employed to test education reforms, allows investigation of a "treatment" randomly assigned to two groups. If the groups are sufficiently similar, then differences in average outcomes of the treatment can be attributed to exposure of the factor under investigation. See P.E. Peterson, "Rigorous Trials and Tests Should Precede Adoption of School Reforms," *The Chronicle of Higher Education*, Jan. 22, 1999: B4.

‡Limited national data are equivocal, suggesting that with some students new technology is being used for the same old drill-and-practice in mathematics; yet in the hands of technology-trained middle school teachers, computers can enhance academic performance. See J. Mathews, "Study Faults Computers' Use in Math Education," *Washington Post*, Sept. 30, 1998: A3; and E. Bonner, "Computers Help Math Learning, Study Finds," *New York Times*, Sept. 30, 1998, <www.nytimes.com/library/tech/98/09/biztech/articles/30math.html>; and A.. Fisher, "High Tech, High Grades?" *Popular Science*, January 1999: 64–69.

§Polls show, not surprisingly, that local schools in turn fail to provide parents with enough information to make them advocates for what their children are expected to know. These are the same people who simultaneously support rigorous content standards but are intimidated by them. See A.D. Coles, "Parents Ill-Informed About Standards, Poll Finds," *Education Week*, Oct. 28, 1998: 6.

Conclusions

The Nation's concern for excellence in K-12 and undergraduate teaching and learning environments is magnified by time: it takes time for any system and the organizations within it to adapt to emerging needs and mounting pressures. We cannot expect instant results.

While the national education goals set by the governors in 1989 will not be realized on the envisioned timetable, the momentum for lifting student performance is unquestioned. Today we take as axiomatic that improved student performance will be short-lived if the conditions for schooling do not change. "To have any real effect, standards must be incorporated into the life of the school: They must be embraced by the students who must learn them, and embraced by the business community and colleges who must make informed decisions about whom to invite into their ranks."[39] The key to energizing education *systems* throughout the Nation is consensus on content standards for the teaching and learning of mathematics and science. This leaves much room for choice and diversity of process and pedagogy, while reinforcing a common market of demand for the skills that will dominate the 21st century workplace.

Through recommendations for implementing content-based materials, teaching, college admissions, and other practices informed by research, the National Science Board affirms that there is no greater national need than equipping the next generation with the tools of the workplace and citizenship. This will require a greater consensus among stakeholders on the content of K-16 teaching and learning. High expectations will not suffice in raising achievement in mathematics and science; neither will a single-minded emphasis on teachers, curriculum, assessment, or technology.

A generation ago, the NSB Commission on Precollege Education in Mathematics, Science and Technology advised: "Our children are the most important asset of our country; they deserve at least the heritage that was passed to us . . . a level of mathematics, science and technology education that is the finest in the world, without sacrificing the American birthright of personal choice, equity and opportunity."[40]

The health of science and engineering tomorrow depends on improved mathematics and science preparation of our students today. The national interest is now a national imperative. We must see educational excellence as a shared responsibility and, above all, a tractable challenge to us all.

Notes

1. D.J. Hoff, "With 2000 Looming, Chances of Meeting National Goals Iffy," *Education Week*, Jan. 13, 1999: 28–30, quote at 28.
2. For details on TIMSS methodology and findings, see W.H. Schmidt et al., *Characterizing Pedagogical Flow: An Investigation of Mathematics and Science Teaching in Six Countries*. Dordrecht, The Netherlands, Kluwer Academic Publishers, 1996; National Center for Education Statistics, *Pursuing Excellence: A Study of U.S. Fourth-Grade Mathematics and Science Achievement in International Context*. Washington, DC: U.S. Department of Education, June 1997 (NCES 97-255); and I.V.S. Mullis et al., *Mathematics and Science Achievement in the Final Year of Secondary School: IEA's Third International Mathematics and Science Study*. Chestnut Hill, MA: TIMSS International Study Center, February 1998. The Commissioner of Education Statistics has also responded to criticisms of the TIMSS methodology and interpretation of findings. See Center for Education Reform and Empower America, *Achievement in the United States: Progress Since A Nation at Risk?* Washington, DC, National Center for Education Statistics, U.S. Department of Education, April 3, 1998: 11 <*http://nces.ed.gov*>.
3. The following is distilled from W.H. Schmidt, Executive Director, U.S. National Center for TIMSS, presentation to the National Science Board, May 7, 1998. Also see G.A. Valverde and W.H. Schmidt, "Refocusing U.S. Math and Science Education," *Issues in Science and Technology* (Winter 1997-98): 60–66; and W.H. Schmidt and C.C. McKnight, "What Can We Really Learn from TIMSS?" *Science*, 282, Dec. 4, 1998: 1830–1831. These characteristics appear to be necessary, but not sufficient conditions for high student performance.
4. National Science Board, *The Federal Role in Science and Engineering Graduate and Postdoctoral Education* (Arlington, VA: Feb. 26, 1998, NSB 97-235); and K. Olson, "Despite Increases, Women and Minorities Still Underrepresented in Undergraduate and Graduate S&E Education," *SRS Data Brief*, Jan. 15, 1999, NSF 99-320.
5. U.S. Department of Education, National Center for Education Statistics, *The Condition of Education—1995*, Indicator 46: Student Mobility <//nces.ed.gov/pubs/ce/c9546a01.html>.
6. American Association for the Advancement of Science, *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology* (Washington, DC: AAAS, 1990); National Council of Teachers of Mathematics, *Curriculum and Evaluation Standards for School Mathematics* (Reston, VA: NCTM, 1989); National Council of Teachers of Mathematics, *Professional Standards for Teaching Mathematics* (Reston, VA: NCTM, 1991); and National Academy of Sciences, National Research Council, *National Science Education Standards* (Washington, DC: National Academy Press, 1996). At a White House "Education Announcement/Roundtable" on April 2, 1997, the President remarked that "240 companies have endorsed this national standards movement" <http://library.whitehouse.gov/cgi-bin/>. NCTM is currently revising and updating the mathematics standards. A draft is available for public comment at <*www.nctm.org/standards2000/*>.
7. See Education Week, *Quality Counts* (January 22, 1997).
8. C.T. Cross, "The Standards War: Some Lessons Learned," *Education Week*, Oct. 21, 1998 <//www.edweek.org/ew/current/08cross.h19>.
9. K.K. Manzo, "Report for Goals Panel Calls for Consensus on Standards," *Education Week*, Sept. 9, 1998 <www.edweek.org/ew/current/01stand.h18>. Also see K.K. Manzo, "Think Tank Inks Blueprint to Lift Achievement," *Education Week*, Nov. 18, 1998: 6, reporting on the Consortium on Renewing Education's *20/20 Vision: A Strategy for Doubling America's Academic Achievement by the Year 2020*.
10. M.S. Tucker, "The State of Standards: Powerful Tool or Symbolic Gesture?" *Expecting More* (Newsletter on Standards-Based Reform), 1 (Spring 1998): 2.
11. Education Week, *Quality Counts '99* (January 11, 1999) <www.edweek.org/sreports/qc99/exsum.htm>.
12. P. Black and D. Wiliam, "Inside the Black Box: Raising Standards through Classroom Assessment," *Phi Delta Kappan*, October 1998: 139–148.
13. American Educational Research Association *Letter*, April 18, 1997.
14. J. Mervis, "U.S. Tries Variations on High School Curriculum," *Science*, vol. 281, July 10, 1998, pp. 161–162.
15. D. Rich, "You Can't Teach What You Don't Know," *Education Week*, Sept. 16, 1998 <www.edweek. org/ew/current/02rich.h18>.
16. "In State of the Union Speech, President Urges Testing of Prospective Teachers," The *Chronicle of Higher Education*, Jan. 20, 1999 <//chronicle.com/daily/99/01/99012001n.html>.
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18. S. Tobias, "Some Recent Developments in Teacher Education in Mathematics and Science," *NISE Occasional Paper*, No. 4, April 1997: 2.
19. D.K. Cohen and H.C. Hill, "State Policy and Classroom Performance: Mathematics Reform in California," *CPRE Policy Brief*, RB-23-January 1998: 10–11.

20. C. Mojkowski, "Teachers and Standards: Sauce for the Goose . . .," *Education Week*, Jan. 13, 1999: 39.
21. R.W. Riley, "An End to 'Quiet Backwaters': Universities Must Make Teacher Education a Much Higher Day-to-Day Priority," *The Chronicle of Higher Education*, Oct. 2, 1998: B10. Also see C. Pipho, "A 'Real' Teacher Shortage," *Phi Delta Kappan*, November 1998: 181–182. Also see N. Lane, "The Integral Role of Two-Year Colleges in Science and Mathematics Preparation of Prospective Teachers," *SACNAS Journal*, Summer 1998 <www.sacnas.org/journal/su98/page5.htm>.
22. See R.L. Linn, "Standards-Based Accountability: Ten Suggestions," *CRESST Policy Brief*, adaptation of Technical Report 490, *Assessments and Accountability*, 1998, available at <www.cse.ucla.edu>.
23. For example, see "Good Teaching Matters: How Well-Qualified Teachers Can Close the Gap," *Thinking K-16* (A Publication of The Education Trust), Summer 1998: 1–15; and H.J. Walberg, "Incentivized School Standards Work," *Education Week, Nov. 4, 1998: 48, 51.*
24. C. Adelman, "To Help Minority Students, Raise Their Graduate Rates," *The Chronicle of Higher Education*, Sept. 4, 1998, p. B8.
25. See M.A. Fletcher, "A Good-School, Bad-Grade Mystery," *Washington Post*, Oct. 23, 1998: A1.
26. Quote from C. Jencks and M. Phillips, "The Black-White Test Score Gap," *Education Week*, Sept. 30, 1998: 44, 32.
27. B. Chase, "A Hope in the Unseen," *Washington Post*, Oct. 18, 1998: C5.
28. For example, see S. Hebel, "Report Urges State Universities to Become Engaged with Their Communities," *The Chronicle of Higher Education*, Feb. 4, 1999 and <www.intervisage.com/Kellogg/STATEMENTS/index.html>.
29. D. Lederman, "Report Sees Lack of Progress by Southern States in Educating Black Students," *The Chronicle of Higher Education*, Sept. 4, 1998: A57.
30. M.W. Kirst, "Bridging the Remediation Gap," *Education Week*, Sept. 9, 1998 <www.edweek.org/ew/current/01kirst.h18>.
31. For example, see The National Center for Education Statistics, *The 1994 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1994, 1990, 1987, and 1982 High School Graduates*. Washington, DC, U.S. Department of Education, 1997 (NCES 97-260).
32. See and National Research Council, Center for Science, Mathematics, and Engineering Education, *Mathematics and Science Education Around the World—What Can We Learn?* Washington, DC: National Academy Press, 1996; and J.M. Atkin and P. Black, "Policy Perils of International Comparisons: The TIMSS Case," *Phi Delta Kappan*, September 1997: 22–28.
33. National Science Board, *Science and Engineering Indicators—1998* (Arlington, VA: National Science Foundation, 1998, NSB-98-1), esp. ch. 1.
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37. For example, see M.A.Vinovskis, *Changing Federal Strategies for Supporting Educational Research, Development, and Statistics* (Washington, DC: U.S. Department of Education, National Educational Research Policy and Priorities Board, September 1998), esp. Appendix C.
38. R. Evans, "The Great Accountability Fallacy," Education Week, Feb. 3, 1999 <*www.edweek.org/ew/current/21revans.h18*>.
39. S. Pimentel and L.A. Arsht, "Don't Be Confused by the Rankings; Focus on Results," *Education Week*, Nov. 25, 1998: 56, 40.
40. National Science Board Commission on Precollege Education in Mathematics, Science and Technology, *Educating Americans for the 21st Century: A Plan of Action for Improving Mathematics, Science and Technology Education for all American Elementary and Secondary Students so that Their Achievement is the Best in the World by 1995* (Washington, DC: National Science Foundation, 1983, CPCE-NSF-03): v.

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