

Changing the Course of Science Education

PREPARING STUDENTS FOR CITIZENSHIP AND EMPLOYMENT IN THE 21ST CENTURY



DRAFT

The National Science Resources Center (NSRC) was established in 1985 by the Smithsonian Institution and the National Academies to improve the learning and teaching of science for all students in the United States and throughout the world. The reputation and credibility of these two world-renowned institutions provide the NSRC with access to research, scientific expertise, and resources to inform our work, as well as an opportunity to engage and partner with educators, business people, and scientists in all aspects of science education reform.

The NSRC advances the mission of each parent institution by:

- Making the work of the National Academies and Smithsonian accessible to teachers and education leaders by translating research into products and services for the classroom;
- Building leadership capacity and involving the science and engineering communities in order to catalyze change in science education at the school district and state levels; and
- Educating a broad constituency of practitioners about the salient issues in science education and the important work of both institutions in this arena.

The National Academies are composed of three academies—the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine—and their operating arm, the National Research Council. These institutions work outside the framework of government to bring independent advice to the nation on matters of science, technology, and medicine.

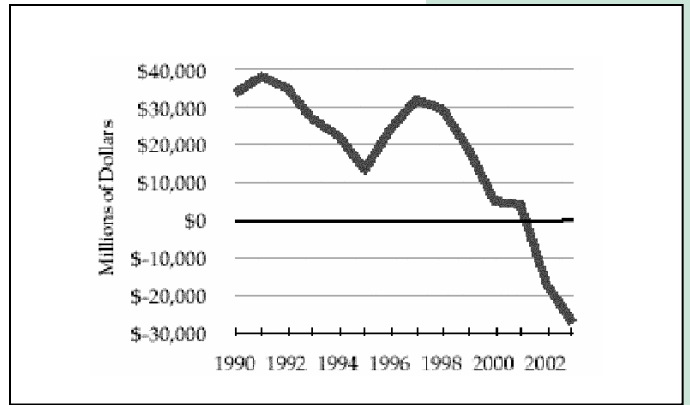
The Smithsonian Institution was established in 1846 with a mission of increasing and diffusing knowledge. For more than 160 years, the Smithsonian has used its unique research, staff and vast collections to inform, educate, and inspire a diverse public. In doing so, it has become one of the most widely recognized institutions in the world for its contributions to science and its unparalleled ability to make its research and collections accessible to people of all ages.

This brochure outlines a way to help children develop the critical thinking and problem-solving skills they will need to thrive in today's—and tomorrow's—world of global challenges. For over 20 years, the National Science Resources Center has developed research-based programs for improving the learning and teaching of science. These programs have been highly effective across the United States and around the globe, particularly where they have the support and active involvement of the entire community.

**You have a stake in America's future. We need you to help us make that future brighter. Read on.
See page 8 to find out what you can do.**

An Alarming Picture

Recent assessments of U.S. Science, Technology, Engineering, and Mathematics (STEM) education have been harsh. Shortcomings in U.S. STEM education have serious implications for the workforce and for citizenship in a knowledge-driven world.



U.S. trade balance for high-technology products, 1990-2003.¹

Education	Workforce	Economy
<p>“When I compare our high schools to what I see when I’m traveling abroad, I am terrified for our workforce of tomorrow.” —Bill Gates, Chairman, Microsoft Corporation²</p> <p>.....</p> <ul style="list-style-type: none"> Only 5% of Hispanic students and 2% of African-American Students scored at the ‘proficient’ level in science, according to the 2005 National Assessment of Educational Progress.³ U.S. 12th graders ranked 16th in an international science test given to students in 21 countries in 1998. “Just 40 percent of students grasped basic concepts such as the relationship between pressure and volume.”⁴ 68% of parents and 64% of elementary school teachers do not consider themselves to be scientifically literate.⁵ 	<p>“When everyone has access to the same technology platform, human talent... is the only sustainable edge.” —Thomas Friedman, writer⁶</p> <p>.....</p> <ul style="list-style-type: none"> Currently, almost half of employers report having trouble finding qualified U.S. workers in a wide range of occupations, from entry-level workers to engineers.⁷ Over two-thirds of employers report that high school graduates are “deficient” in almost all essential workplace skills.⁸ In 2007, Business executives ranked education and workforce preparedness as their top concern, ahead of healthcare, energy, global competitiveness, and national security.⁷ 	<p>“We can’t hope to keep intact our standard of living, our national security, our way of life, if Americans aren’t competitive in science. Period.” —David Baltimore, President of the California Institute of Technology, Nobel Laureate</p> <p>.....</p> <ul style="list-style-type: none"> In 2005, for the first time, the United States lost its lead in world economic competitiveness, and dropped to sixth place.⁴ American investors made more new investments in foreign stock funds than in domestic stock portfolios in 2005.⁹ An estimated 14 million U.S. jobs are now at risk of being sent offshore.¹⁰

Children need to learn science for reasons even more crucial than current and future workforce demands. All people need to know science because good citizenship requires at least a basic understanding of how the world works. Today’s students are tomorrow’s voters; they will be asked to pass judgment on many issues—environmental, biomedical, technological—in which science literacy will be essential for making intelligent, well-reasoned decisions.

Fragmented Efforts

These issues are not new, nor have they gone unnoticed. For more than a generation, **distinguished panels have issued increasingly urgent calls for action.** For example:

- The 1983 report *A Nation at Risk* stated, “Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world.”
- The Glenn Commission report, *Before It’s Too Late*, released in 2000 stated that our children are “simply not ‘world-class learners’ when it comes to mathematics and science.”
- The Business-Higher Education Forum, in its 2005 report *A Commitment to America’s Future*, wrote that “a lack of national focus on renewing our science and technology infrastructure [has] created a new economic and technological vulnerability as serious as any military or terrorist threat.”
- In its 2005 report *Tapping America’s Potential*, the Business Roundtable wrote, “One of the pillars of American economic prosperity—our scientific and technological superiority—is beginning to atrophy even as other nations are developing their own human capital.”
- The report “Rising Above the Gathering Storm,” released in late 2005 by the National Academies, set forth recommendations for strengthening U.S. scientific and technological capacity—including steps to improve K–12 science education. The report’s title invites comparison to the dark days leading up to World War II.

Although many organizations are raising their voices on behalf of science education, **they convey no collective or coordinated message.** Though seeking similar ends, these organizations are pursuing independent means. They call for educational policy changes, but few have the capacity to translate policy into effective action.

“A thousand points of light is a wonderful thing. However, it is still dark on a starry night, and it takes a single blazing sun to make a bright day”

—Terry C. Wallace, Jr., Los Alamos National Laboratory

Our Vision of a Brighter Future

As leaders in industry, research, and education, we need to work together to promote and sustain educational programs that meet the needs of young people who are faced with an increasingly competitive and complex world. Thorough training in a scientific manner of thinking provides students with the critical thinking and problem-solving skills now demanded of every citizen.

By changing the course of science education, we can help create a brighter future in which:

- Students move beyond rote learning to become **thinking, engaged citizens** with the skills and information they need to make wise decisions about problems that affect their daily lives;
- More students enter college seeking degrees in science and engineering, and more graduates enter the **science and engineering workforce**;
- Our system of **education leads the world** in quality and innovation, and our graduates are fully prepared for work and citizenship in a democracy;
- Our research institutions become and **remain global leaders in innovation**, attracting international investment in financial and human capital; and
- Growth in science and technology industries stimulates **overall economic growth**, reducing the U.S. budget deficit and improving our standard of living.



“Science is a way of thinking much more than it is a body of knowledge.”
— Carl Sagan

Why Science Education?

The crucial role science plays in our daily lives and in the great problems of our day places science education at the core of our concern about the effectiveness of education. **Good science education is more than learning and teaching a set of facts.** Good science programs help children understand not only how the world works but also the process of science. Children in such programs more easily grasp the concepts and skills of science and open their minds to a logical and rational way of thinking and problem solving.

Students who learn science well can use critical thinking skills to enhance their job performance in any sector of the workforce and help ensure their employability. As the writer Thomas Friedman said, “We have entered an era in which ‘comfort with ideas and abstractions is the passport to a good job, in which creativity and innovation are the key to the good life’ and in which **the constant ability to learn how to learn will be the only security you have.**”¹¹

Science is essential not only for training future workers, but also for training responsible and informed citizens of our democracy. In the early days of the republic, Thomas Jefferson wrote, “Freedom is the first-born daughter of science.” This simple statement conveys the profound idea that the way we govern ourselves today is based on knowledge and reason. **Citizens must be scientifically literate for our form of government to work.** Sound science education is the place to start.

In their book *Teaching the New Basic Skills: Principles for Educating Children to Thrive in a Changing Economy*, Richard Murnane and Frank Levy discuss how the U.S. education system currently fails to prepare students for the professional world. Through examples from today’s most successful businesses, Murnane and Levy offer a set of New Basic Skills that students need upon completing high school in order to be successful in the workplace¹²:

- Improved computational skills;
- Greater reading aptitude;
- Better problem-solving ability;
- Proficiency in working in groups to build strong interpersonal and effective communication skills;
- The ability to make effective oral and written presentations; and
- The capability to use personal computers to carry out simple tasks, such as word processing.

An excellent education in science provides students with opportunities to develop all of these skills.

“The biggest gap that adults have in their scientific knowledge is not that they’ve forgotten the details of DNA’; it’s rather that they don’t know what science is about. Understanding the nature of science is even more important than mastering its details.”

—Alan Leshner, Chief Executive Officer, American Association for the Advancement of Science

A Different Way of Learning and Teaching Science

While most science classrooms in the United States still use a traditional textbook, **growing numbers of school districts are applying recent findings from cognitive and educational research**¹³ to teaching and learning. An emerging body of research indicates that when science is taught in a way that mirrors how children naturally learn, students successfully learn scientific concepts and reach high levels of scholastic achievement.

Students who experience research-centered science instruction, also called ‘inquiry-based science education,’ **score much higher on assessments, including standardized tests**, than do their peers who are taught using traditional textbook methods.¹⁴ Inquiry-based science education also has been effective at closing the ‘achievement gap’ (the difference in achievement scores between minority and non-minority students) in American schools. This research-based approach to science instruction has been **shown to help children excel in areas other than science, such as reading, writing, and mathematics.**

Encompassing much more than ‘hands-on’ or open-ended science teaching, comprehensive inquiry-based science instruction:

- Teaches students how to think— not just what to think;
- Assesses students’ current knowledge and skills, then builds upon them;
- Encourages students to conceptualize a question and then seek a possible explanation;
- Actively engages children;
- Brings the real world into the classroom and into children’s lives;
- Promotes teamwork and collaboration;
- Accommodates different learning styles; and
- Enhances learning in other content areas, especially reading, mathematics, and social studies.

To succeed in this rigorous kind of science class, students must develop critical thinking skills— they can’t simply memorize facts for a test. With the higher-level thinking skills developed by an inquiry-centered science education, today’s students will be able to create and master the continually changing technologies that will be prevalent in the workplace of the future.

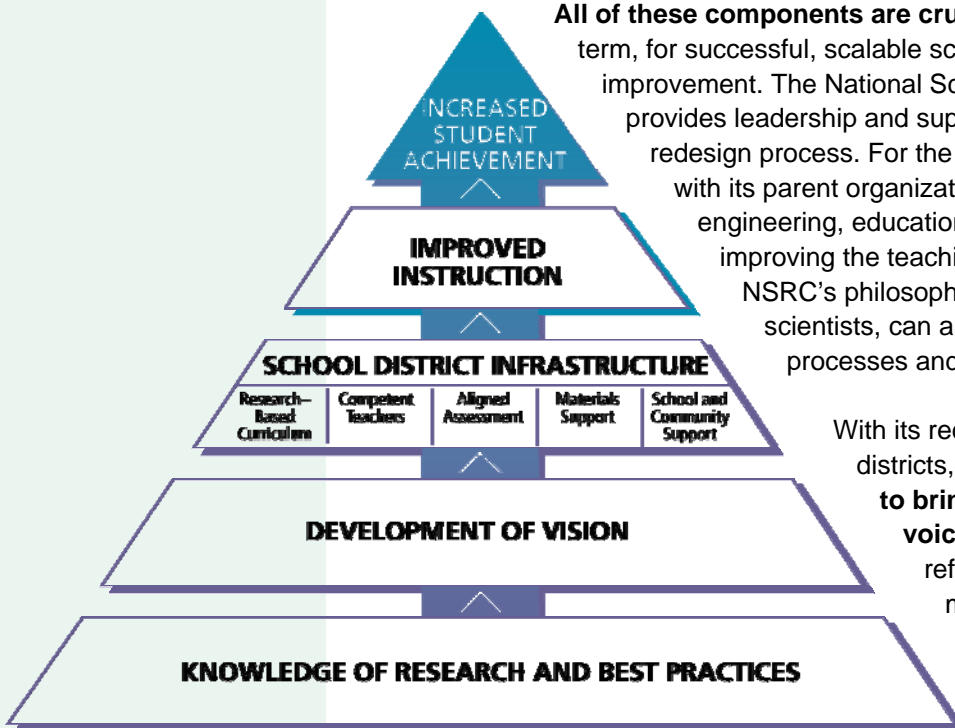
“Discussing ideas, along with reading and writing about them, is especially beneficial for building students’ vocabularies and their ability to use complex sentence structures.... Taking an inquiry approach to informational texts helps students learn to question and be critical of texts rather than to always defer to the text or use texts simply for finding answers.”

—Annemarie Palincsar, Jean and Charles Walgreen Professor of Reading and Literacy,
School of Education, University of Michigan

Powerful, Systemic Education Redesign

Our experience has taught us that to be effective, science programs—whether at the school, district, or state level—must integrate five essential elements:

- An exemplary research-based curriculum;
- Professional development for teachers in science content and teaching skills;
- Ongoing assessment of student performance;
- An efficient science materials support infrastructure; and
- Support from school administration, the community, and local businesses.



All of these components are crucial, and must be maintained long-term, for successful, scalable science education redesign and improvement. The National Science Resources Center (NSRC) provides leadership and support for all five elements and for the redesign process. For the last 22 years, the NSRC has worked with its parent organizations to actively engage the scientific, engineering, education, and business communities in improving the teaching and learning of science. The NSRC's philosophy holds that all children, not just future scientists, can and should understand natural processes and technological possibilities.

With its record of accomplishment for states and districts, **the NSRC offers the nation a way to bring together the many disparate voices** calling for science education reform. Its goal is to create a critical mass of integrated stakeholders for quality science education everywhere—speaking with one voice and moving in one direction:

- Developing a concrete plan for disseminating research-based science programs, leading to increased student motivation and achievement in all 50 states and abroad;
- Emphasizing the importance of ongoing professional development for teachers; and
- Informing leaders about the process of implementing research-based programs and the system necessary to support it.

“I view the National Science Resources Center as a major national and international resource for empowering teachers, scientists, and school districts.”

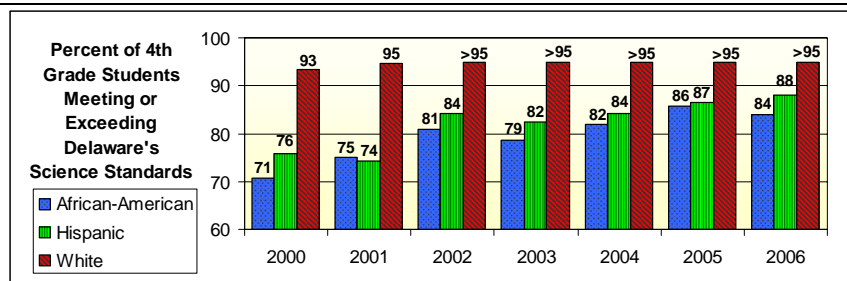
—Bruce Alberts, President Emeritus, National Academy of Sciences

Established Effectiveness

Through the work of the NSRC, more than 800 diverse school districts representing **22% of the K–8 student population in the United States** are now implementing research-based, inquiry science programs in their communities. The educational gains made in these districts, which have been implementing strategic reform programs for a decade or more, demonstrate the effectiveness of a strategic, research-based education reform process.

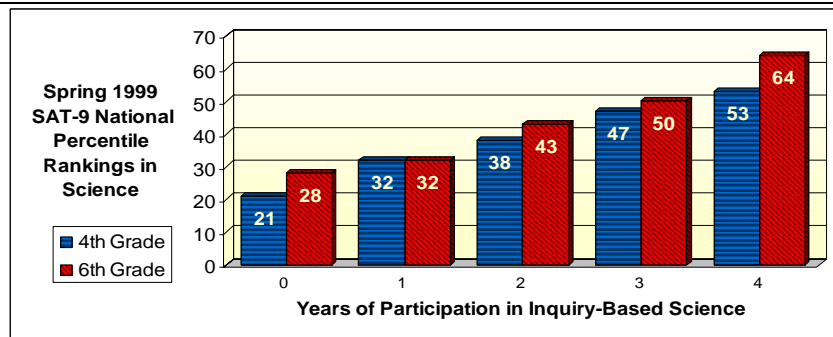
Following are two examples. To read more about research on inquiry-based science education, please see our website:

http://www.nsrconline.org/about_the_nsrc/impact.html.



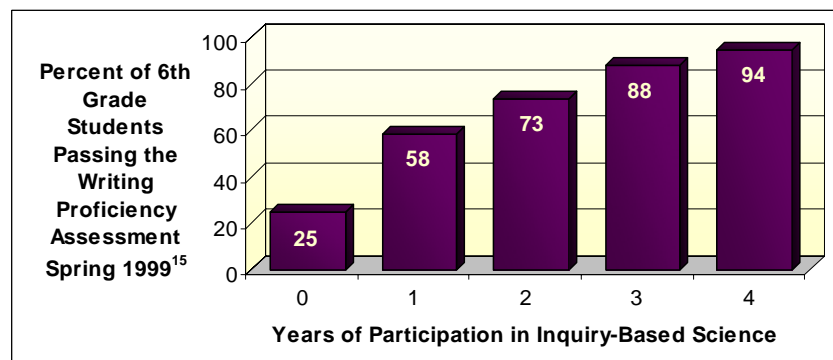
Delaware shows the impact of NSRC's reform process.

- Economically and ethnically diverse
- Partnered with NSRC in 1996 to begin strategic reform
- Developed a comprehensive technical assistance infrastructure
- Created sustained professional development programs
- Aligned state tests to state standards
- Is closing the achievement gap.¹⁵



In El Centro, California, excellence in science carries into other subjects.

- Highest levels of poverty in California
- Implemented reform based on the NSRC model
- Inquiry-based science instruction facilitated higher levels of achievement in science, math, reading, and writing.¹⁶



Stages of Leadership Development

Successful organizational change for establishing effective K–12 science education programs requires leaders to move through a continuum of knowledge from awareness to informed leadership.

Stages of Reform	Goal	Proposed Strategies
Awareness	Build awareness of research, policies, and successful methods for reforming K–12 science education programs.	<ul style="list-style-type: none"> • Arrange for presentations at professional meetings of scientists and engineers with the aim of engaging them in the educational reform process. • Sponsor annual national symposia to help leaders of business, foundations, government, media, academia, and K–12 education learn in-depth about exemplary district and state efforts for science education reform.
Initiation	Develop the initial knowledge and skills for creating an effective strategic plan for science education reform.	<ul style="list-style-type: none"> • Recruit leadership teams for participation in professional development and leadership development experiences such as the NSRC strategic planning institutes. • Develop mechanisms for securing financial support for district, state, regional, and national team participation in institutes.
Implementation	Bring about organizational change through implementation of strategic plans.	<ul style="list-style-type: none"> • Support full implementation of strategic plans through development of academies, networking opportunities, and related events and services.
Informed Leadership	Lead statewide and national efforts to bring reform to scale.	<ul style="list-style-type: none"> • Recruit leaders to serve as faculty for leadership development events such as the NSRC strategic planning institutes. • Encourage leaders' active involvement in statewide, regional, and national efforts to improve science education.

End Notes

1. The National Academies, 2005. *Rising Above the Gathering Storm*. p. 70
2. February 26, 2005; National Education Summit on High Schools
3. <http://nces.ed.gov/nationsreportcard/>
4. Adler, Robert. Oct. 21, 2006. Doing it for the kids. *New Scientist*, Vol. 192 Issue 2574, p. 24.
5. Bayer Facts of Science Education I, 1995. An Assessment of Elementary School Parent and Teacher Attitudes toward Science Education.
6. Friedman, T.L. March 24, 2006. Worried About India's and China's Booms? So Are They. *The New York Times*.
7. The Business Council Survey of Chief Executives in Collaboration with The Conference Board: CEO Survey Results, February 2007, pg.6-7
8. Are They Really Ready to Work? Employers Perspectives on the Basic Knowledge and Applied Skills of New Entrants to the 21st Century U.S. Workforce. 2006. pg. 13
9. Paul J. Lim. 2006. "Looking Ahead Means Looking Abroad." *New York Times*, January 8, 2006.
10. A. Bardhan and C. Kroll. *The New Wave of Outsourcing*. Fisher Center Research Reports #1103. Berkeley, Calif.: University of California, Berkeley, Fisher Center for Real Estate and Urban Economics, Nov. 2, 2003.
11. Friedman, T. L. Dec. 13, 2006. Learning to Keep Learning. *The New York Times*.
12. Murnane, R. J., and Levy, F. *Teaching the New Basic Skills: Principles for Educating Children to Thrive in a Changing Economy*. The Free Press, New York, NY, 1996.
13. Summarized in *How Students Learn*, 2005. National Academies Press.
14. Links to research at http://www.nsrconline.org/about_the_nsrc/impact.html
15. <http://dstp.doe.k12.de.us/DSTPMart/#Disagg>
16. *Data from Klentschy, Michael, Leslie Garrison, and Olga Maia Amaral. 1999. "Valle Imperial Project in Science (VIPS): Four-Year Comparison of Student Achievement Data, 1995-1999".*

What You Can Do—A Continuum of Action

- **Educate yourself**
Learn about research on and successful methods for systemic improvement of science education programs.
- **Attend an NSRC education leadership symposium**
Learn more about the current research on education and how you can take a leadership role in science education reform.
- **Contribute knowledge**
Donate expertise, time, and other resources to the design and development of research-based programs.
- **Collaborate with the NSRC**
Inform and partner with the NSRC to have collaborative national impact on how science is taught.
- **Partner with state and local school districts leaders**
Lead science education redesign and improvement by implementing systemic change at the state and local levels with the support of the NSRC redesign and improvement process.
- **Become an advocate**
Tell your peers, organization, and local school board about the recent research on science learning and the resources available to translate research into practice in the classroom.

For more information about any of these steps, visit www.nsrconline.org/actionplan or contact LASER@si.edu to receive a step-by-step Action Pack with practical ways for you to help improve science education in your state and across the nation.

