Empowering our best teachers: A grand challenge in education

NATIONAL ACADEMIES TEACHER ADVISORY COUNCIL CONVOCATION

Washington, DC
June 5, 2014

Bruce Alberts,
University of California, San Francisco (UCSF)

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The central lesson from my 12 years in Washington as president of the National Academy of Sciences

It is critically important that science, science teachers, and scientists, achieve a much higher degree of influence, throughout both their nations and the world.

In particular, we need much more of the creativity, rationality, openness, and tolerance that are inherent to science --- what Indian Prime Minister Nehru called a "**scientific temper**" -- for both the US and all other nations

The image we want for science

A Disturbing Recent Fact

A third grade student comes home from school and tells his mother:

“Now I get it, **science is just like spelling; you just need to memorize it and it doesn’t make any sense**.”

What science should look like in school

What 5 year olds can do

1) Put on clean white socks and walk around school yard.
2) In class, collect all black specks stuck to socks and try to classify them: which are seeds and which are dirt?
3) Start by examining each speck with a 3 dollar, plastic “microscope”.
4) End by planting both those specks believed to be dirt and those believed to be seeds, thereby testing **their own idea** that the regularly shaped ones are seeds.

The Vision

Imagine an education that includes solving hundreds of such challenges over the course of 13 years of schooling

I believe that children who are prepared for life in this way would be:

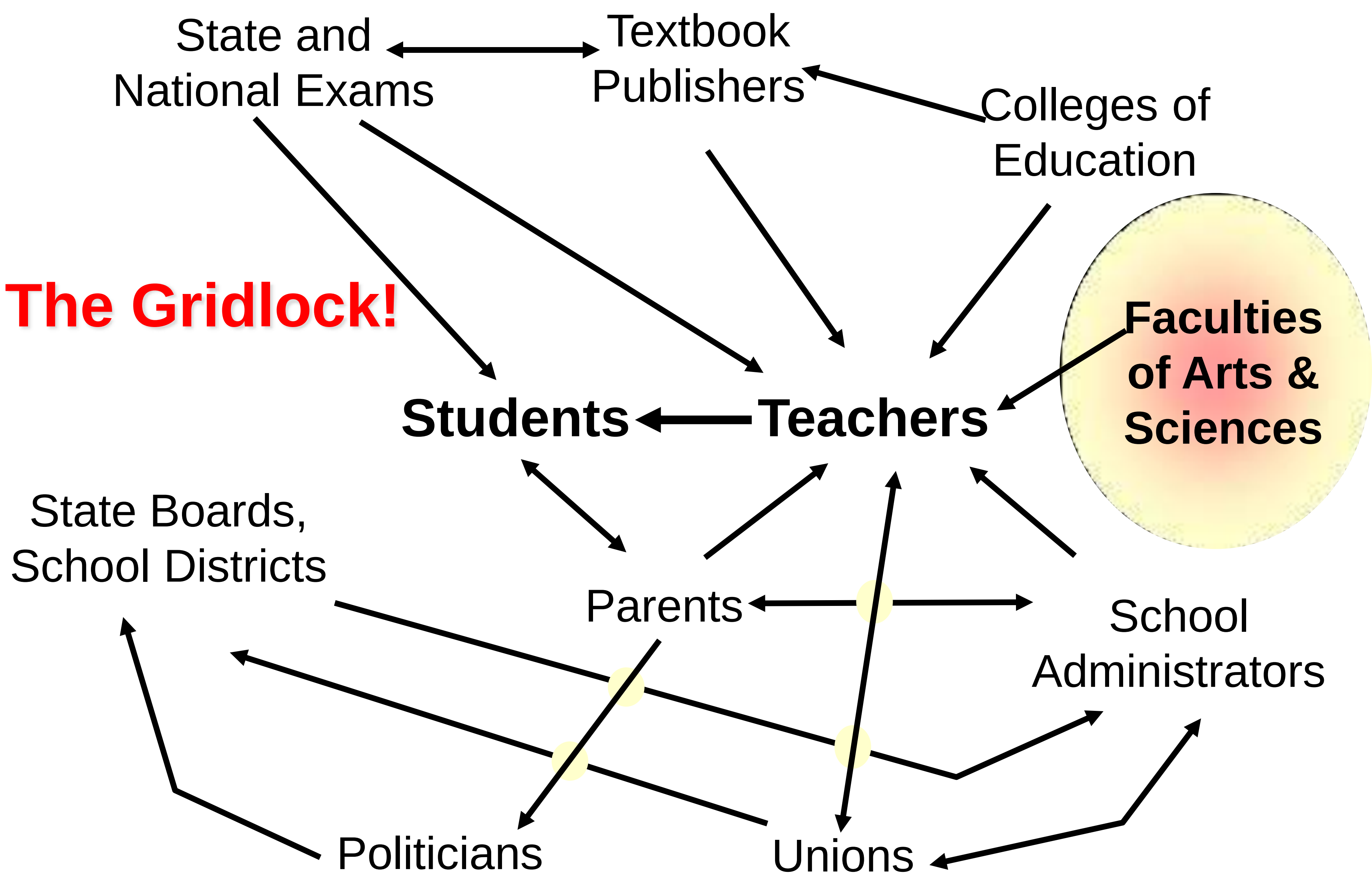
- **great problem solvers in the workplace**
- **people who are able to make wise judgments for their family, their community, and their nation**
- **Adults who reject "MAGICAL THINKING"**

The special opportunity <u>now</u>

The New Common Standards in Reading and in Math, plus the NGSS Science Standards, all require major, **synergistic** changes in K-12 education.

Students need to *use* information—to sort, analyze, and critique it, to make and defend arguments, to solve problems and incubate ideas.

To remove a major barrier to progress, science education at the college level must change


State and National Exams
Textbook Publishers
Colleges of Education
The Gridlock!
Faculties of Arts & Sciences
Students
Teachers
State Boards, School Districts
Parents
School Administrators
Politicians
Unions

Interactive, "no lecture" science classrooms
University of Minnesota
(22 tables, each with 9 chairs, two computers, overhead screen)

Robin Wright, Dean of Biology Education

Active learning in college biology class

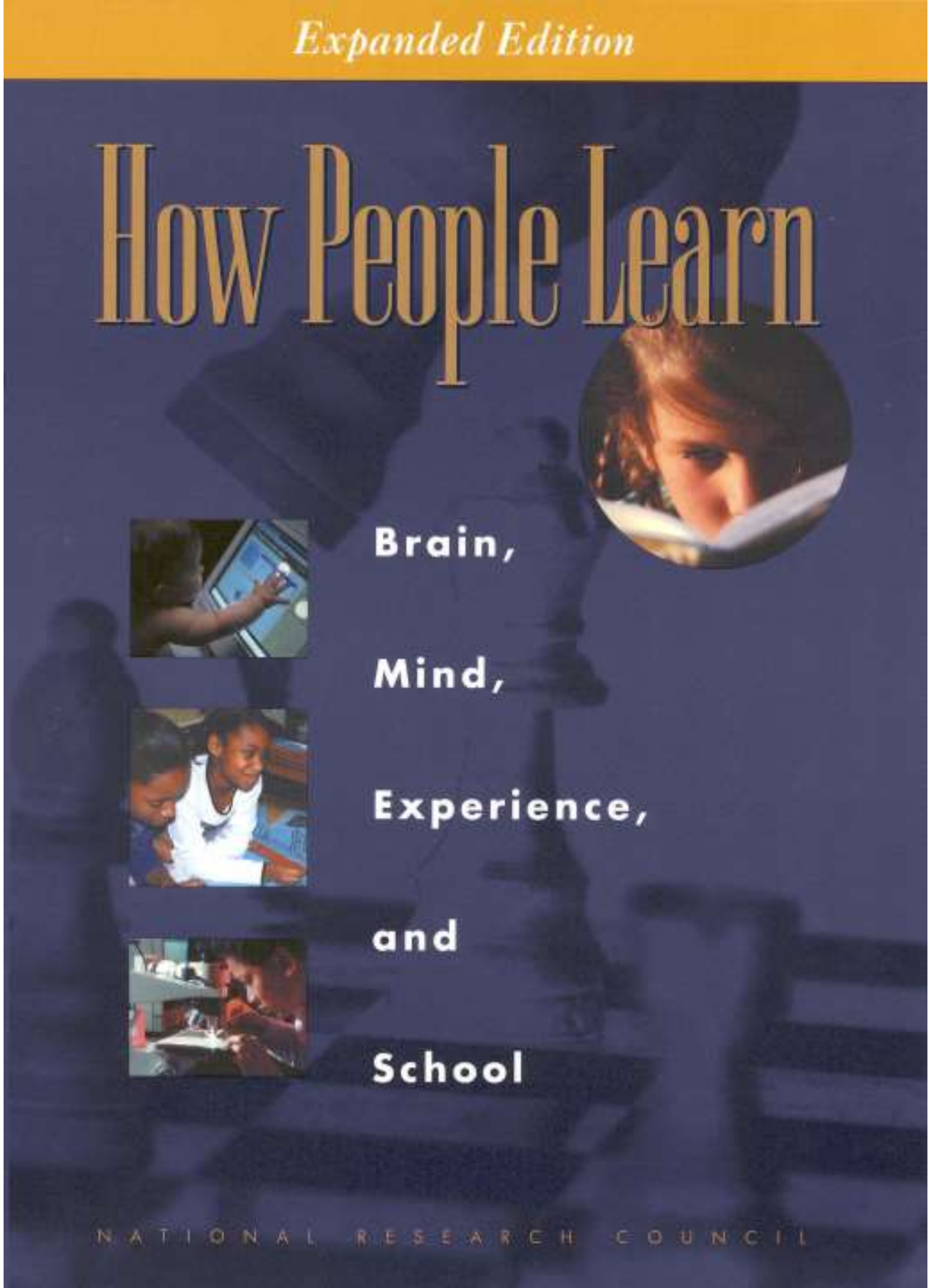
At all levels, we need to make a science out of science education!

This will require a much more focused and effective system of education research!

- Otherwise our nation's schools will continue to be driven by one simple "**magic bullet**" solution after another, as each new leader seeks a quick fix.

The Academies first attempt to harvest what we know.

Published 2000



The National Academies' recipe for effective education research:

SERP

Published 2003

The major question posed to the SERP committee:

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 together in practice settings to:

- Observe, explain, document, replicate and evaluate practice as a source of new knowledge.
- Define problems and test solutions in context.

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SERP Field Site #1
Boston Public Schools

Focus: Middle school literacy (ages 11 -13)
Catherine Snow (Harvard), Field Site Director

Examples of work:

- Design and pilot middle school literacy assessment for teacher use, with screening and diagnostic value.
- Design and pilot intensive instruction in academic vocabulary, coordinated across subject areas.

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SERP's first free product

site map | search | home

SERP

About In Schools Presentations Research Resources Events Download

Welcome to the SERP website for Word Generation.

Word Generation is a middle school academic language program developed under the direction of Harvard University Professor Catherine Snow, one of the nation's most prominent experts in literacy. The program originated at the SERP-Boston field site in collaboration with teachers and administrators in the Boston Public Schools. It is geared toward all students, in all subject areas, and can be used in all three middle grades simultaneously. The program is strategically designed to create a coherent school-wide effort that gives students the sustained exposure to academic language they need for success in school—even while demanding relatively little (15 minutes, once a week) from any single subject area teacher.

Students find Word Generation engaging.

Teachers report a change in classroom climate as students and teachers listen to each other formulate and defend arguments on important social issues of the day. Initial results for students are promising. While students read, discuss, and write about highly engaging topics, they register gains in vocabulary knowledge, with the largest gains for language minority students. Furthermore, those gains are related to better performance on state accountability tests. A larger scale field trial is under way.

Explore rationale, view teaching, download materials.

This site allows you to explore the purposes of the Word Generation program,

Online professional development for teachers based on brief teacher videos

Classroom Video Collection

SERP was invited to schools in Massachusetts and California to record **ten** different Word Generation lessons. Select from below to view video clips, transcripts, student work samples!

Topic Intro & Target Words	Science Activity	Problem of the Week	Class Debate	Taking a Stand Essay
↓	↓	↓	↓	↓
Wiretapping	Pet Rentals	No Pass/No Play	Wiretapping	Wiretapping
				
Children's Health	Media Violence	Children's Health	Children's Health	Children's Health
				

New use-inspired products for math

Math

- **AlgebraByExample***
  math.serpmedia.org/algebra_by_example

  Algebra I problem sets that address misconceptions and provide struggling students with a 10 percentage point gain in conceptual understanding

- **Poster Problems**
  math.serpmedia.org/diagnostic_teaching

  Lessons on critical math concepts in 6th and 7th grades ideal for diagnostic teaching, and for just-in-time content tune-ups for teachers

- **Tools for Sense-making in Mathematics**
  math.serpmedia.org/sense-making

  Strategies for shifting the focus in mathematics classrooms toward understanding the mathematics of a situation rather than jumping immediately to answer-getting

www.serpinstitute.org

SERP Strategic Education Research Partnership

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SERP Institute

Never has high quality education been of greater importance for individuals, families, businesses, and the economic strength and well-being of our nation.

From 2008-2013, I tried to ask "How can *Science* magazine help to promote the needed revolution in science education?"

EDITORIAL

It was great to have control of the editorial page!

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

Teaching Real Science

IN THIS ISSUE OF *SCIENCE*, WE ARE PUBLISHING THE FIRST OF 15 WINNING ENTRIES FOR the 2011 *Science* Prize for Inquiry-Based Instruction (p. 418), a laboratory module entitled *Light, Sight, and Rainbows*. Created for introductory college science courses, each module can be readily used in many different settings and schools. The winning modules were selected by a jury of more than 70 scientists and science teachers, and the subjects include physics, math, chemistry, geology, molecular biology, plant science, and evolution. Throughout 2012, each will be published as a two-page printed synopsis supplemented by online material that contains the details needed to teach it.

Our goal is to make it much easier for teachers everywhere to provide their students with laboratory experiences that mirror the open-ended explorations of scientists, instead of the traditional "cookbook" labs where students follow instructions to a predetermined result. To this end, we are announcing a second year of the contest, now broadened to include engineering in addition to science, as well as courses at the advanced high-school level (see www.scim.ag/inquiryprize). We hope that these contests will help support a rethinking of science education that is consistent with the new *Framework for K-12 Science Education* (precollege) from the U.S. National Academies, as well as with one of the central goals in the international Programme for International Student Assessment (PISA) Science Competencies: "Understands the characteristic features of science as a form of human knowledge and enquiry."*

Although our 2011 contest focused on college science teaching, the same goals can be applied even to early years of schooling. Consider, for example, an article published by the U.S. National Science Teachers Association, *Growing Seeds and Scientists*, which describes a science lesson for kindergarten students (age 5).† The students are presented with seeds of very different sizes and shapes—an avocado seed, a corn kernel, a marigold seed, and so on—mixed with objects such as pebbles and shells. For three times a week over the course of 6 weeks, the students explore the question, "How do we know if something is a seed?", forming a "scientists' conference" to share ideas respectfully and learn from each other as real scientists might in a laboratory. Thus, after the students discover that they disagree

The last of 4 special issues on education

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

EDITORIAL

Prioritizing Science Education

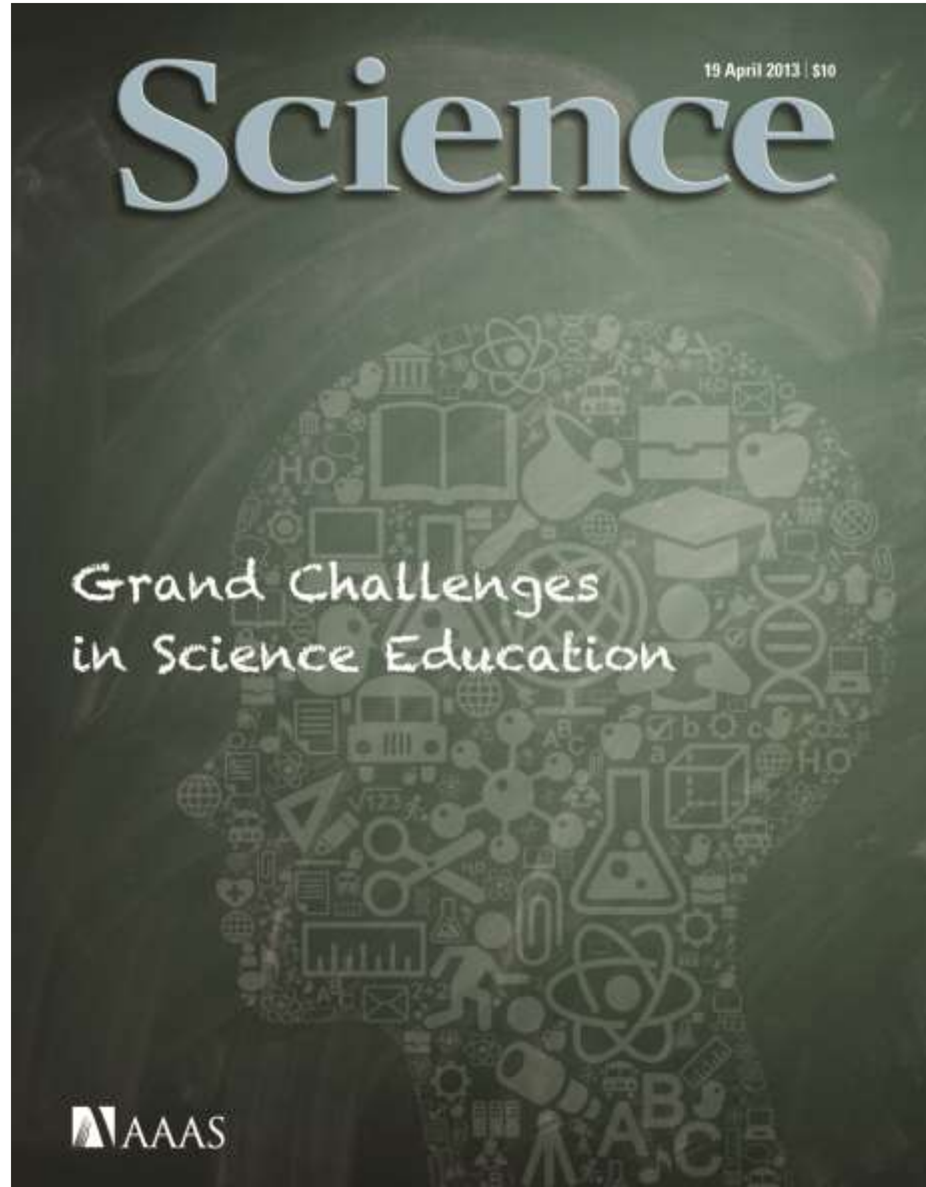
THIS SPECIAL ISSUE OF *SCIENCE* EXPLORES "GRAND CHALLENGES IN SCIENCE EDUCATION," A CRITICAL set of the problems and exciting opportunities now facing science education on a global level. The 20 Challenges, addressed by a team of education experts, range from "Enable students to build on their own enduring, science-related interests" to "Shift incentives to encourage education research on the real problems of practice as they exist in school settings." Here I propose three additional Grand Challenges. These focus on harnessing the wisdom of teachers, helping the business community promote new directions in precollege science education, and—last but not least—catalyzing major changes in the way we teach college-level science.

From my many close contacts with outstanding U.S. teachers, I have come to deeply appreciate their wisdom. They uniquely understand today's 5- to 18-year-old students and have many valuable suggestions for improving education systems. I am also painfully aware of the many past failures that have been caused by not giving the best teachers a strong voice in the public policies that profoundly affect their profession. In the 1980s, the Japanese taught the world that building a better automobile requires listening to workers on the assembly line. More generally, experience shows that actively soliciting advice from those most intimately involved is essential for wise decision-making at higher levels. Regrettably, education is one of the few parts of U.S. society that fails to exploit this fact. Hence, my initial Grand Challenge: "Build education systems that incorporate the advice of outstanding full-time classroom teachers when formulating education policy." A start has been made,* but much more remains to be done (see the Perspective by B. Berry on p. 309).

To be competitive in the global economy, businesses need to be able to hire workers who can "think for a living." More specifically, studies reveal that the private sector seeks employees who can apply a capacity for abstract, conceptual thinking 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." These employees must also have "the capacity to function effectively in an environment in which communication skills are vital—in work groups."† Achieving the revolution in U.S. science education that is called for in the *Next Generation Science Standards* released last week‡ would go a long way toward creating the type of high-school graduates that the private sector needs (see the Perspective by R. Stephens and M. Richey on p. 313). Business leadership in the United States often fails to advocate for wise education policies, despite its potential for influence. Hence, my second Grand Challenge: "Harness the influence of business organizations to strongly support the revolution in science education specified in the *Next Generation Science Standards*."

Several years ago on this page, I pointed out that, "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."§ College science courses are taught by scientists, and they define "science education," modeling for teachers and adults what should be done at lower levels. Most college faculty have not yet faced up to the urgent need to improve on the standard one-size-fits-all lecture format (see News story by J. Mervis on p. 292). Thus, my final Grand Challenge: "Incorporate active science inquiry into all introductory college science classes."

The aim is nothing less than a more rational world.



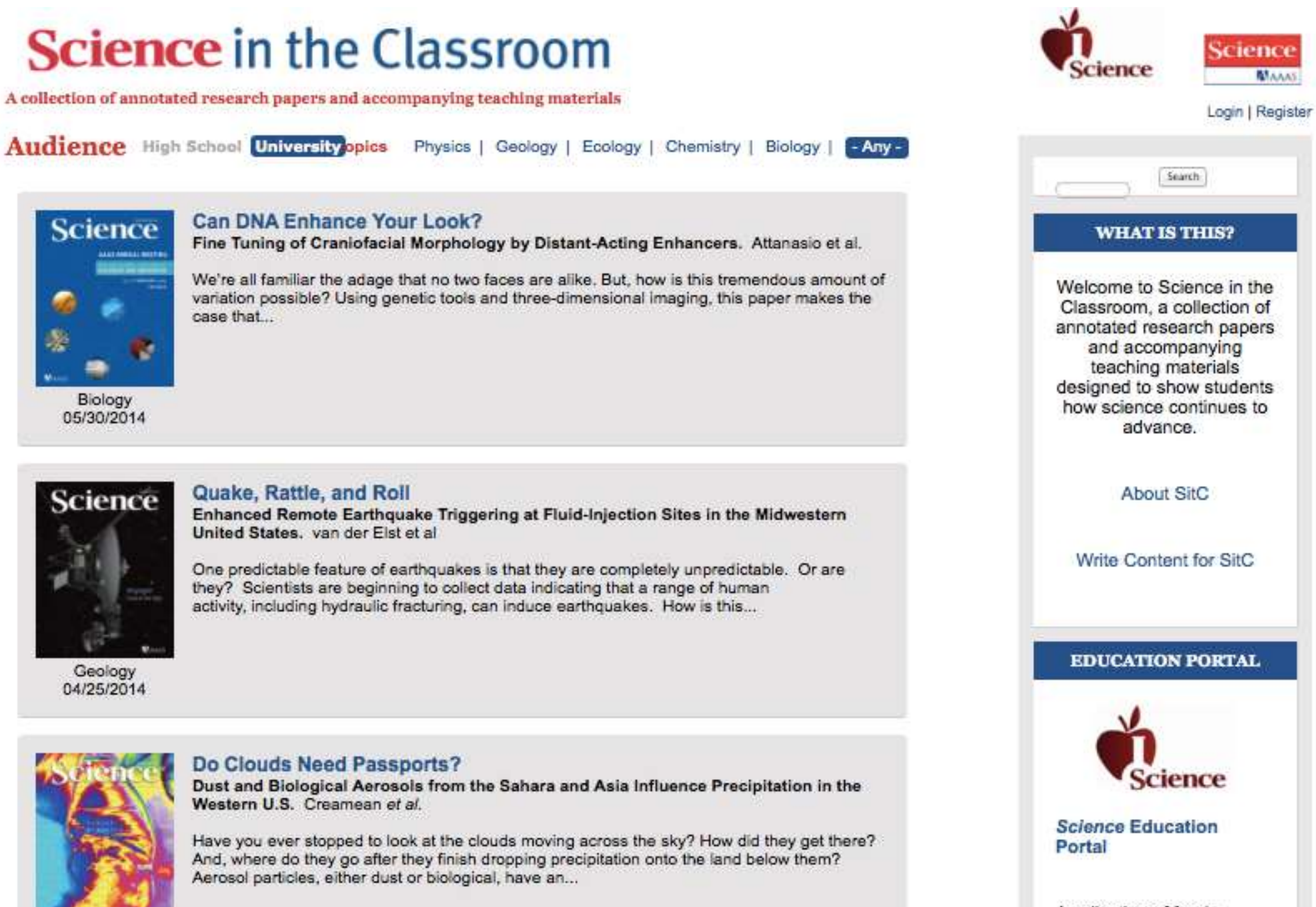
Reading an actual scientific article should be part of science education

- The Framework for the "Next Generation Science Standards" (NGSS) emphasize the **Practice of Science** and active science learning.

- All high school students are to "engage in a **critical reading of primary scientific literature** or of media reports of science and discuss the validity and reliability of the data, hypotheses, and conclusions."

With support from the NSF, *Science* magazine has been trying to help

Currently ten *Science* papers have been annotated and are ready for use in the classroom.



Features include a "Learning Lens" with guidance that one can turn on and off

Science in the Classroom

UNDERSTANDING SCIENTIFIC RESEARCH - FOR STUDENTS AND TEACHERS

Science AAAS

TEACHING RESOURCES | ABOUT THIS PROJECT | CONTRIBUTE/GET INVOLVED

1 INTRODUCTION | RESEARCH PAPER | ACTIVITIES | COMMENTS | TEACHERS NOTES

Science 6 August 2010
Vol. 329 no. 5992 pp.679-682
DOI: 10.1126/science.1188594

REPORT

An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species

Winifred F. Frick[1,2,*], Jacob F. Pollock[3], Alan C. Hicks[4], Kate E. Langwig[4,1], D. Scott Reynolds[5,1], Gregory G. Turner[6], Calvin M. Butchkoski[6] and Thomas H. Kunz[1]

ABSTRACT

White-Nose Syndrome (WNS) is an emerging disease affecting hibernating bats in eastern North America that causes mass mortality and precipitous population declines in winter hibernacula. First discovered in 2006 in New York state, WNS is spreading rapidly across eastern North America and currently affects seven species. Mortality associated with WNS is causing a regional population collapse and is predicted to lead to regional extinction of the little brown myotis (*Myotis lucifugus*), previously one of the most common bat species in North America. Novel diseases can have serious impacts on naïve wildlife populations, which in turn can have substantial impacts on ecosystem integrity.

LEARNING LENS

- GLOSSARY
- PREVIOUS WORK
- AUTHOR'S EXPERIMENTS
- CONCLUSIONS
- NEWS AND POLICY LINKS
- CONNECT TO ADVANCED PLACEMENT ™

Expanded figures include further explanations

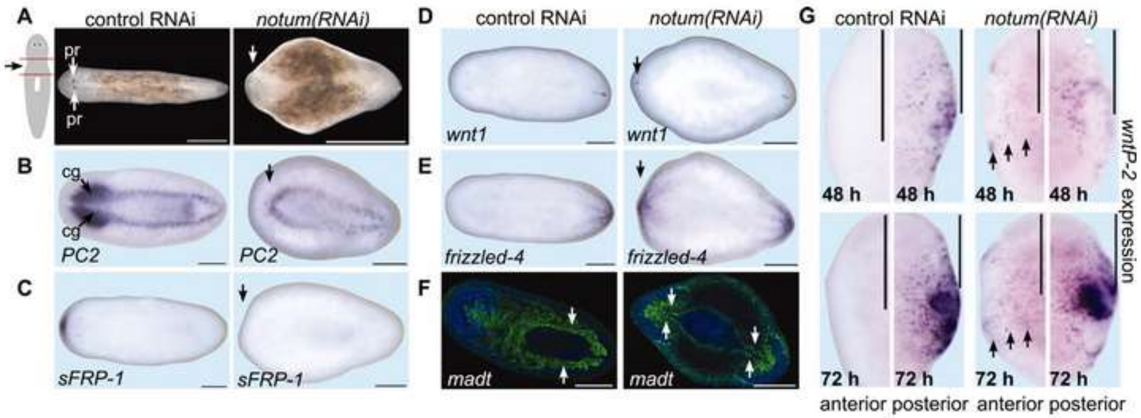


Fig. 2. notum is required for head-tail regeneration polarity. (A) notum(RNAi) fragments failed to regenerate a head by 14 days after amputation (47%, n = 133; controls were normal, 100%, n = 101). (B to F) Control or notum(RNAi)-regenerating animals lacking photoreceptors were probed for expression of (B) PC2 (prohormone convertase 2, central nervous system marker), (C) sFRP-1 (anterior-pole marker), (D) wnt1, (E) fzd-4 (posterior markers), or (F) madt (gut marker, green). Blue, Hoechst stain. Arrows indicate lack of anterior marker [(B) and (C)], posterior marker presence [(D) and (E)], or posterior gut morphology (F) in notum(RNAi) animals. cg, cephalic ganglia; pr, photoreceptors. Images are representatives: (B) 9/11, (C) 8/25, (D) 7/24, and (E) 11/38 notum(RNAi) animals; other panels, 100%, n ≥ 7. (G) Anterior- or posterior-facing wounds, probed for wntP-2 expression. wntP-2 has been proposed to be Wnt11-related with the name wnt11-5 (8). Arrows indicate ectopic wntP-2 expression. Images represent ≥five of six animals per panel. Anterior to the left. Scale bars, 500 mm (A); 200 mm (all other panels).

RNAi | Panel A | Panel B and C | Panel D and E | Panel F | Panel G

The anterior blastemas of notum RNAi planarians lack a brain and do not express a gene normally expressed specifically in the head (sFRP-1). This demonstrates that anterior-facing blastemas are not heads.

LEARNING LENS

Click on a category below to display annotations. You can find more information by clicking the highlighted text to the left. To close the note, click on the text again.

- GLOSSARY
- PREVIOUS WORK
- AUTHOR'S EXPERIMENTS
- CONCLUSIONS
- NEWS AND POLICY LINKS
- CONNECT TO LEARNING STANDARDS
- REFERENCES AND NOTES

Annotated References place previous work into context

References and Notes:

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2. H. McCallum, A. Dobson, Trends Ecol. Evol. 10, 190 (1995).

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11. S. J. Puechmaille et al., Emerg. Infect. Dis. 16, 290 (2010).

12. T. J. O'Shea, M. A. Bogan, Monitoring Trends in Bat Populations of the United States and Territories: Problems and Prospects (Biological Resources Discipline, Information and Technology Report USGS/BRD/ITR-2003-003, U.S. Geological

Learning Lens ×

A research paper describing the use of 26 years of Breeding Bird Survey data to determine the impact of West Nile virus (WNV) on 20 potential avian hosts across North America. This study demonstrates significant changes in population trajectories for seven species from four families. This study served as a model for the authors' current study as they are calculating similar projections on how a specific pathogen is affecting population.

LEARNING LENS

Click on a category below to display annotations. You can find more information by clicking the highlighted text to the left.

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- CONNECT TO LEARNING STANDARDS
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Melissa McCartney

More teacher feedback wanted!

A free website to know

Science Education Portal

A collection of freely available education content published by Science

Science In The Classroom | *Science* Homepage

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SPECIAL ISSUES	RESEARCH	REVIEWS	NEWS

Highlights

Making business students science-savvy

Editors' Choice 05/30/2014

AAAS National STEM Volunteer Program

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

Blog 10/31/2013

With nearly 100 volunteers spending a day a week in K-12 classrooms in the D.C. area, and a budding program in Seattle, AAAS is committed to working with scientists and engineers to make scientific literacy possible for all students. Now, thanks to a generous

Convergence Between Science and Environmental Education

Forums 05/09/2014

Citizen science and concerns about sustainability can catalyze much-needed synergy between environmental education and science education.

Login or Register to download this content.

Last but not least, the critical issue of **teacher empowerment**

- Some 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 failed to exploit this fact.

What keeps me up at night

- Our best teachers need to have much more influence on the education system.
- This influence is needed at every level: from school districts, to States, to the Federal Government.
- How can we institutionalize such an influence, as needed to create a continuously improving education system?


A national Teacher Advisory Council
Every State and District also needs one!

A California Teacher Advisory Council (CTAC) has been established

- Sponsored by the California Council on Science and Technology (CCST), a state version of the National Academies
- Making connections to legislators and education leaders in Sacramento

The Amazing Power of Science-Education Partnerships

- Scientists and engineers are urgently needed to support teachers.

- And we all have a great deal to learn from outstanding teachers of children age 5 to 18 that will improve our own teaching.

UCSF's 25 year-old Science Education Partnership

Each year:

- Scientist volunteers contribute >10,000 hours
- Are active in 90% of SFUSD schools
- Involve >350 Teachers and > 250 UCSF Volunteers

UCSF University of California San Francisco

SCIENCE & HEALTH EDUCATION PARTNERSHIP UNIVERSITY OF CALIFORNIA · SAN FRANCISCO

What I have learned about partnerships

1. Any effective partnership requires that the partners deeply respect and honor each other's unique expertise.

(e.g., scientists, science teachers, and science education researchers)

2. Partnerships flourish best when the partners can focus on accomplishing an important discrete task.

(e.g., schools, informal sector, and after school programs working together to create a powerful STEM Badge program across the U.S.)

3. Funding agencies must work to decrease the strong incentives for "uniqueness": an enemy of coherence.

(e.g., overcome the "not invented here" aversion to copying outstanding programs)

Our Joint Mission: My favorite quote

"The society of scientists is simple because it has a directing purpose: to explore the truth. Nevertheless, it has to solve the problem of every society, which is to find a compromise between the individual and the group. It must encourage the single scientist to be independent, and the body of scientists to be tolerant. From these basic conditions, which form the prime values, there follows step by step a range of values: dissent, freedom of thought and speech, justice, honor, human dignity and self respect.

Science has humanized our values. Men have asked for freedom, justice and respect precisely as the scientific spirit has spread among them."

Jacob Bronowski, Science and Human Values, 1956

An urgent challenge today

- It is much easier to test for science words than for science understanding and abilities.

- Bad tests force a trivialization of science education and drive most students, including many potential scientists, away from science.

New types of assessments are needed for the NGSS

Grand Challenges in Science Education
www.sciencemag.org/special/education2013

REVIEW

Proficiency in Science: Assessment Challenges and Opportunities

James W. Pellegrino

Proficiency in science is being defined through performance expectations that intertwine science practices, cross-cutting concepts, and core content knowledge. These descriptions of what it means to know and do science pose challenges for assessment design and use, whether at the classroom instructional level or the system level for monitoring the progress of science education. There are systematic ways to approach assessment development that can address design challenges, as well as examples of the application of such principles in science assessment. This Review considers challenges and opportunities that exist for design and use of assessments that can support science teaching and learning consistent with a contemporary view of what it means to be proficient in science.

We face extraordinary promise for the future of science learning, juxtaposed with substantial challenges in achieving the vision of what it means to be proficient in science (*1*). Among those challenges are determining how the proficiency of our students will be assessed relative to that vision and doing so in ways that support, rather than inhibit, teaching and learning. Educational assessments ought to be statements about what scientists, educators, policy-makers, and parents want students to learn and become. It is well established that what we choose to assess

work for K-12 Science Education (*1*): (i) core or "big" ideas within disciplinary areas, (ii) practices of scientific and engineering reasoning, and (iii) cross-cutting concepts. Collectively they define what it means to know science, not as separate elements but as intertwined aspects of knowledge and understanding [see also (*12*)]. It is not just the description of each and their intersection that matters but also that the meaning of proficiency is realized through performance expectations about what students at various levels of educational experience should know and be able to do. These statements move

point targets at grades 2, 5, 8, and 12 for each component of each core idea. The framework also provides sketches of possible progressions for acquiring each practice or cross-cutting concept but does not indicate the expectations at any particular grade level. The Next Generation Science Standards (NGSS) (*7*) build on these suggestions and include tables that define what each practice might encompass and the expected uses of each cross-cutting concept for students at each grade level.

This integrated perspective of what it means to know science suggests that assessment should help determine where a student can be placed along a sequence of progressively more "scientific" understandings of a given core idea that by definition includes successively more sophisticated applications of practices and cross-cutting concepts. This is an unfamiliar idea in the realm of science assessments, which have more often been viewed as simply measuring whether students know particular grade-level content. It means that assessments must strive to be sensitive both to grade-level appropriate performances and to intermediate performances that may be appropriate at somewhat lower or higher grade levels. This is particularly important for the design of assessment materials and resources that can be used in classrooms to support instruction.

The NRC Framework states that assessment tasks must be designed to gather evidence of students' ability to apply the practices and their understanding of the cross-cutting concepts in the contexts

New use-inspired products for math

Diagnostic Teaching in Mathematics

SERP Strategic Education Research Partnership

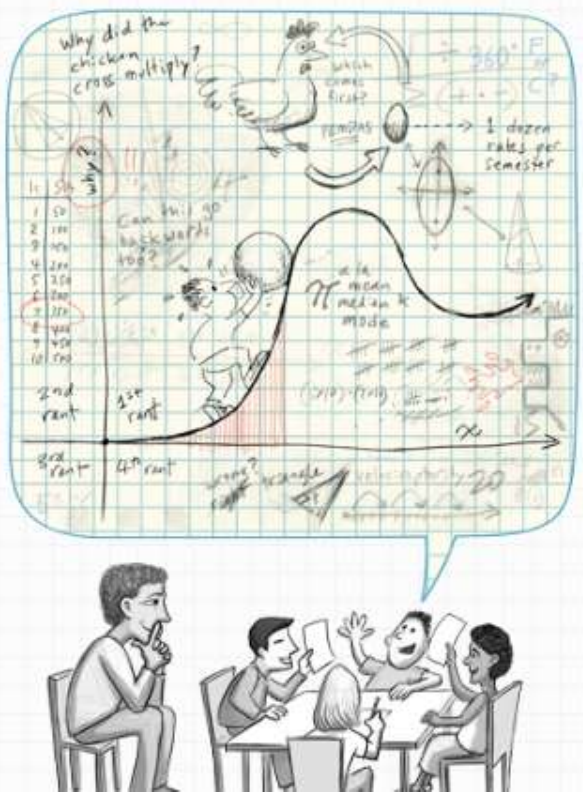
POSTER PROBLEMS

Home | Teaching Poster Problems | Curriculum | Teacher Tune-ups

What is diagnostic teaching?

It is an approach that aims to:

- → bring the thinking of students out into the open so teachers can use it to promote math discourse;
- → allow for a range of solution approaches - all valid, but some using more basic math that can seamlessly lead to using more advanced math;
- → give teachers lots of information as students complete tasks so they see and hear how students are advancing.



- -

Read about the team who developed these materials.

Sixth Grade Problems

- The Intensity of Chocolate Milk
- No Matter How You Slice It
- Toothpick Patterns
- Rating Rate Plans
- Knowing Nets
- Roving Ranges

Seventh Grade Problems

- Drag Racer Dragonfly
- Seeing Sums
- Walking the Line
- On the Download