The Challenge of Transforming Science Education in the United States

PCAST
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Three ambitious goals

Through science education for all Americans:

1. Enable all children to acquire the problem-solving, thinking, and communication skills of scientists – so that they can be productive and competitive in the new world economy.

2. Generate a “scientific temper” for our nation, with scientifically trained people in many professions, ensuring the rationality and the tolerance essential for a democratic society.

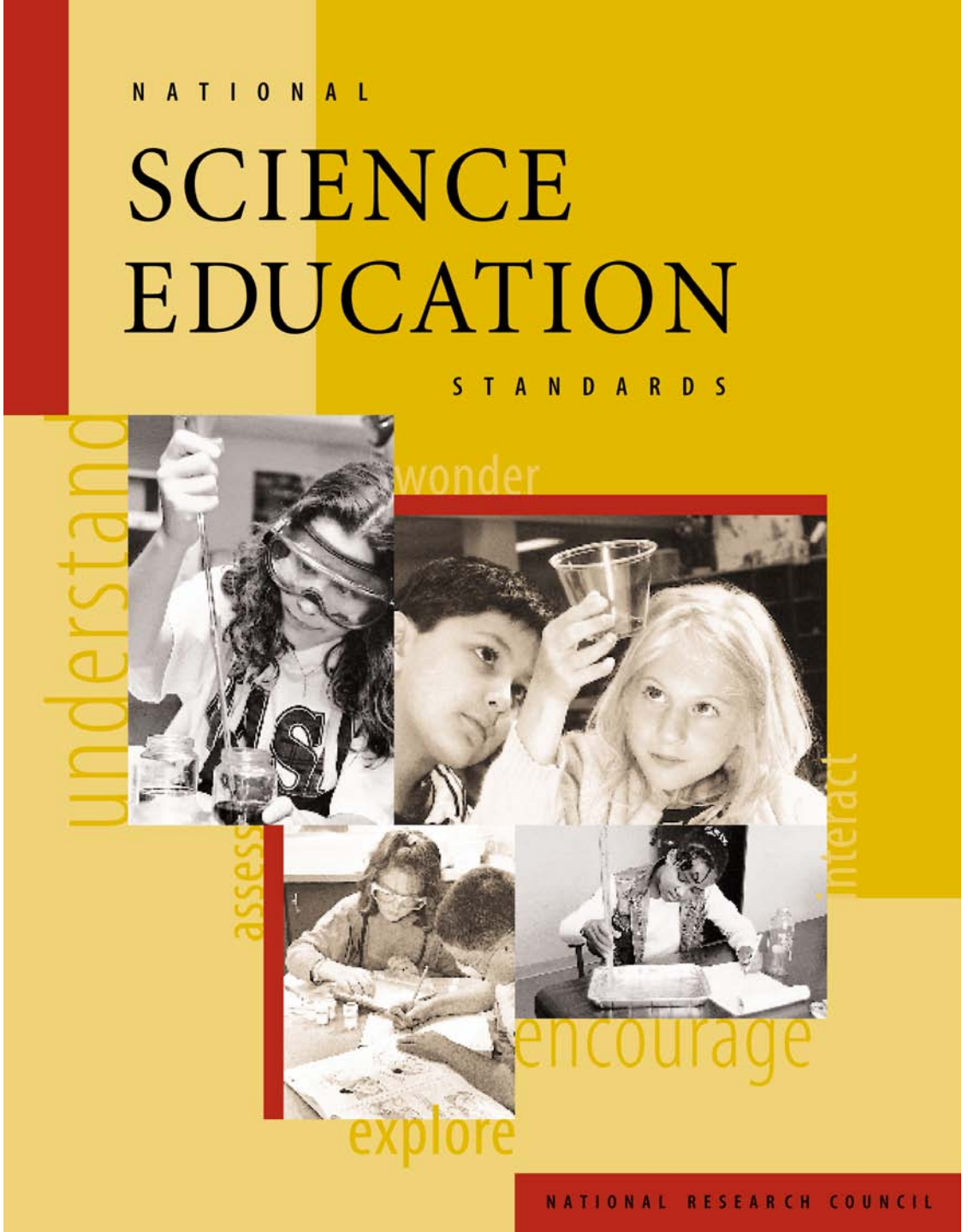
3. Help the US generate new scientific knowledge and technology by casting the widest possible net for talent.

My History

Requested by the 50 state governors, this is what I spent half my time on at the US National Academies, from 1993-1995

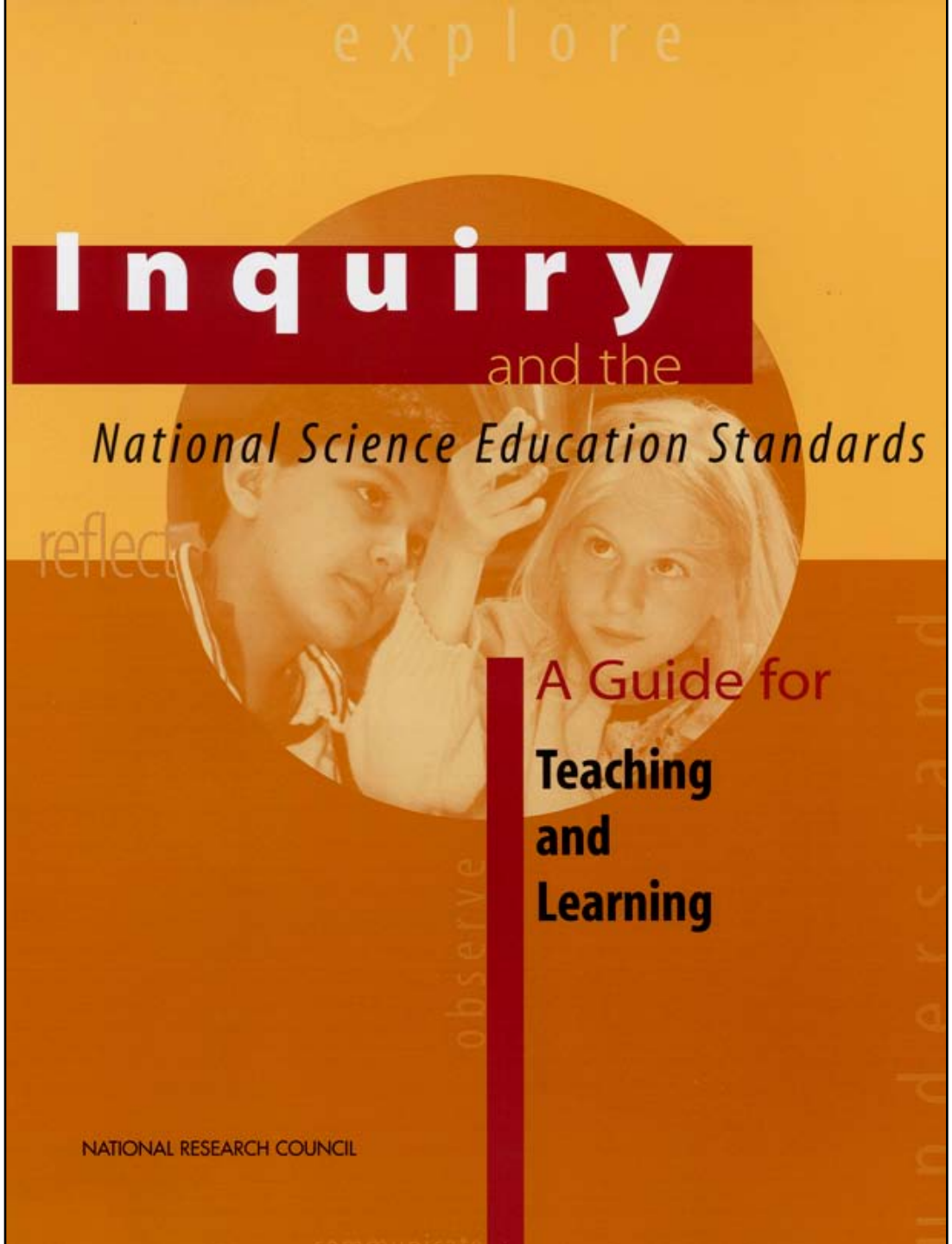
18,000 reviewers

250 pages



What science should look like in school

An emphasis on active inquiry



The disaster that followed

- With little expertise and much politics, the states went on to produce their own standards for science education, often paying little attention to the National Science Education Standards.

- Tremendous time is now wasted by curriculum developers attempting to make their textbooks and other materials match the needs of multiple states.

- The diversity of standards prevents any national effort to make high quality assessments.

- The nail in the coffin has been No Child Left Behind rules and high stakes testing, using inexpensive tests that drive poor teaching.

Science education as "**mentioning**"

From a 7th grade life sciences textbook:

"Running through the cell is a network of flat channels called the **endoplasmic reticulum**. This organelle manufacturers, stores and transports materials."

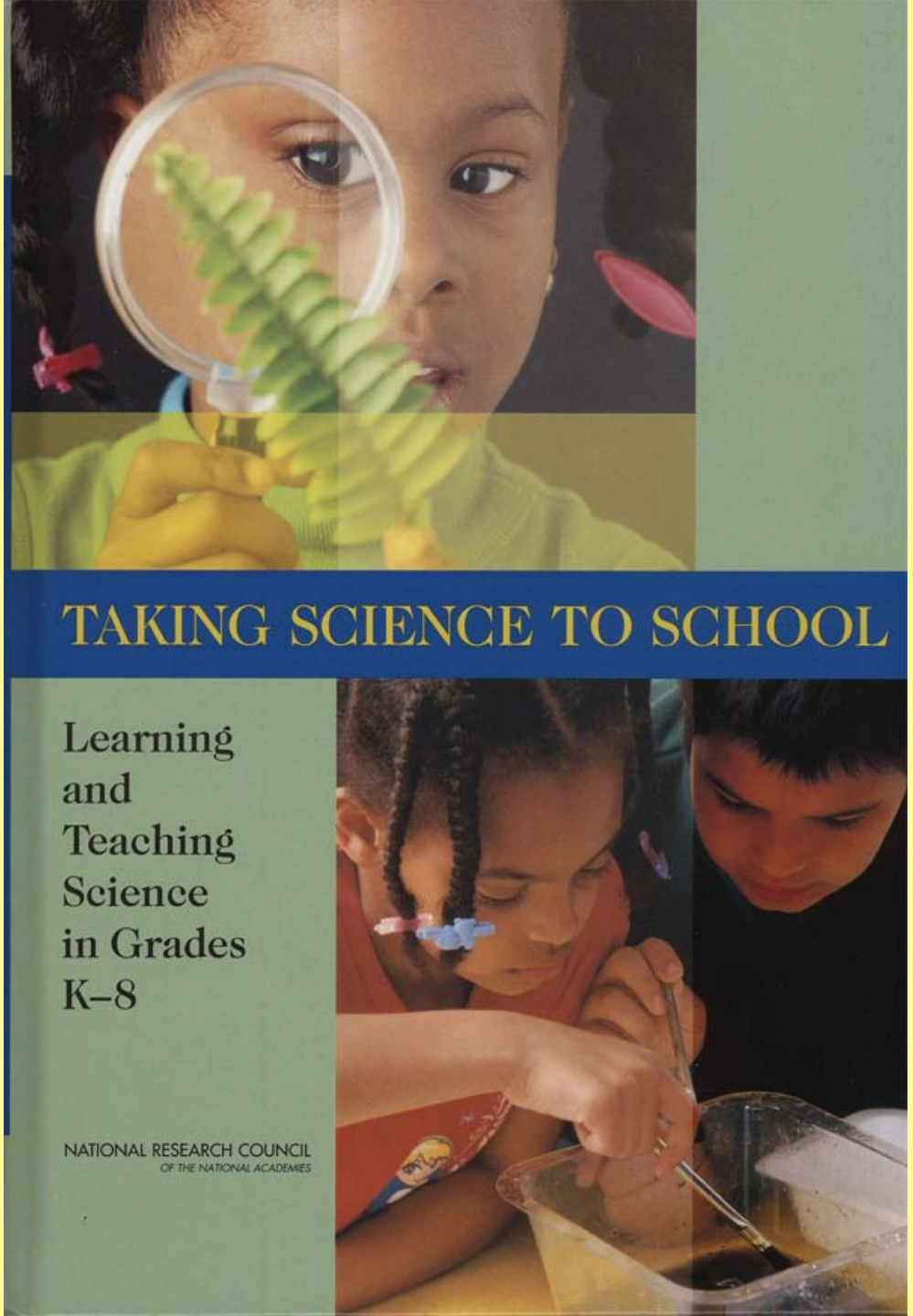
Supported by trivial tests

From the Chapter Self-Test:

"Write a sentence that uses the term **endoplasmic reticulum** correctly".

How can the US recover?

A scholarly 2007 update of the *National Science Education Standards*, emphasizing what has been learned from research in the subsequent decade



This important report claims that students who are proficient in science should be expected to:

1. Know, use, and interpret scientific explanations of the natural world.

2. Generate and evaluate scientific evidence and explanations.

3. Understand the nature and development of scientific knowledge.

4. Participate productively in scientific practices and discourse.

Each of the above four strands of science education are judged to be of equal importance!

Note that strands 2 and 4 can ONLY be taught through active inquiry!

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2. Generate and evaluate scientific evidence and explanations.

3. Understand the nature and development of scientific knowledge.

4. Participate productively in scientific practices and discourse.

Some advantages of meeting this challenge

1. Retaining the curiosity and energy for learning that young children bring to kindergarten, throughout all their years of schooling.

2. Giving many more children a chance to excel at **something** in the classroom (critical for their motivation).

3. Creating a nation of “can-do” problem solvers.

4. Insulating the next generation from scams, TV rant, and talk radio!

Some good news

- This definition of science education precisely fits the needs for workforce skills that have been widely expressed by US business and industry

The skills needed to be successful competitors in the modern world economy

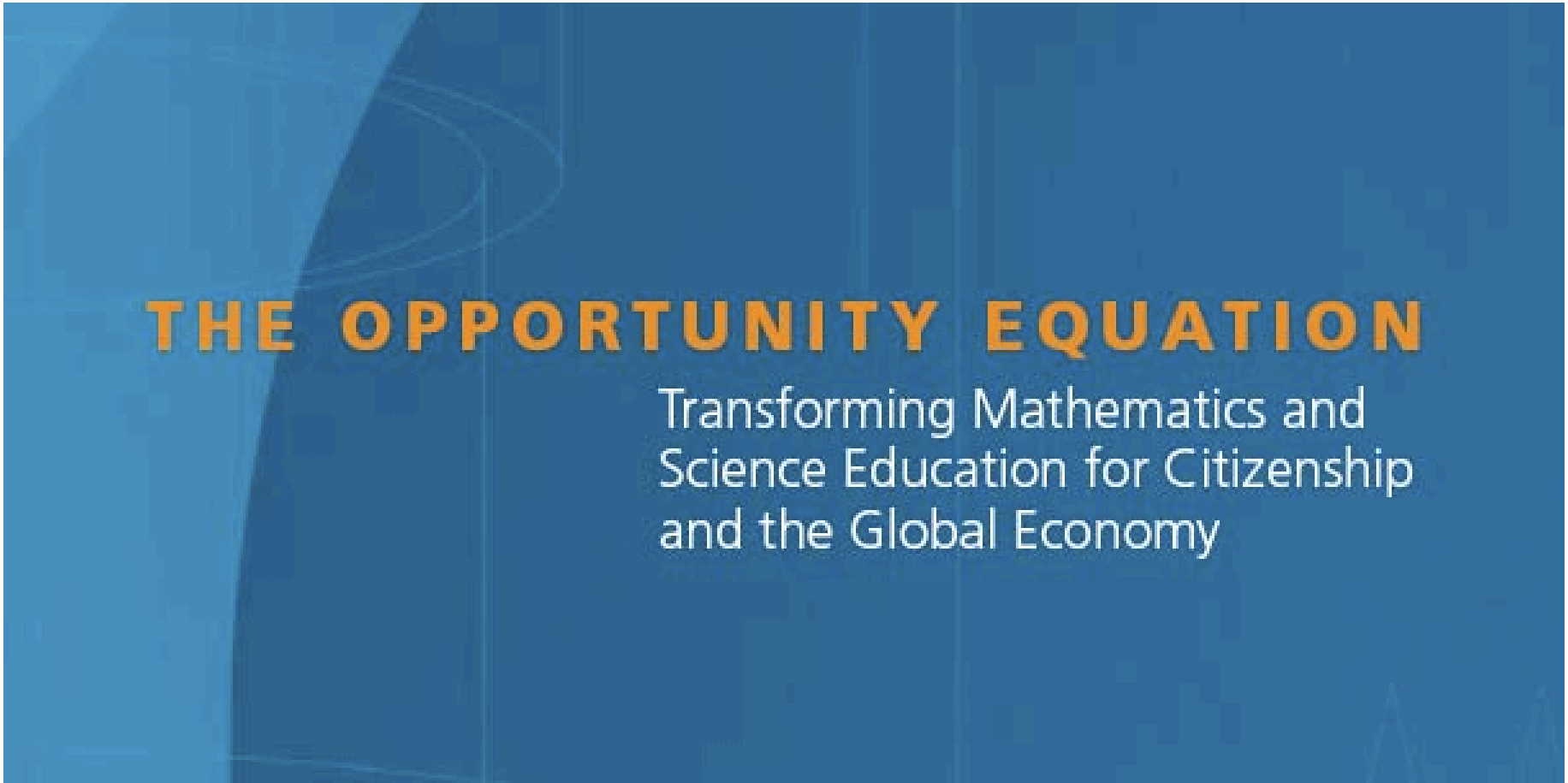
- A high capacity for abstract, conceptual thinking.
- The ability to apply that capacity for abstract thought to complex real-world problems—including problems that involve the use of scientific and technical knowledge—that are nonstandard, full of ambiguities, and have more than one right answer.
- The capacity to function effectively in an environment in which communication skills are vital – in work groups

Ray Marshall and Marc Tucker, Thinking for a Living, 2002

How PCAST can make a difference

1. Encourage **common standards** across the US, accompanied by **new high quality assessments.**
2. Develop a "**science of education**": link all future education reform efforts to high-quality in-school research that respects teacher knowledge.
3. Catalyze more support for programs that **connect the scientific community to schools**.

1). For **common standards** across the US, accompanied by **new high quality assessments,** **see this recent Carnegie - Institute of Advanced Studies report**



Specific challenge: can PCAST catalyze a DARPA-like project that recruits the best science and assessment talent to create good science tests?

- It is much easier to test for science words than for science understanding and abilities
- Bad tests are currently forcing a trivialization of science education and drive most students, including many potential scientists, away from science

The critical criterion for a good test: One that motivates good teaching and learning!

2). Develop a "**science of education**": link all future education reform efforts to high-quality in-school research that respects teacher knowledge.

The National Academies' recipe for effective education research:

SERP

published 2003

The major question posed to the SERP committees:

Why has research supported innovation and continuous improvement in medicine, agriculture, and transportation, but not in education --and what can we do about it?

The SERP answer

Education is missing the equivalent of the teaching hospital in medicine, that is:

Field Sites: places where **researchers, teachers, and designers** work in practice settings to:

- Observe, explain, document, replicate and evaluate practice as a source of new knowledge.
- Define problems and test solutions in context.
- Train new researchers and practitioners for "**use-inspired**" research and development.

SERP Field Site #1
Boston Public Schools

Focus: middle school literacy

SERP Field Site #2
San Francisco Unified School District

Focus: middle School math and science

Design team meeting San Francisco

SERP also provides an avenue for teacher empowerment

- More than 40 years ago, US industry learned from the Japanese that building a better automobile requires listening to workers on the assembly line – **ground truth is essential for wise decision making**!

- Education is one of the few parts of our society that has thus far failed to exploit this fact.

Specific challenge: can PCAST ensure that the next round of science education standards and assessments are supported by a powerful SERP-like research process that provides feedback?

- Education is an extremely complex endeavor; we must stop pretending that know the answers.
- For example, how much science content can be accommodated in real classrooms without loosing the other 3 strands?
- And how are the new assessments affecting science teaching?

www.serpinstitute.org

SERP Strategic Education Research Partnership

About Approach Tools & Resources News

Deep and reciprocal connections between practice and research

SERP stimulates innovation in education through sustained collaborations among distinguished researchers, educators, and designers. SERP partnerships expand the capacity for continuous improvement while remaining mindful of what teachers do, how schools operate, and how students learn.

News and Notes

We are pleased to announce that **Sheila A. Brown** has joined the SERP Team as the Director of the Boston Field Site. more

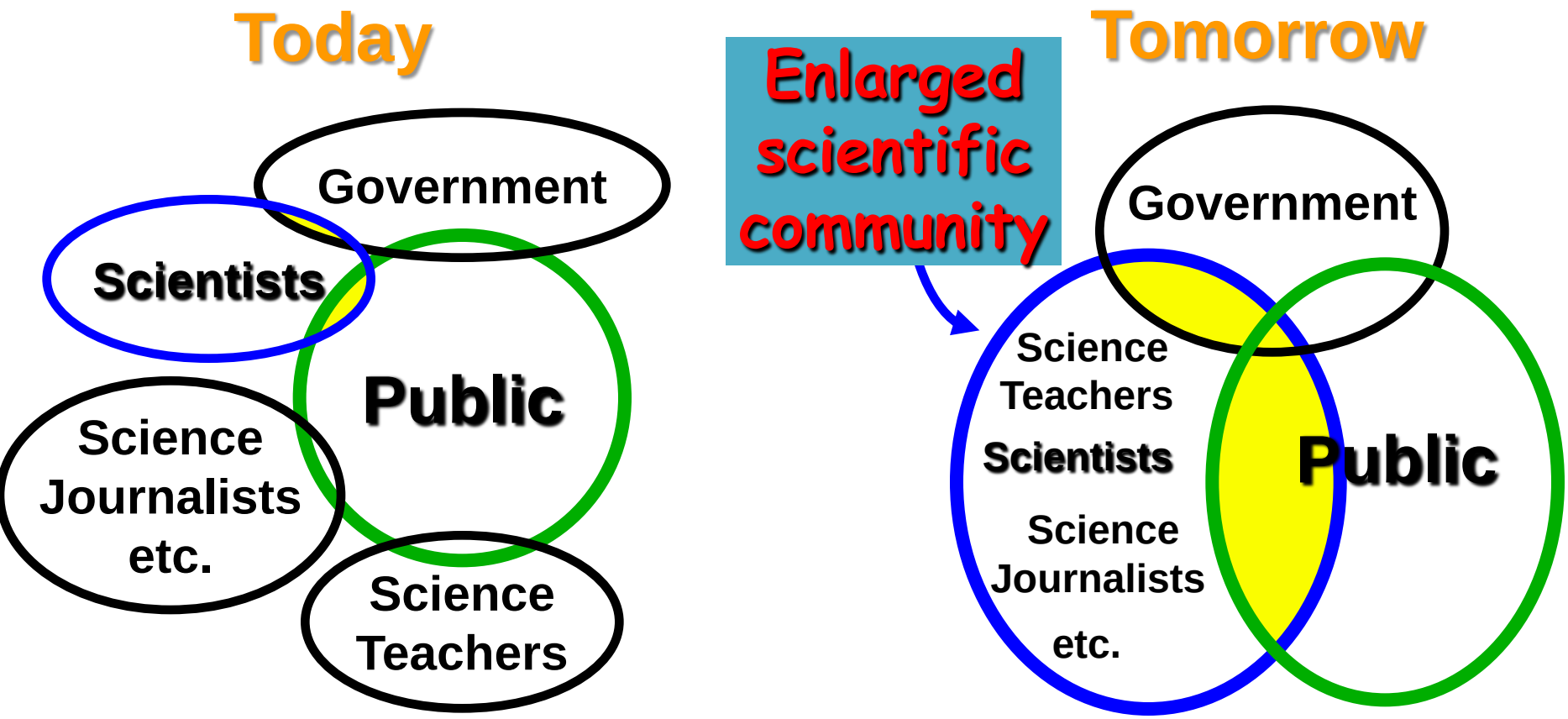
Word Generation is a SERP initiative that focuses on academic vocabulary, i.e., words that students are likely to encounter in textbooks and on tests, but not in spoken language. Learn more about the program or visit SERP's new

SERP Field Sites

The SERP field sites are structured as a set of three closely connected, and partially overlapping, groups.

- General Field Site Information
- Boston Field Site
- Minority Student Achievement Network (MSAN) Field Site
- San Francisco Field Site

3). Catalyze more support for programs that **connect the scientific community to schools**.



As "**adaptors**", we need scientifically trained people in all professions

- These individuals are invaluable for connecting our scientific community to the very different cultures of pre-college education, government, law, the media, business, etc.

- Note the enormous success of the AAAS fellowships that bring scientifically trained young people to government positions in Washington for a year.

Specific challenge: can PCAST catalyze a training / certification process to convert PhD scientists into science curriculum specialists that school districts would want to hire?

1) School districts need such an inside person with "science in his/her soul" to connect them to the enormous outside resources that exist to aid school science, including the local scientific and engineering community.

2) Many talented science graduate students and postdocs would be interested in such a career, if a productive new pathway for entry could be developed and promoted.

Science magazine can help in multiple ways

Bruce Alberts is Editor-in-Chief of *Science*.

EDITORIAL

Redefining Science Education

THERE IS A MAJOR MISMATCH BETWEEN OPPORTUNITY AND ACTION IN MOST EDUCATION SYSTEMS today. It revolves around what is meant by "science education," a term that is incorrectly defined in current usage. Rather than learning how to think scientifically, students are generally being told about science and asked to remember facts. This disturbing situation must be corrected if science education is to have any hope of taking its proper place as an essential part of the education of students everywhere.

Scientists may tend to blame others for the problem, but—strange as it may seem—we have done more than anyone else to create it. Any objective analysis of a typical introductory science course taught today in colleges and universities around the world, whether it be biology, chemistry, physics, or earth sciences, would probably conclude that its purpose is to prepare students to "know, use, and interpret scientific explanations of the natural world" (strongly emphasizing the "know"). This is but one of four goals recommended for science education by the distinguished committee of scientists and science education experts convened by the U.S. National Academies that produced *Taking Science to School: Learning and Teaching Science in Grades K-8*. And yet college courses set the model for the teaching of science in earlier years.

The three other goals of equal merit and importance are to prepare students to generate and evaluate scientific evidence and explanations, to understand the nature and development of scientific knowledge, and to participate productively in scientific practices and discourse (summarized in the Academies' *Ready, Set, Science!*). Scientists would generally agree that all four types of science understanding are critical not only to a good science education but also to the basic education of everyone in the modern world. Why then do most science professors teach only the first one?

As the scientist and educator John A. Moore emphasized in his pro-

Next year's special education issue

Science as the core subject in school:
What do we know, from research, about teaching reading, writing, and communication skills through K-8 science education?