Osher Lifelong Learning Institute – UCSD Extension

An Industrial Perspective On Improving Science, Technology, Engineering, and Mathematics (STEM) Education
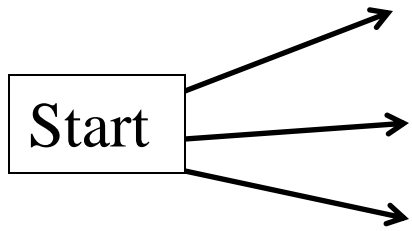
Dr. Larry Woolf
General Atomics Aeronautical Systems, Inc
General Atomics Sciences Education Foundation
January 12, 2012
www.sci-ed-ga.org/GASEFPresentations.html
Larry.Woolf@ga.com

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Start

Goal

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Outline

- ❖ **The new reality**
- ❖ **STEM status/comparisons**
- ❖ **Calls for action**
- ❖ **Professional responses**
- ❖ **Status of K-12, undergrad, grad STEM**
- ❖ **STEM and Innovation**
- ❖ **Recommendations for improved STEM**

Caveats

❖ **Personal bias (physics-centric) and perspective based on my experiences**

❖ **I've never taught an official class, K-graduate**

❖ **35 years since I've been a student in a K-graduate classroom**

The New Reality

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"When Did the Rules Change?"

❖ "A general guideline is that people are rewarded when they can do things that take trained judgment and skill – things, in other words, that can't be done by computer or lower wage workers in other countries"

❖ "One of the greatest challenges is that a college degree is no longer a guarantee of a middle-class existence … To get a good job, you have to have some special skill – charm, by the way, counts – that employers value"

❖ "[We] should go to school, learn some skills and prepare for a rocky road."

Adam Davidson, New York Times Magazine 11/27/11

"How did the robot end up with my job?"

❖ "In the hyperconnected world, there is only "good" "better" and "best""

❖ "That makes it more vital than ever that we have schools elevating and inspiring more of our young people into that better and best category because even good might not cut it anymore and average is definitely over."

Thomas Friedman, New York Times 10/2/11

"Employability Means More Than Technical Job Skills"

❖ "Employers … tell me … that they need employees who are clear thinkers, know how to get information, gather data, exercise judgment and are good communicators in multiple business contexts."

❖ "… graduates should improve their practical skills by making a commitment to lifelong education. In many fields a college degree is necessary but no longer sufficient for lifelong employability."

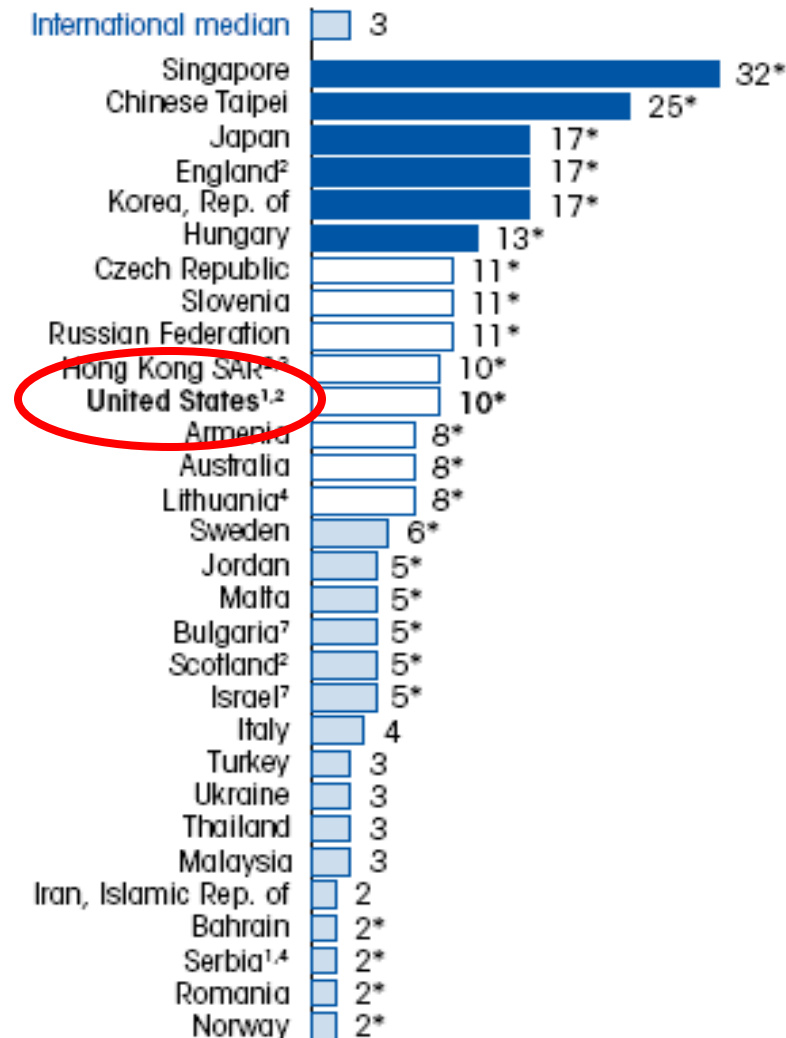Mary Walshok, Dean of UCSD Extension, San Diego Union Tribune 12/30/11

STEM Status/Comparisons

STEM student comparisons and preparedness

❖ **Trends in International Mathematics and Science Study (TIMSS)**

  • Mathematics and science achievement

❖ **Program for International Student Assessment (PISA)**

  • Applying knowledge to real-life situations

❖ **National Assessment of Educational Progress (NAEP)**

  • The Nation's Report Card

❖ **Science and Engineering Readiness Index (SERI)**

 • Measurement of how well states are preparing K-12 students for college STEM

  Bottom line – The USA is not #1

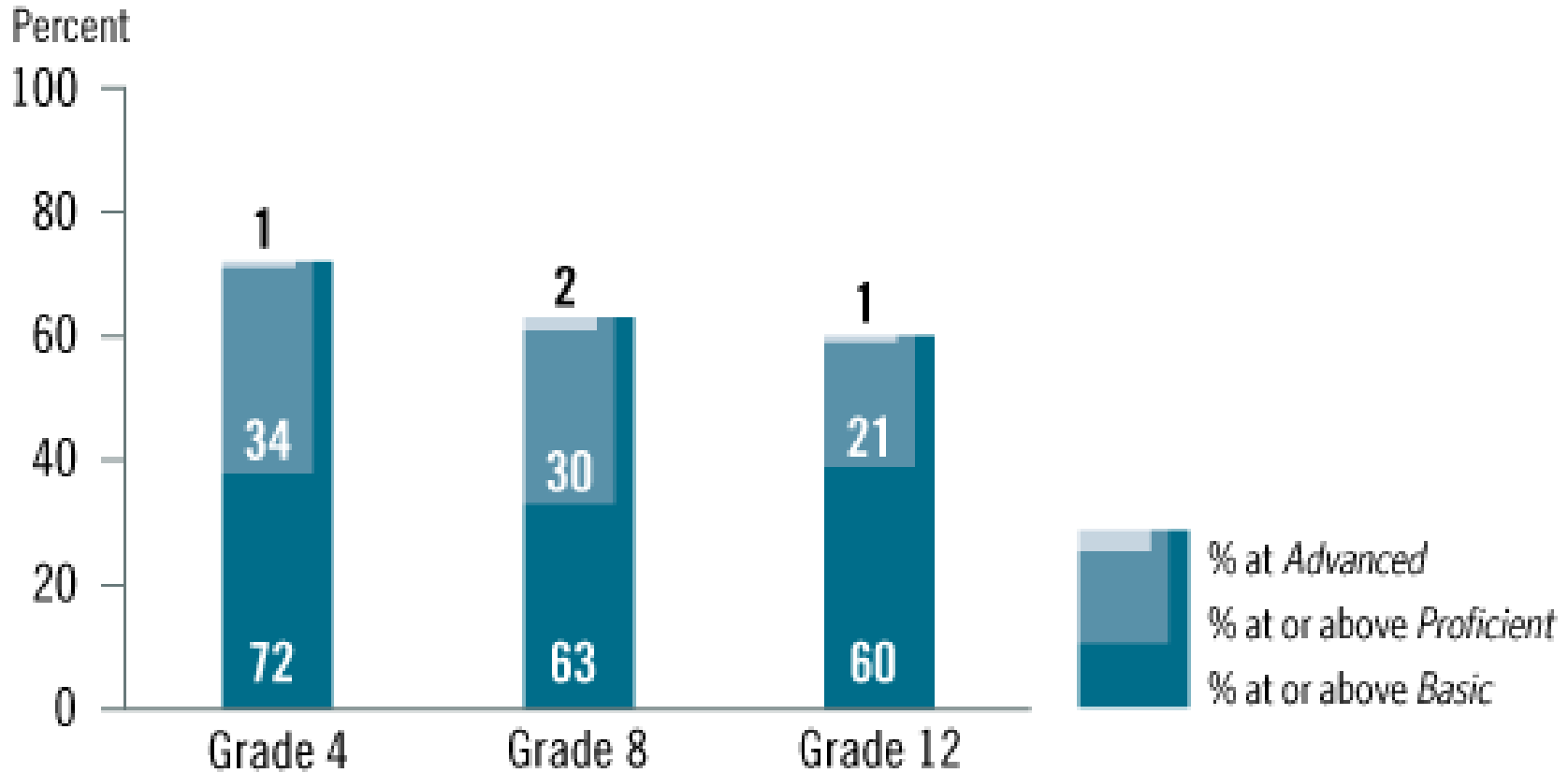# Percentage of eighth-grade students who reached the TIMSS advanced international benchmark in science

International median — 3
Singapore — 32*
Chinese Taipei — 25*
Japan — 17*
England[2] — 17*
Korea, Rep. of — 17*
Hungary — 13*
Czech Republic — 11*
Slovenia — 11*
Russian Federation — 11*
Hong Kong SAR[1,3] — 10*
United States[1,2] — 10*
Armenia — 8*
Australia — 8*
Lithuania[4] — 8*
Sweden — 6*
Jordan — 5*
Malta — 5*
Bulgaria[7] — 5*
Scotland[2] — 5*
Israel[7] — 5*
Italy — 4
Turkey — 3
Ukraine — 3
Thailand — 3
Malaysia — 3
Iran, Islamic Rep. of — 2
Bahrain — 2*
Serbia[1,4] — 2*
Romania — 2*
Norway — 2*

PISA 2009 Results: Top performers in reading, mathematics and science
Percentage of students reaching the two highest levels of proficiency

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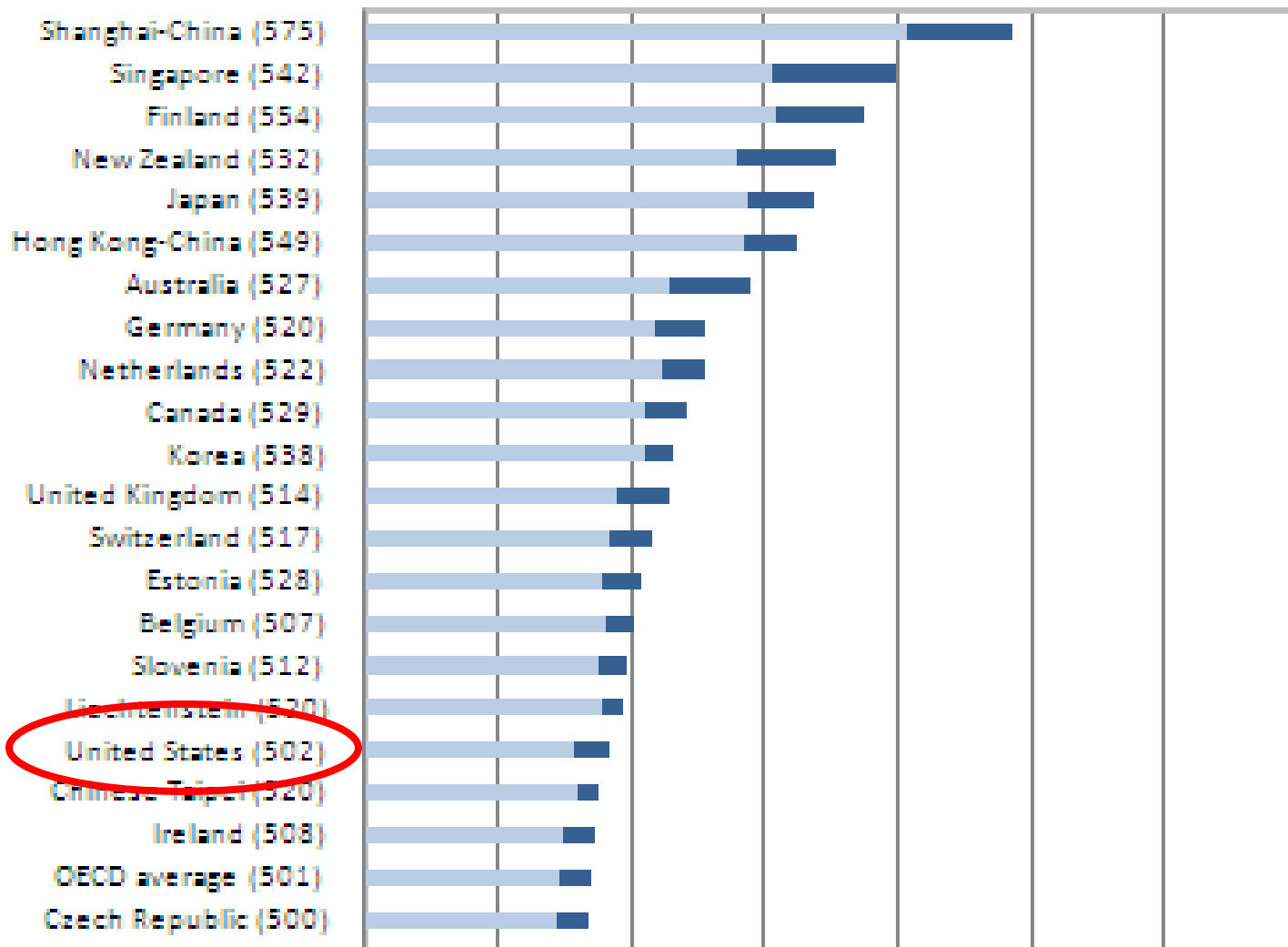
Achievement-level results in NAEP science at grades 4, 8, and 12: 2009

Science and Engineering Readiness Index - 2011

Legend
- Best in the US
- Well above average
- Above average
- Average
- Below average
- Far below average
- Worst in the US

http://www.aps.org/units/fed/newsletters/summer2011/white-cottle.cfm

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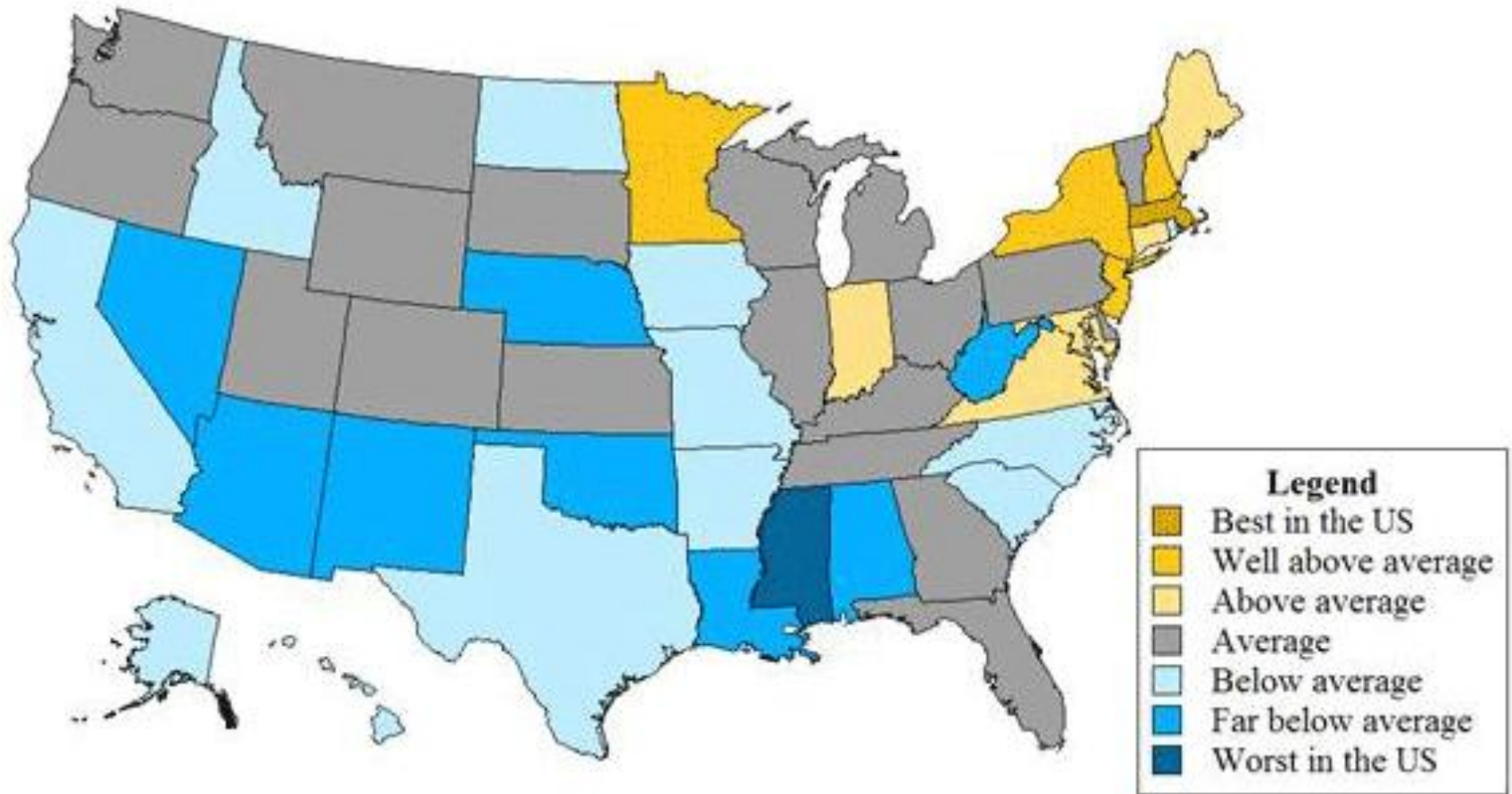
Survey of MIT ME Grads '92-'96

Source of Learning

ME Core

Professional skills

How & Why
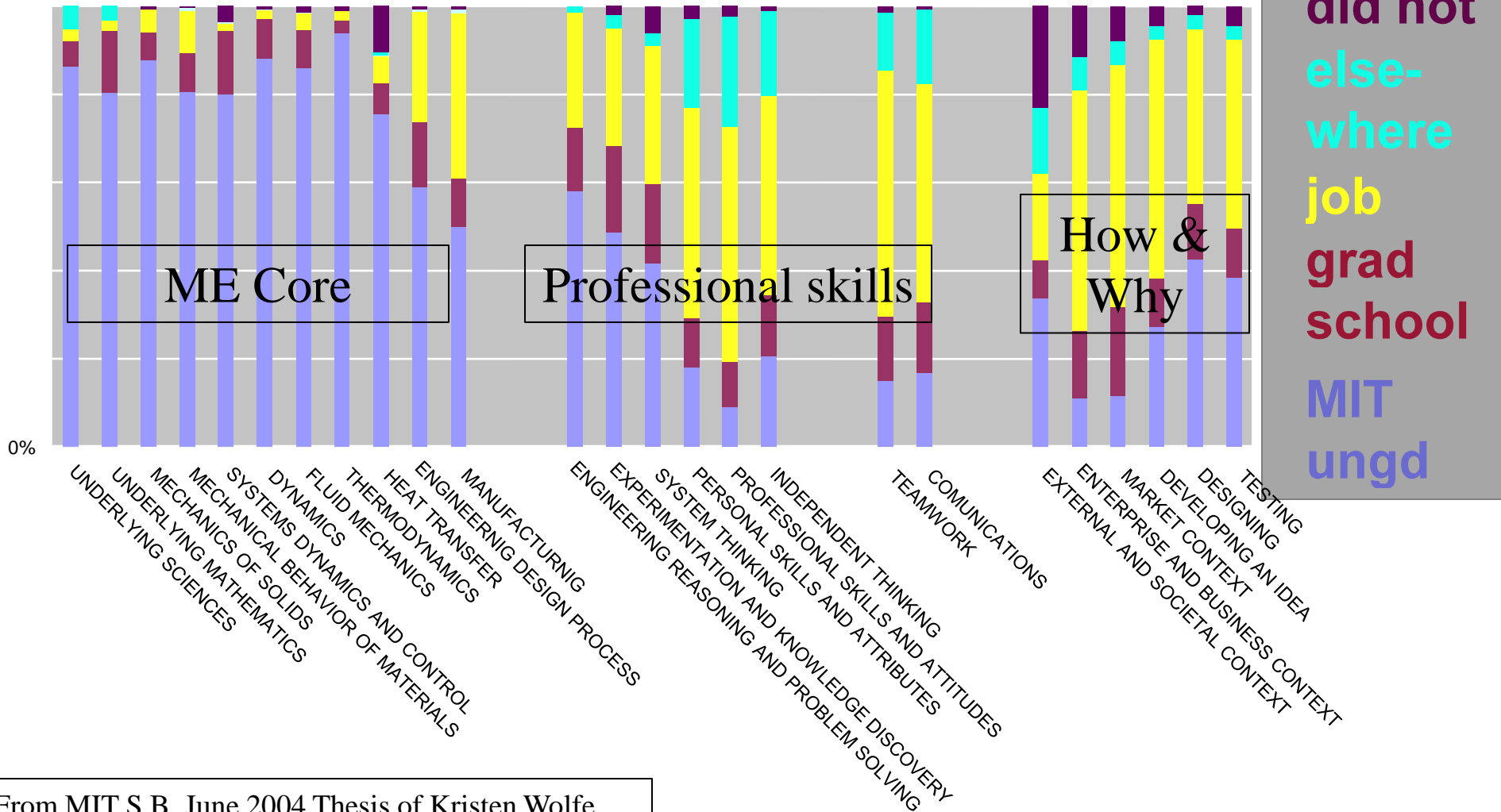
did not
else-where
job
grad school
MIT ungd

UNDERLYING SCIENCES
UNDERLYING MATHEMATICS
MECHANICS OF SOLIDS
MECHANICAL BEHAVIOR OF MATERIALS
SYSTEMS DYNAMICS AND CONTROL
DYNAMICS
FLUID MECHANICS
THERMODYNAMICS
HEAT TRANSFER
ENGINEERNIG DESIGN PROCESS
MANUFACTURNIG
ENGINEERING REASONING AND PROBLEM SOLVING
EXPERIMENTATION AND KNOWLEDGE DISCOVERY
SYSTEM THINKING
PERSONAL SKILLS AND ATTRIBUTES
PROFESSIONAL SKILLS AND ATTITUDES
INDEPENDENT THINKING
TEAMWORK
COMUNICATIONS
EXTERNAL AND SOCIETAL CONTEXT
ENTERPRISE AND BUSINESS CONTEXT
MARKET CONTEXT
DEVELOPING AN IDEA
DESIGNING
TESTING

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"Soft Skills" used by new physics PhDs

**Interpersonal and Management Skills Regularly Used by New Physics PhDs, Classes of 2007 and 2008 Combined.**

Postdocs: All Sectors (N=529)

Potentially Permanent: Private Sector (N=174)

- Work on a Team
- Technical Writing
- Manage Projects
- Speak Publicly
- Manage People
- Manage Budgets
- Work With Clients

0 25 50 75 100

Percent Who Use Regularly
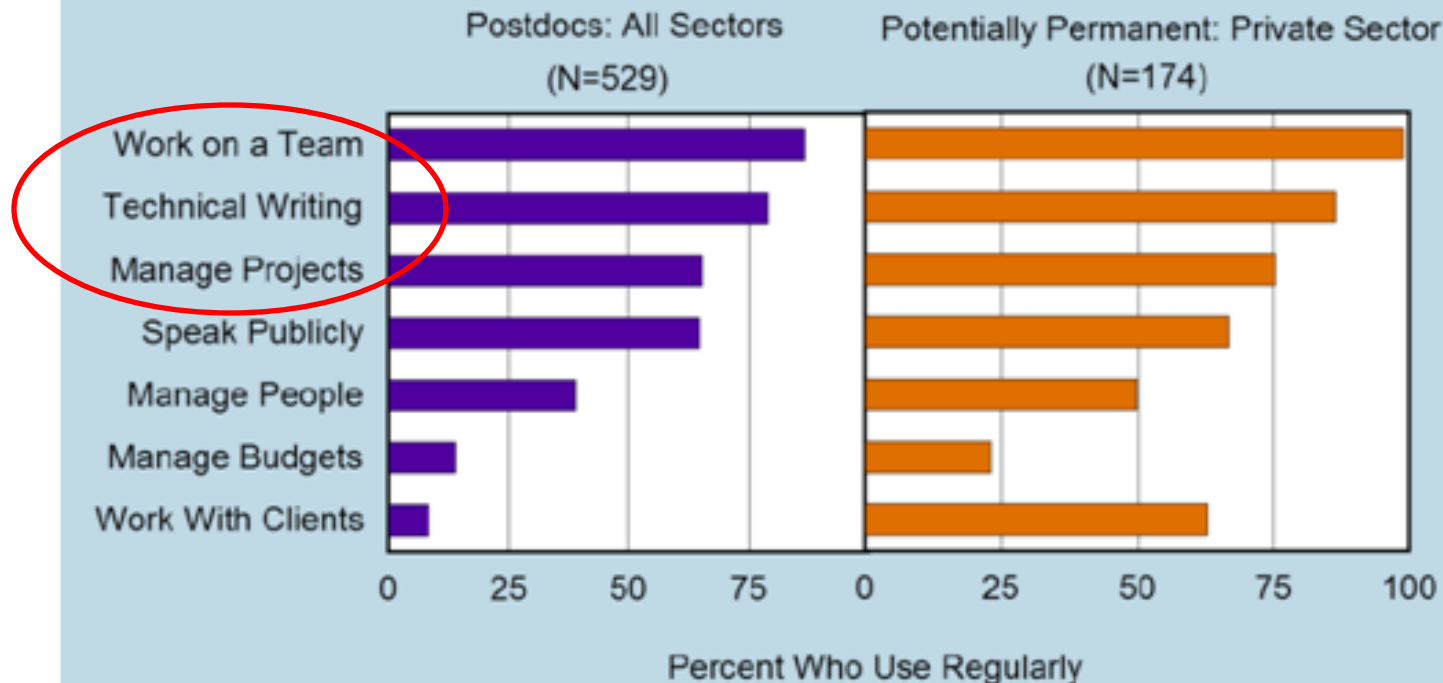
Note: Percentages represent the proportion of physics PhDs who chose "daily", "weekly" or "monthly" on a four-point scale that also included "never or rarely".

Data are limited to PhDs who earned their degrees from a US institution and remained in the US.

http://www.aip.org/statistics

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Scientific skills used by new physics PhDs

Scientific and Technical Knowledge Regularly Used by New Physics PhDs, Classes of 2007 and 2008 Combined.
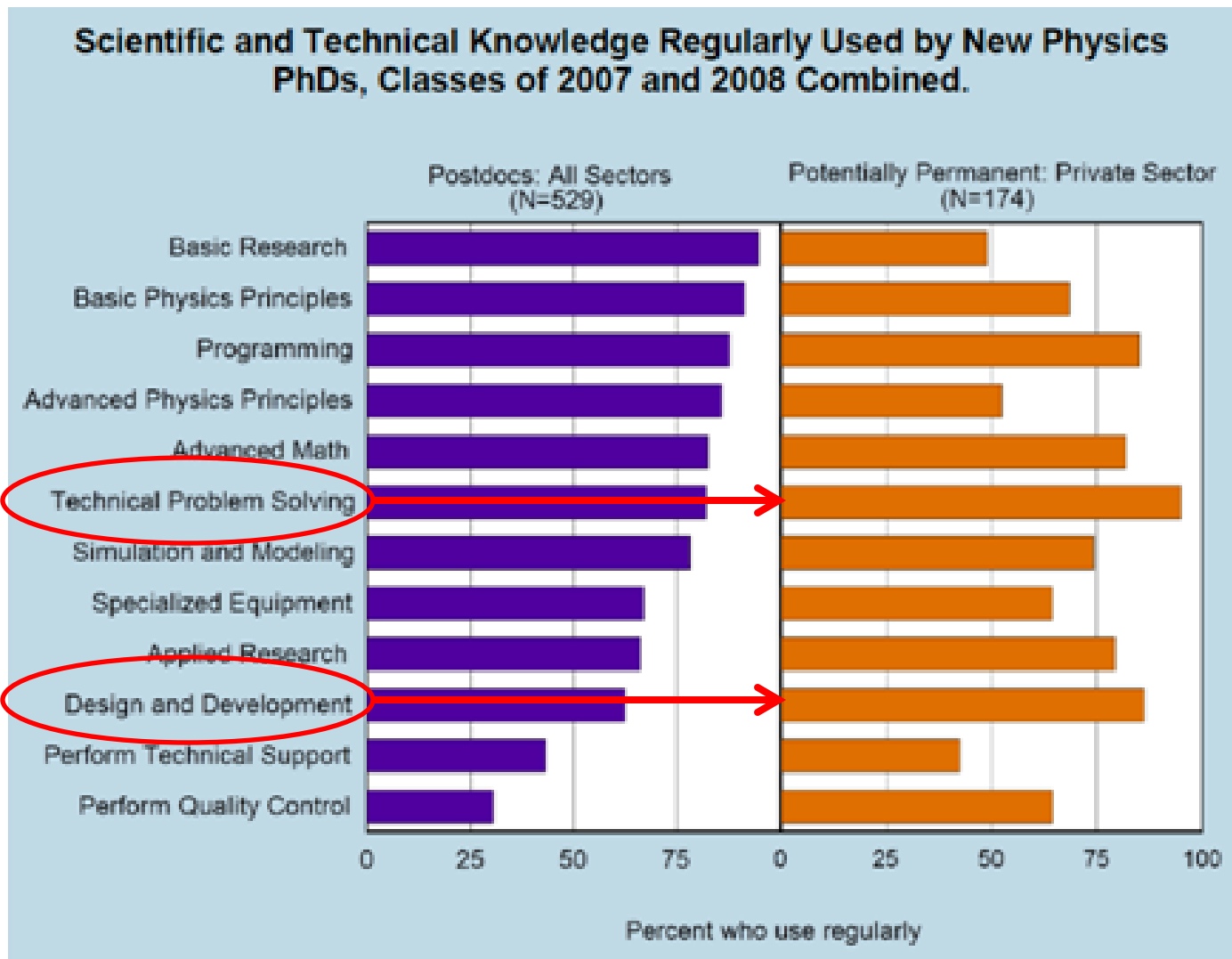
Current status of formal education does not promote expertise in innovation

- ❖ **Focus on procedural problem solving**
- ❖ **Few opportunities for original experimentation**
- ❖ **No margin for failure or mistakes: we are graded primarily on getting answers right**
- ❖ **Educational system overemphasizes analytical skills at expense of creative thinking skills like design**
- ❖ **Does not inspire and nurture the desire and ability to constantly learn**

Little Bets: How Breakthrough Ideas Emerge from Small Discoveries by Peter Sims

Calls for Action

UNENDING CALLS FOR ACTION

- ❖ **A Nation at Risk: The Imperative For Educational Reform (1983)**
    - • **"Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world"**
    - • **"If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. We have, in effect, been committing an act of unthinking, unilateral educational disarmament."**
- ❖ **Before It's Too Late: Glenn Commission Report on Mathematics and Science Teaching for the 21st Century – (2000)**
- ❖ **Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2007)**
- ❖ **Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5 (2010)**

Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future (2007)

• **What are the top 10 actions that federal policymakers could take to enhance the science and technology enterprise?**

• *Four overarching recommendations, 2 of them related to STEM education.*

  • **Move the US K-12 education system in Science and Engineering to a leading position by global standards**

  • **Encourage more US citizens to pursue careers in STEM.**

• **To maintain or enhance our future standard of living requires that we lead the world in innovation.**

  • **first to acquire new knowledge through leading edge research**

  • **first to apply that knowledge to create products and services**

  • **first to introduce those products and services into the marketplace.**

  How can we incorporate innovation characteristics into STEM education? See later slides.
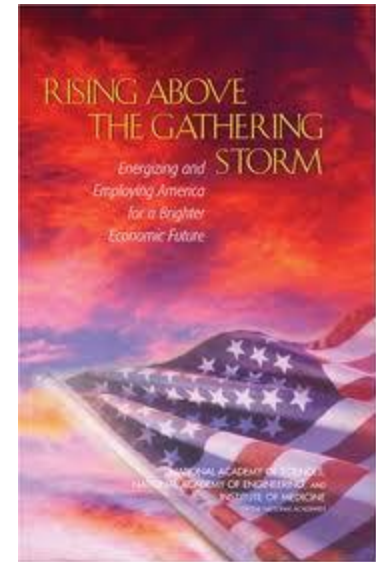
Professional Responses

Has anything good happened since "A Nation at Risk (1983)? – details on following slides

- ❖ National and state standards for learning at K-12 level
- ❖ Curricula that actively engage students in scientific processes – K-12 and beginning undergraduate – (but not very widely used)
- ❖ Growth and impact of discipline based science education research (physics education research as university-recognized discipline)
- ❖ Growth of informal STEM education – science festivals, citizen scientist opportunities, Exploratorium-type museums
- ❖ Increase in attention being paid to STEM education – and many STEM initiatives and programs for K-12
- ❖ STEM education via professional organizations (short courses and tutorials) and university extension

Standards for K-12 science

❖ **Project 2061: Benchmarks for Science Literacy (AAAS, 1993) [Education change ~ Halley's Comet]**

❖ **National Science Education Standards (NRC, 1996)**

❖ **California State Science Standards, 1998**
  - +49 other different state science standards

❖ **A Framework for K-12 Science Education, Practices, Crosscutting Concepts and Core Ideas (NRC, July 2011)**
  - **Scientific and Engineering Practices**
    — **e.g. asking questions and defining problems**
  - **Crosscutting Concepts**
    — **e.g. Patterns, Structure and Function**
  - **Disciplinary Core Ideas**

❖ **Next generation science standards (Achieve, Inc., AAAS, NRC, NSTA) – potential basis for all 50 states**
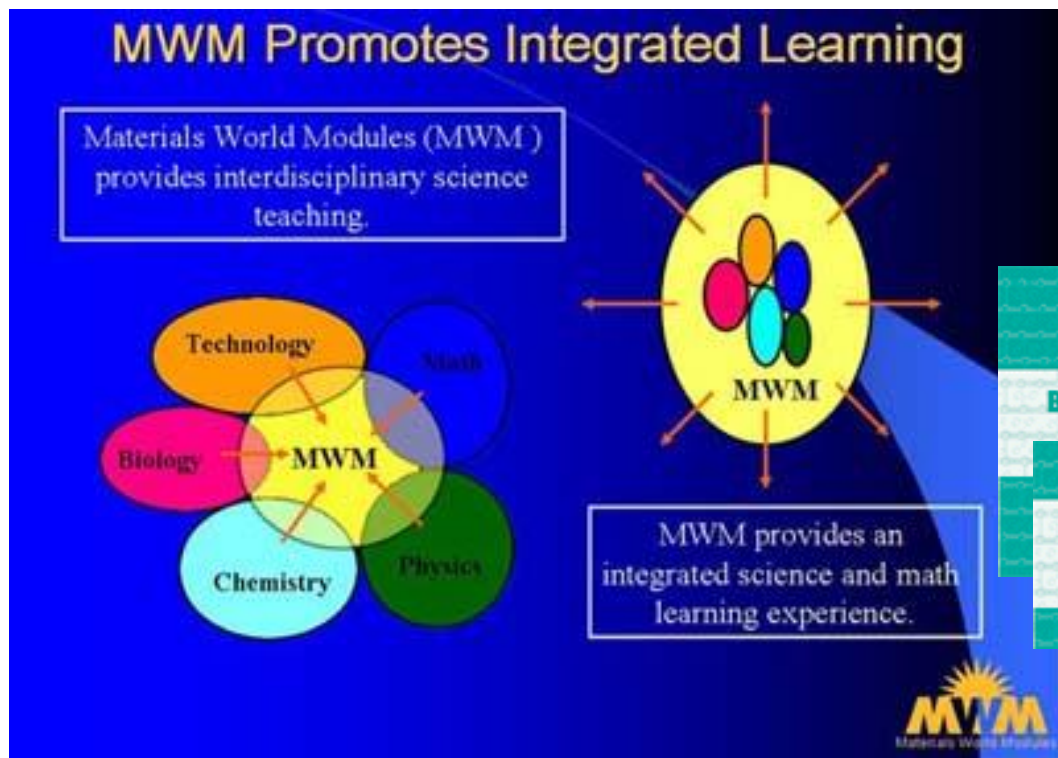 - **20 states involved in development**

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Hands on Science Kits (e.g. FOSS for K-8)

Learning Cycle
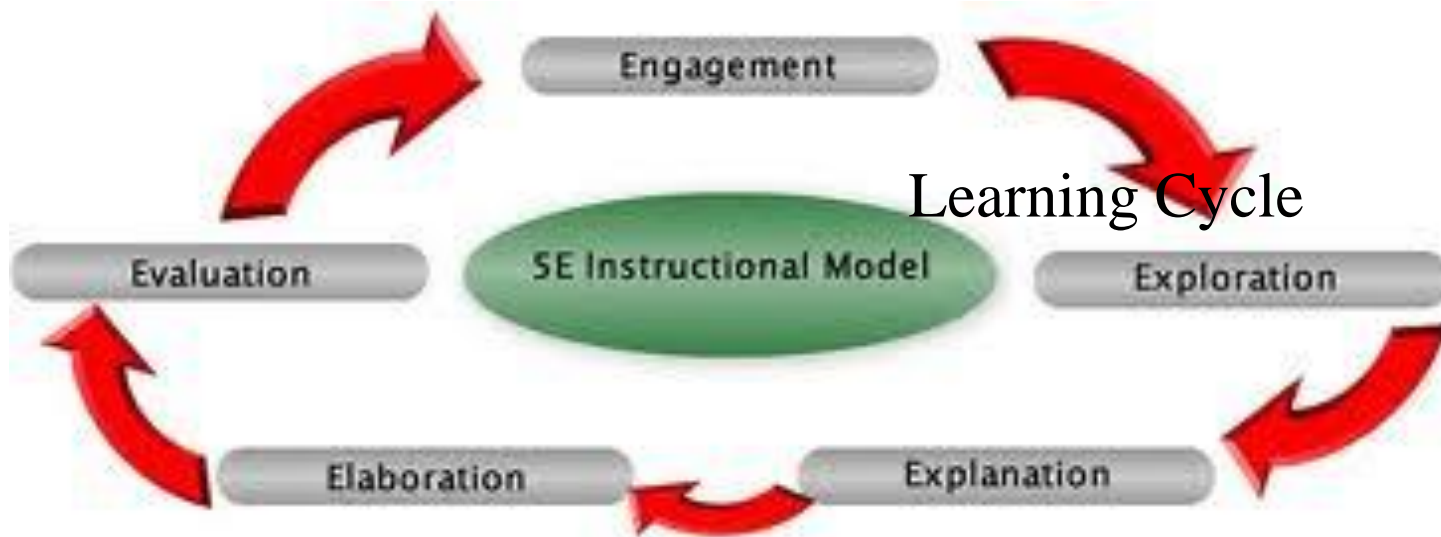
Materials World Modules are NSF funded STEM curricula for grades 7-12

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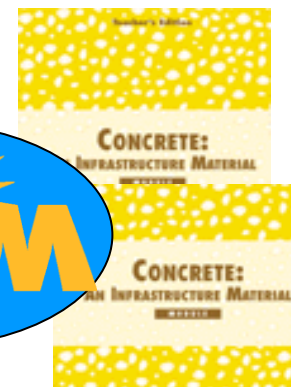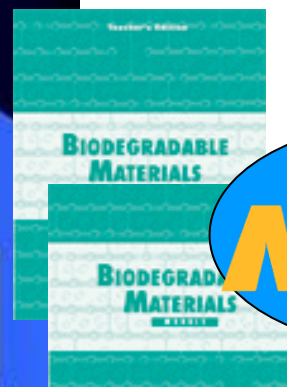
Physics Education Research (PER)

- ❖ **Development of research-based and research-informed instructional materials**
  - **Concept inventories (Force Concept Inventory-FCI)**
    - **Evidence for improved conceptual understanding using pre- and post-testing**
  - **Curricula (ASU Modeling, U of WA Tutorials in Introductory Physics)**
  - **Instructional strategies (Interactive Engagement)**
  - **Resources**
    - **compadre.org/per**
    - **perusersguide.org**
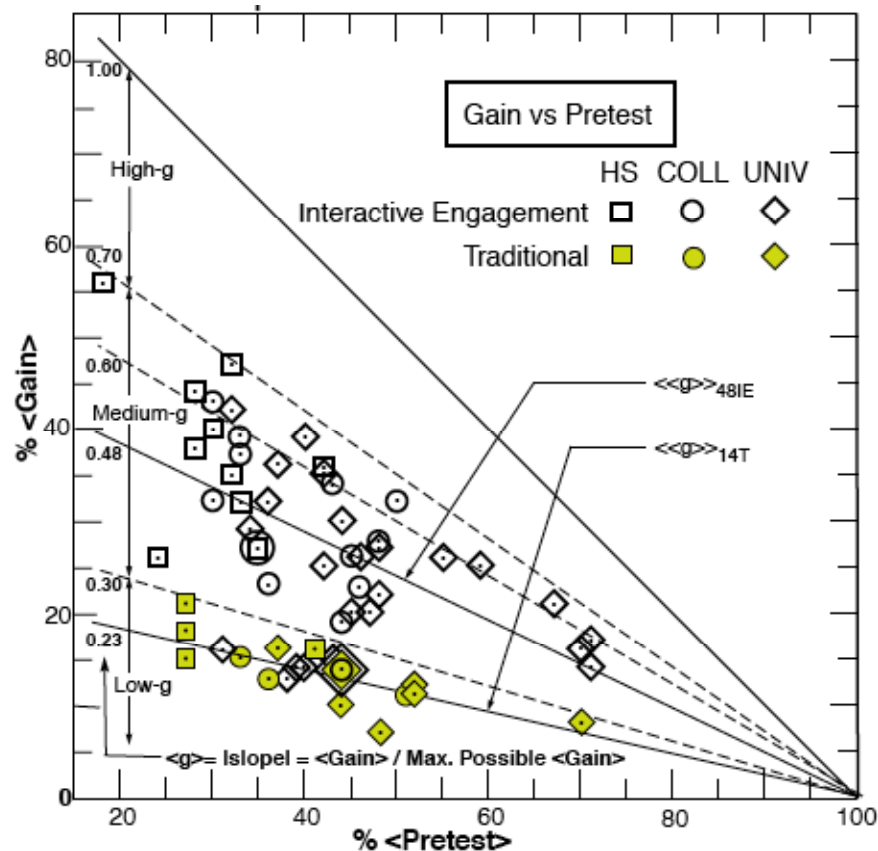
Improvement in learning using interactive instruction (Richard Hake)

Physics Education Research Based Methods of Instruction

- Constructing understanding.
- Active engagement
- Conceptual focus
- Verbalizing thinking
- Peer discussion
- Group work
- Model-building
- Explicitly taking students' prior thinking into account
- Confronting student difficulties

- Socratic dialog
- Formative assessment
- Rapid feedback
- Multiple representations
- Organizing knowledge
- Metacognition
- Explicitly addressing epistemology

INTERACTIVE TEACHING

Promoting Better Learning Using *Peer Instruction* and *Just-in-Time Teaching*

FEATURING the award-winning documentary
FROM QUESTIONS TO CONCEPTS
with Harvard Physics Professor Eric Mazur

Silver Remi Award, 2005 WorldFest-Houston International Film Festival
Bronze Plaque, 2004 Columbus International Film Festival
Award of Distinction, 2004 Communicator Awards

Discipline Based Education Research

❖ **The Board on Science Education (BOSE) at the National Research Council is conducting a synthesis study on the status, contributions, and future direction of Discipline Based Education Research (DBER) across undergraduate physics, biological sciences, geosciences, and chemistry**

❖ **Physics - http://www7.nationalacademies.org/bose/DBER_Docktor_October_Paper.pdf**
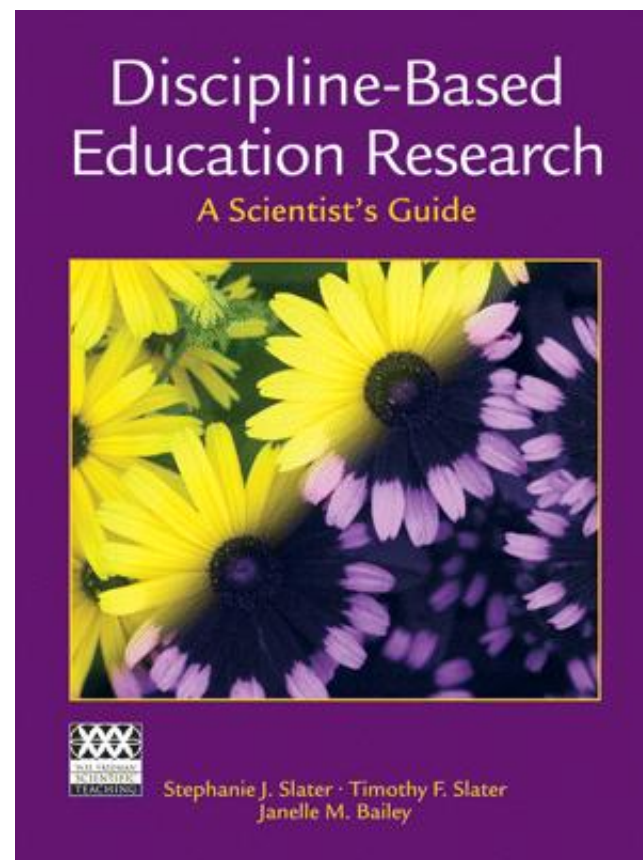
Science Festivals

- **The 2012 San Diego Festival of Science and Engineering will be held March 17-24.**
- **2012 USA Science & Engineering Festival Expo in Washington DC on April 28-29**

FIRST (For Inspiration and Recognition of Science and Technology) Robotics - 1989

- **294,000+ students**
- **26,900 teams**
- **24,300+ robots**
- **51,000 Mentors/adult supporters**
- **Started by Dean Kamen (Segway)**

Jr.FLL
Junior FIRST® LEGO® League
Grades K-3 (ages 6-9)

FLL.
FIRST® LEGO® League
Grades 4-8 (ages 9-16)
9-14 in the U.S. and Canada

FTC.
FIRST® Tech Challenge
Grades 9-12 (ages 14-18)

FRC.
FIRST® Robotics Competition
Grades 9-12 (ages 14-18)

Project Lead the Way - 1997

- ❖ **Provides middle and high school STEM curricula**
- ❖ **Students create, design, build, discover, collaborate and solve problems while applying what they learn in math and science.**
- ❖ **High school**
  - **Pathway To Engineering**
  - **Biomedical Sciences**
- ❖ **Middle school**
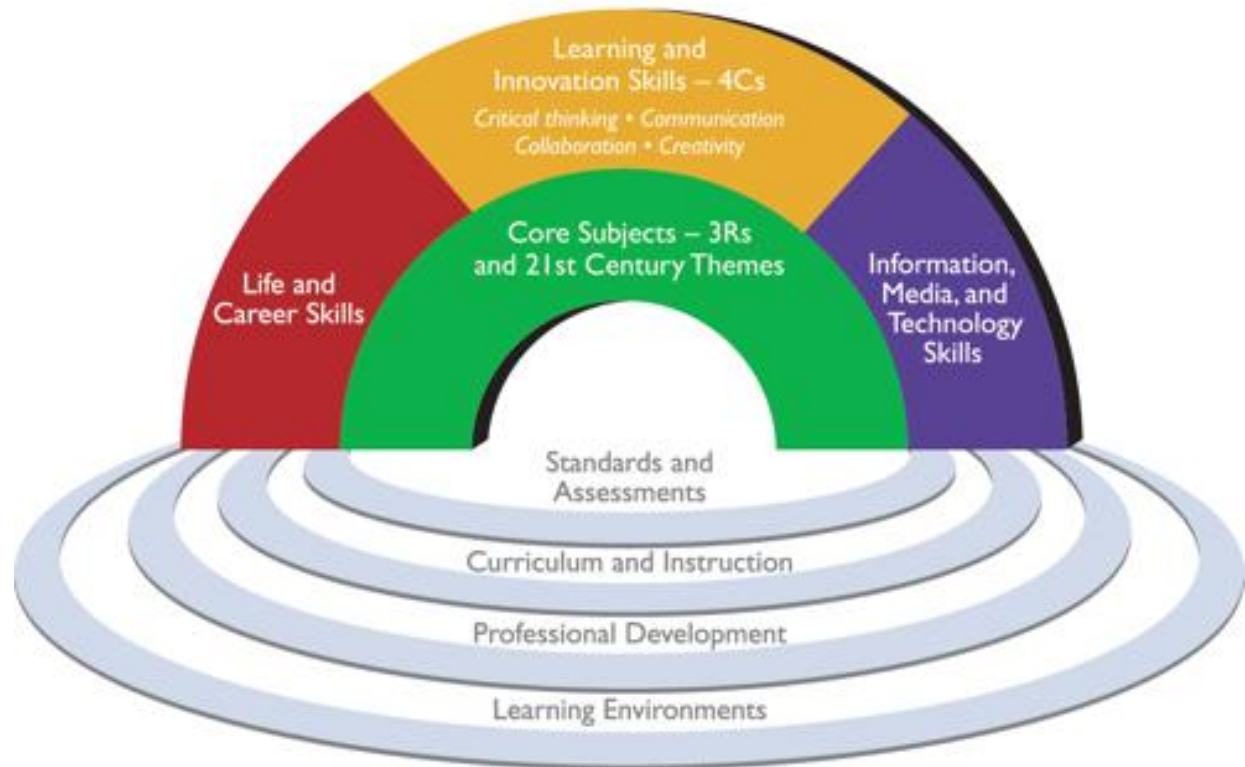 - **Gateway To Technology (GTT) program for middle schools**

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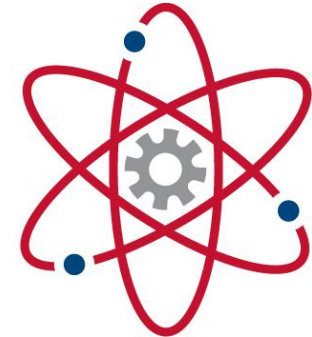
• Partnership advocating for 21st century skills

    • U.S. Department of Education

    • AOL Time Warner Foundation, Apple Computer, Inc. Cable in the Classroom, Cisco Systems, Inc., Dell Computer Corporation, Microsoft Corporation, National Education Association, SAP

# National Math and Science Initiative - 2007

- ❖ **$125 million**
- ❖ **ExxonMobil**
- ❖ **To better prepare talented students and teachers for STEM**
- ❖ **Replicates proven programs with quantifiable results**
  - • **UTeach**

UTEACH GRADUATES TO DATE
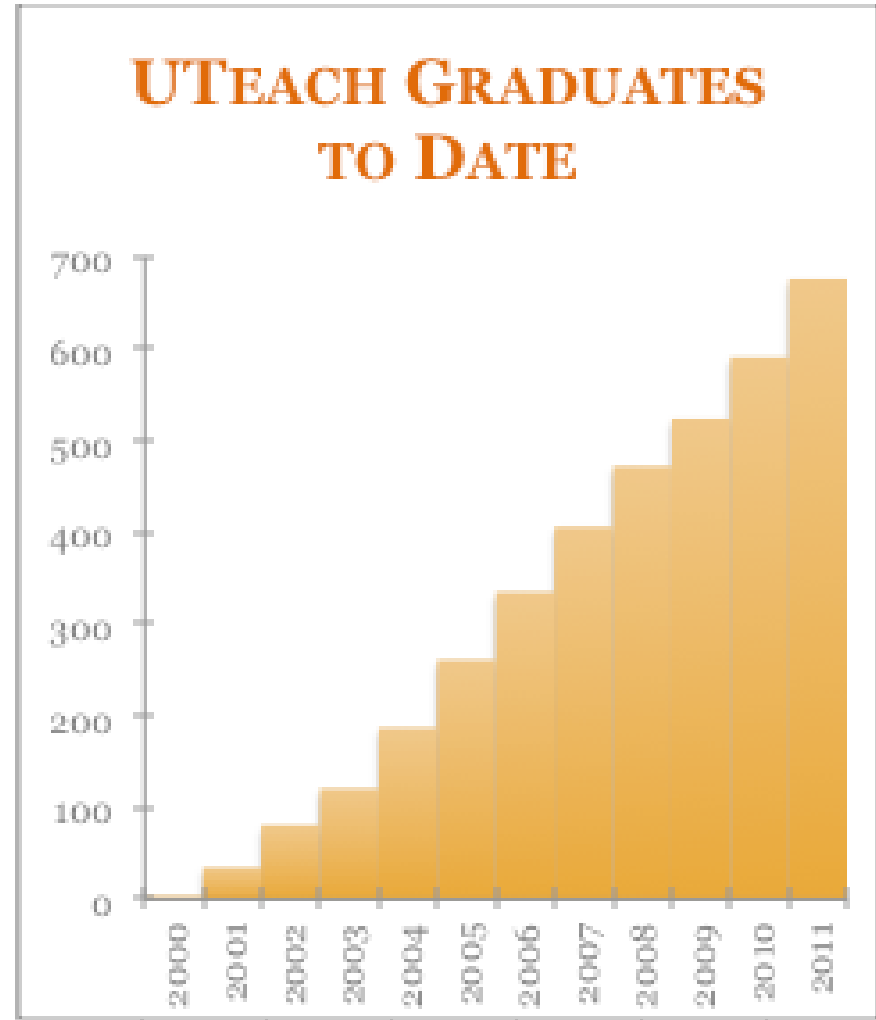
• **American Physical Society and American Association of Physics Teachers program**
• **Demonstrate successful models for**
  • **Increasing the number of highly qualified high school physics teachers**
  • **Improving the quality of K-8 physical science teacher education**
• **Spread best-practices**
• **Transform physics departments**

Increase in Physics Teachers Educated at PhysTEC Institutions
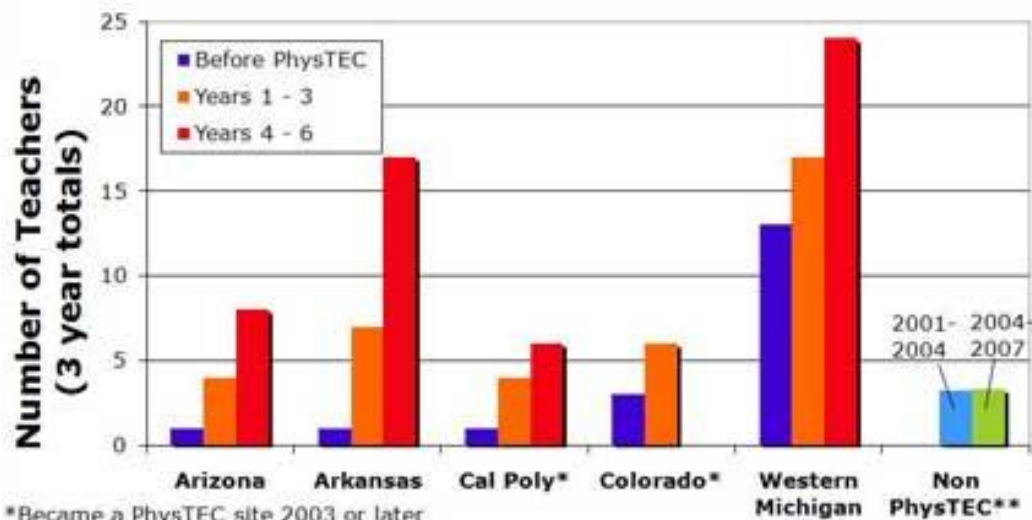
*Became a PhysTEC site 2003 or later
**Number of physics certifications averaged over 319 institutions in 15 states. Note that all PhysTEC teachers are more highly qualified than the minimum standards in most states.

The California STEM Learning Network - 2008

❖ **Building coherence among California's many STEM-related programs and identifying solutions that can be addressed by a concerted statewide effort**

❖ **CSLNet is collaborating with the California Afterschool Network and STEM-rich institutions such as museums, aquaria, zoos and science centers to expand the number of hours students spend engaging in quality STEM activities.**

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APLU Science and Mathematics Teacher Imperative (2008)

❖ **Association of Public and Land Grant Universities (APLU)**

❖ **Committed to increase the number and improve the preparation of science and mathematics teachers in its 120 member institutions.**

SMTI — Science & Mathematics Teacher Imperative
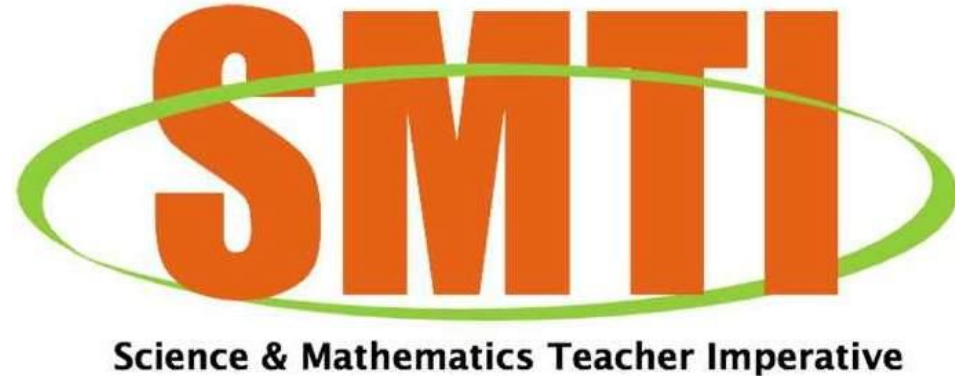
White House Educate to Innovate Campaign - 2009

❖ **Increase STEM literacy so that all students can learn deeply and think critically in science, math, engineering, and technology.**

❖ **Move American students from the middle of the pack to top in the next decade.**

❖ **Expand STEM education and career opportunities for underrepresented groups, including women and girls.**

Connect a Million Minds - 2009

❖ **Time Warner Cable's (TWC) Connect a Million Minds (CAMM) is a five-year, $100 million cash and in-kind philanthropic initiative to address America's declining proficiency in science, technology, engineering and math (STEM), which puts our children at risk of not competing successfully in a global economy**

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- ❖ **Carnegie Corporation of New York-Institute for Advanced Study Commission on Mathematics and Science Education report**
  - — **provide our students with the STEM knowledge and skills that are crucial to virtually every endeavor of individual and community life.**
  - — **Endorsed by over 65 organizations**

THE PROBLEM

Weak or **unaligned** strategies to recruit, prepare, select, and support teachers and leaders **limit teacher performance** and student achievement

THE GOAL

LEADERSHIP
SUPPORT
SELECTION
PREPARATION
RECRUITMENT

A coherent system **recruits, prepares, develops, and retains strong teachers and leaders,** leading to significantly better student outcomes

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Change the Equation (2010) - 110 CEO led initiative

K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future (2010) - PCAST

❖ **Issued by the President's Council of Advisors on Science and Technology (PCAST)**

❖ **Prepare students so they have a strong foundation in STEM subjects and are able to use this knowledge in their personal and professional lives**

❖ **Inspire students so that all are motivated to study STEM subjects in school and many are excited about the prospect of having careers in STEM fields**

REPORT TO THE PRESIDENT
PREPARE AND INSPIRE:
K-12 EDUCATION IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) FOR AMERICA'S FUTURE

Executive Report

Executive Office of the President

President's Council of Advisors on Science and Technology (PCAST)

SEPTEMBER 2010
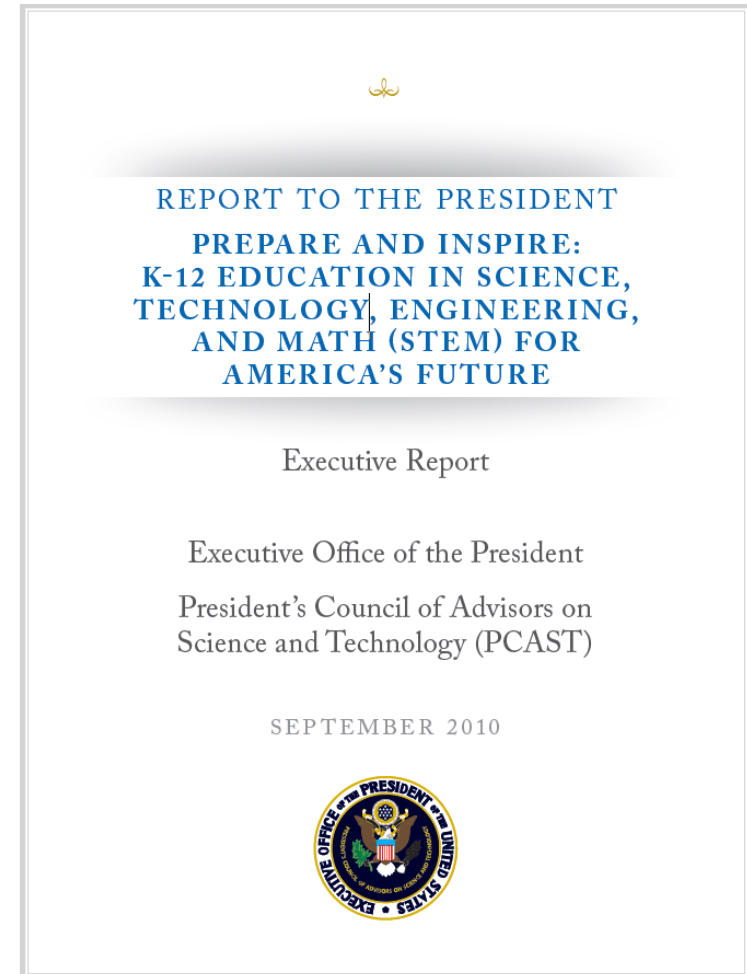
The Case for Being Bold: A New Agenda for Business in Improving STEM Education (2011)

❖ **Report from the American Enterprise Institute and the Institute for a Competitive Workforce of U.S. Chamber of Commerce**

❖ **A New Agenda for Business in Improving STEM Education**
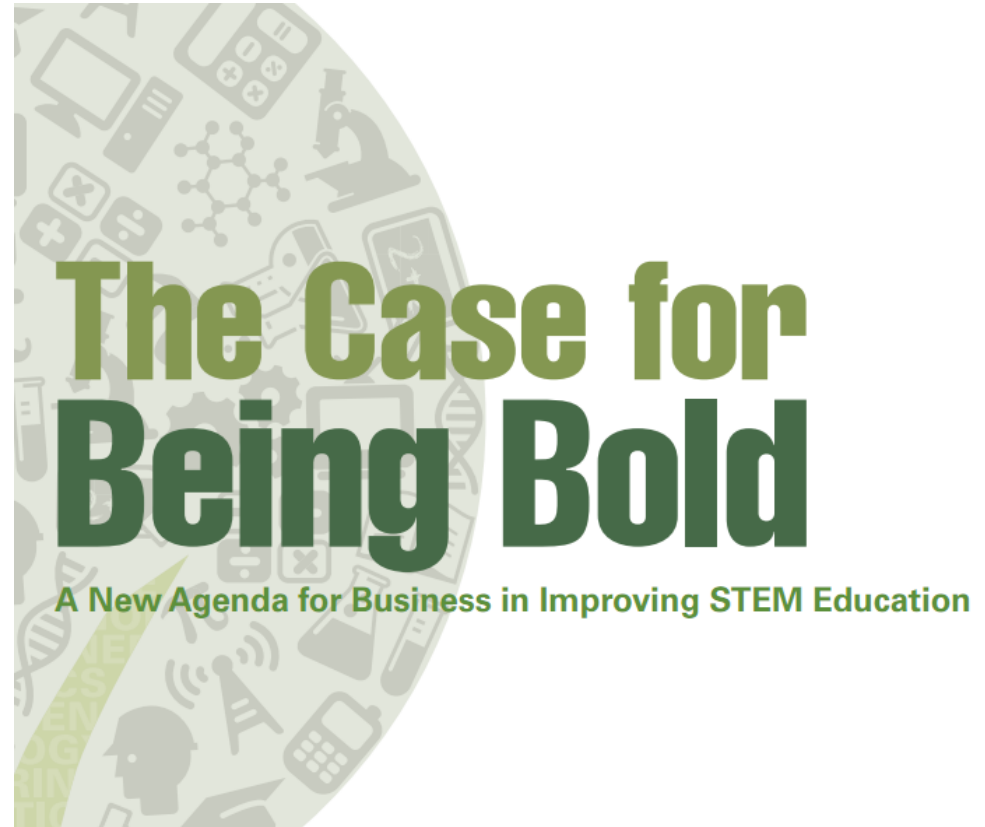
❖ **Report by the National Research Council**

❖ **Overview of the landscape of K-12 STEM education**

- **considering different school models,**

- **highlighting research on effective STEM education practices**

- **identifying some conditions that promote and limit school- and student-level success in STEM**
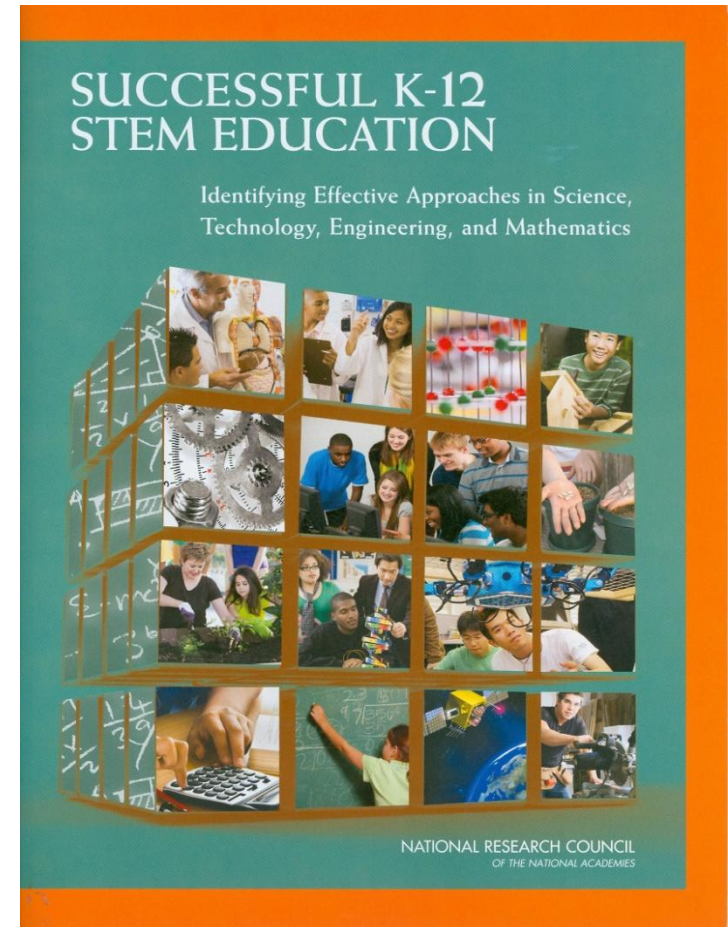
Association of American Universities (AAU) - 2011

- ❖ Five-year initiative to improve the quality of undergraduate teaching and learning in science, technology, engineering and mathematics (STEM) fields at its member institutions.
- ❖ Implement the results of the latest research into science and math pedagogy.
- ❖ Of entering college freshmen who declare that they plan to major in STEM-related fields, over 40 percent switch to non-STEM majors by the time they graduate
- ❖ Completion rates for STEM majors are lower than for non-STEM majors.

AAU Initiative Goals

- ❖ **Develop framework for assessing and improving the quality of STEM teaching and learning**
- ❖ **Create a demonstration program at a subset of AAU universities**
- ❖ **Develop tools to survey and assess**
  - —the quality of teaching and learning in STEM classes
  - —the extent to which effective teaching methods are being used by academic departments
  - —the effects of improved teaching on retention of STEM majors and completion of STEM degrees.
- ❖ **Explore mechanisms that institutions and departments can use to train, recognize, and reward faculty members who want to improve the quality of their STEM teaching.**
- ❖ **Work with federal research agencies to develop mechanisms for recognizing, rewarding and promoting efforts to improve undergraduate learning.**

AAU working with others

❖ **Association of Public and Land-grant Universities (APLU)**
  - Major efforts to expand the number/quality of K-12 STEM teachers
  - Redesign gateway courses at universities and community colleges using online learning,

❖ **Business-Higher Education Forum**
  - Launched major initiatives to improve
    — college readiness,
    — issues relating to STEM workforce needs.

❖ **Howard Hughes Medical Institute (HHMI)**
  - Funds efforts to improve undergraduate biology teaching and learning through its HHMI Professors Program and other initiatives;

❖ **the President's Council of Advisors on Science and Technology (PCAST),**

❖ **American Physical Society (APS)**
  - New Faculty Workshop - help new faculty learn to implement more effective methods of teaching and assessment

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Status of K-12, undergrad, grad STEM

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Grades K-6 Status

+ Students are interested in science

+ Well defined state standards

+ Good curricula available and somewhat widely used; Learning Cycle (e.g. FOSS)

- Limited time for teaching science – reading and math dominate

- Extensive testing (NCLB)

- Teachers have minimal science training

+ Some NSF programs to assist teachers – GK-12 (science graduate students in K-6 (12) classrooms)
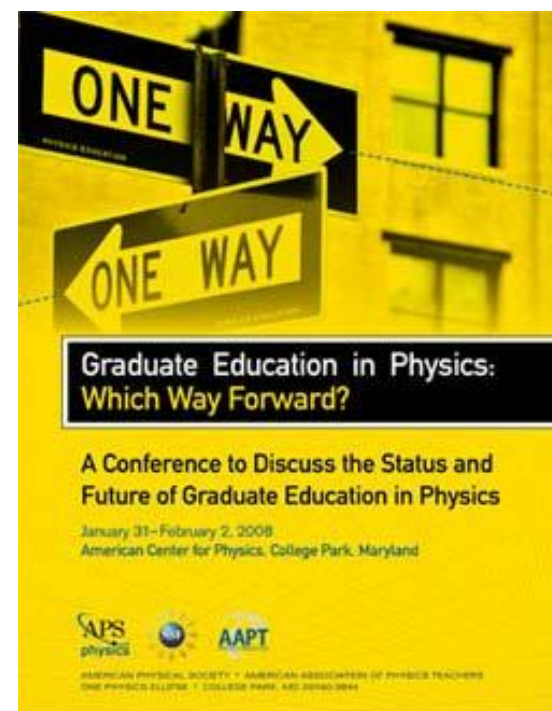
Grades 7-12 Status

+ Well defined state standards

+ Good curricula available, but not extensively used

+ Significant formal professional development

- Minimal exposure to engineering

- Students are growing less interested in science

- Many teachers are teaching outside of their majors

Undergraduate Status

- No well defined overall standards/learning goals for science

+ National learning goals for engineering (Accreditation Board for Engineering and Technology (ABET))

+ Much research based curricula available; mostly used in first year (physics)

+ Growing use of interactive engagement, less passive lecturing (physics)

+ Growing research in how students learn (physics)

- Minimal formal education for professors on how to teach

- Many students drop out of STEM majors

Graduate Status

- No well defined standards/learning goals

- No research based curricula available

- Minimal use of interactive engagement

- Minimal research in how students learn (physics)

- Minimal formal education for professors on how to teach

- Minimal consideration of future industrial job needs (more so in science, less so in engineering

+ Excellent preparation for university style basic research

Graduate Education in Physics: Which Way Forward?

A Conference to Discuss the Status and Future of Graduate Education in Physics

January 31–February 2, 2008
American Center for Physics, College Park, Maryland

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K-Graduate STEM Education Matrix

	K-6	MS	HS	Undergrad	Grad
Standards	🟩	🟩	🟩	🟥	🟥
Curricula	🟩	🟩	🟩	🟨	🟥
Teacher science knowledge	🟥	🟨	🟨	🟩	🟩
Teacher science pedagogy knowledge	🟥	🟨	🟨	🟥	🟥

🟩 Good

🟨 Fair

🟥 Poor

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STEM and Innovation

Characteristics of innovators

❖ **Experiment. Learn By Doing. Fail quickly to learn fast.**

❖ **A playful, improvisational, humorous atmosphere: prevents creative ideas from being prematurely judged**

❖ **Immerse: gather fresh ideas**

❖ **Define: define problems and needs**

❖ **Reorient: Be flexible in pursuit of larger goals, use small wins to chart course to completeness**

❖ **Iterate: repeat, refine, and test frequently**

<u>Little Bets: How Breakthrough Ideas Emerge from Small Discoveries</u> by Peter Sims

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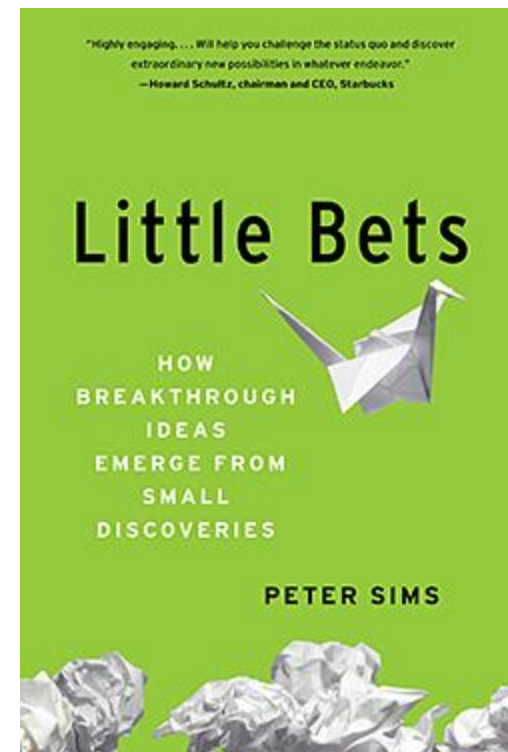
Characteristics of innovators

- ❖ Working under constraints
  - Creative people use constraints to limit their focus and isolate a set of problems that need to be solved
- ❖ Smallifying
  - Breaking a project down into discrete, relatively small problems to be resolved
  - Small "wins" move the project towards goal
- ❖ Rapid prototyping
- ❖ "Peer Plussing"
  - Providing feedback during development, but not overly specific

❖ **Develop an initial approach that gets you closer to your goal**

Start ⟶

Goal

Start ⟶⟶⟶
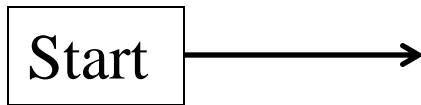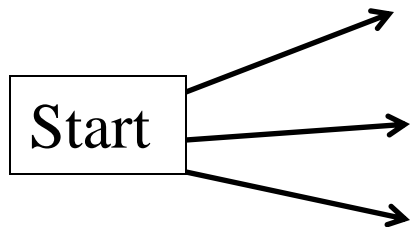
Goal

Characteristics of creativity

❖ **Connect diverse experiences and synthesize new things**

❖ **Diversity of perspectives, experiences, backgrounds fuels creativity**

❖ **Lucky people tend to be open to opportunities or insights that come along spontaneously, unlucky people tend to be creatures of routine, fixated on specific outcomes**

❖ **Coming up with new ideas often entails 2 essential parts**

- **Doing a very deep dive in the area where one wants to come up with an idea**

- **Being curious about a broad array of topics**

- **Simmer**

❖ **I suggest we want a comb approach**

❖ Some very deep investigations and understanding

❖ Also general awareness of many topics, but not necessarily detailed understanding

❖ So that we can say, I think I remember reading about this or I think … and then we can investigate further

Recommendations for improved STEM

My recommendation for broad goals for physics education

- ❖ **<u>Specific deep content knowledge</u>** in the core areas of physics – mathematical, pictorial, verbal

- ❖ **<u>Broad awareness of a wide range of topics</u>** in physics, other sciences, engineering, manufacturing, quality assurance, intellectual property, and program management

- ❖ **<u>Skills for solving both well defined and ill-defined problems</u>**, generating new ideas/innovating, experimental design to model and test those ideas, data analysis and documentation, and written and verbal communication, including proposals, papers, and presentations.

- ❖ **<u>Ability for lifelong learning</u>**. While learning tends to exclusively utilize the professor/student format in classrooms, such a structure is rare after graduation. Students need to be able to transition from a structured classroom learning environment to a non-structured environment.

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My general recommendations for STEM education

❖ **Students should be able to adapt and transform themselves so that they are one of the most capable and innovative STEM workers in the world in their particular area of expertise [Thomas Friedman's Best]**

❖ **Eliminate rote memorization**

❖ **Promote long term understanding that is transferrable to new situations, namely expert knowledge.**

    ❖**Have students actively acquire their knowledge using design challenges, inquiry, and other research based programs that have demonstrated effectiveness**

❖ **Interest more students in STEM.**

    ❖ **expose more students to STEM disciplines, and**

    ❖ **improve their level of understanding of STEM using quality curriculum and associated professional development**

Overall: need to educate for innovation

❖ "The inability of graduating students to integrate all they have learned in the solution of a real-world problem, at any level, is a failure." [System level education]

❖ "Innovation, the process of inventing something new, desirable, useful, and sustainable, happens at the intersection of technology (is it feasible?), business (is it viable and sustainable), human factors (is it desirable?), and complexity (is it usable?)"

❖ "[students] must be able to identify the needs of people and society, critically think and solve problems, generate human centered ideas and rapidly prototype concepts, integrate human values and business into concepts, manage complexity, work in multidisciplinary teams, and effectively communicate results"

Kevin Craig, Chair in Engineering Design, Marquette University, in Design News Magazine, February 2010, page 16.

My 15 Point Guide to Success

1. Be responsive – return phone calls and emails promptly. When asked to do something, do it on time – be sure to ask when it should be done. Document requests and responses in writing.

2. Become the world expert in your particular area.

3. Continually expand the depth and breadth of your knowledge and skills.

4. Utilize all information resources available - books, science magazines, web sites, search engines, search services, colleagues, patents, trade magazines, catalogs, sales reps, conferences.

5. Get involved with or develop projects that have a high probability of contributing to the company's success.

6. Understand and be aware of project constraints such as your personnel and company capabilities, competitor's strengths, and customer needs.

7. Innovate continuously. Always push your envelope as well as the science and technology envelope. Stay uncomfortable with what your skills and knowledge are.

8. Document your work in manner that can be easily understood by a co-worker a year from now. Use spreadsheets, tables and charts to convey your results in a concise, visual, and easy-to-understand manner.

9. Make sure that you learn something useful from any tests or experiments that you perform. These results should form the basis for future tests.

10. Learn from your mistakes. Don't repeat them.

11. Don't believe everything you are told, even if it is company lore or told to you by an expert. Be skeptical.

12. Enjoy your work.

13. Treat everyone you work with (above and below you) with respect. Thank them for their work. Acknowledge their contributions whenever possible. Keep them informed as to what you are doing and why you are doing it.

14. Have a sense of humor.

15. **Develop a unique and necessary skill and knowledge set that complements those of your co-workers and greatly increases the value of your project/team. Be indispensible.**

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Expanding on these points …

❖ **"… you need to be very good at whatever you are hired to do. One aspect of communication is to let your colleagues know that you are being productive."**

❖ **"Being good at what you are hired to do will help you keep your job today. Constantly learning and growing in your abilities will help you remain competent tomorrow. Taking on project management responsibilities will broaden your experience and build your reputation and network of contacts. What you learn in the process will keep you employable, not to mention being more valuable to your company."**

Milton Chang in the Business Forum feature of Laser Focus World magazine, October 2009, p.33.

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Thank You!

This presentation will be posted at:

www.sci-ed-ga.org/GASEFPresentations.html