DRK-12 Research and Development:
Disruptive innovations, evolutionary improvements … or both?

2012 Discovery Research K-12
Principal Investigators Meeting

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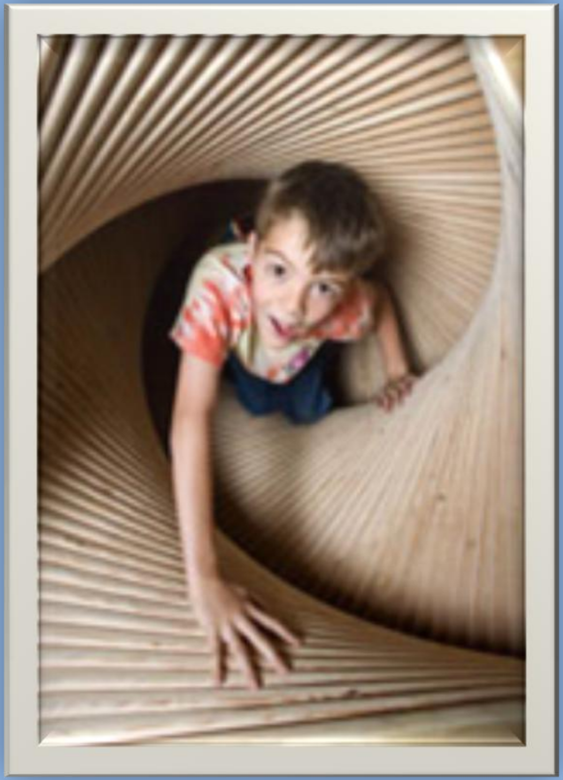
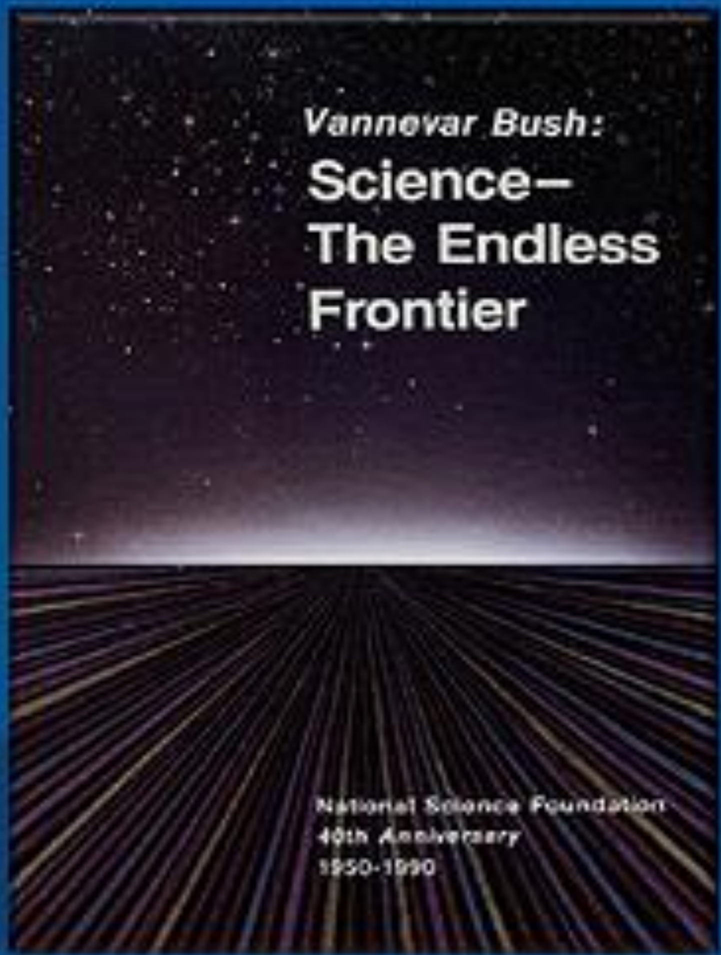
Directorate for Education and Human Resources (EHR)
June 14, 2012

A few things to think about:

1. Science and NSF
2. Why does NSF fund education?
3. What's next?



1. SCIENCE AND NSF

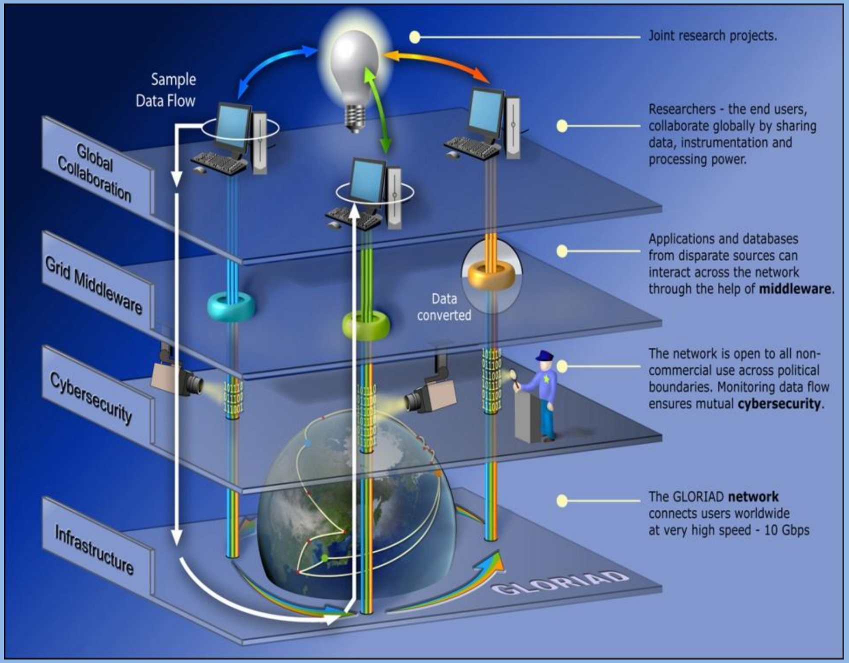


The NSF Mission:

To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense. . .

New Era of Science

Era of Observation (Theory, experiment, computation, "citizen science")

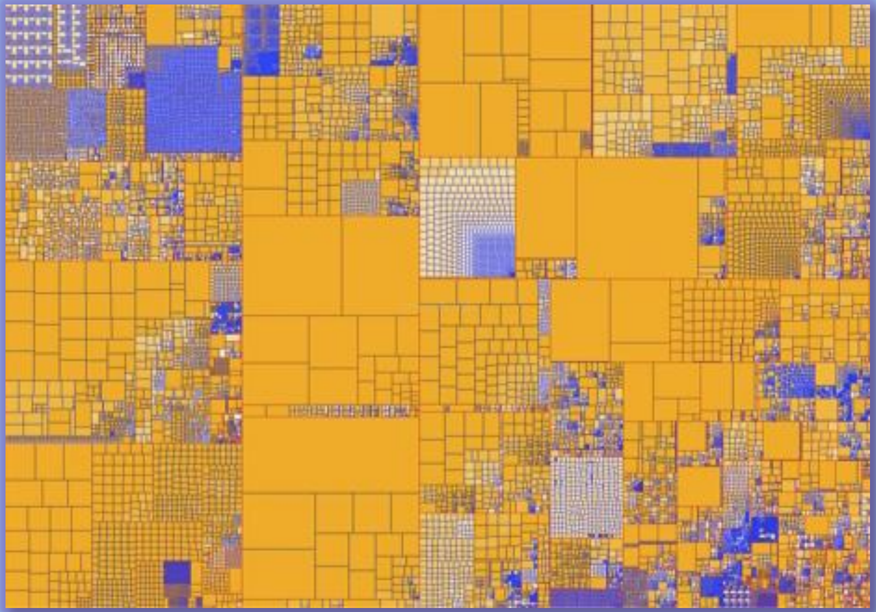


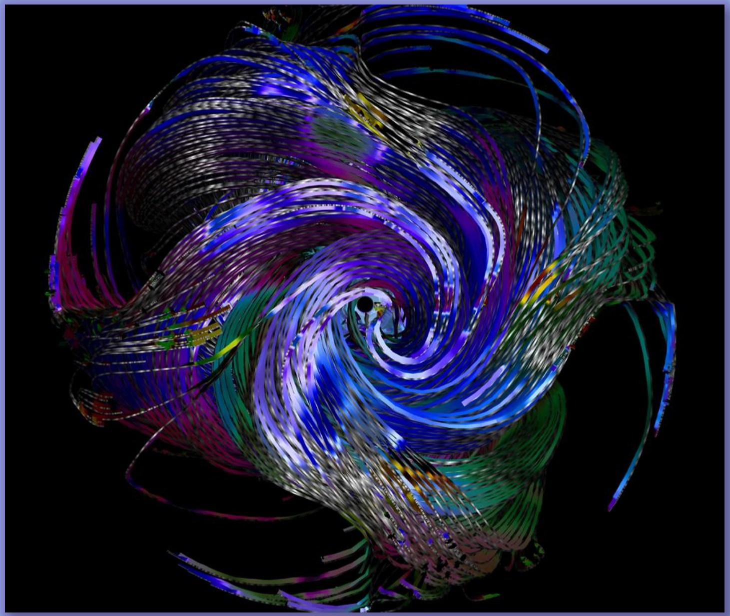
Era of Data and Communications


Science, Engineering, and Education
for Sustainability (SEES)
Creating new knowledge for a clean energy
economy and sustainable future
One NSF
NSF


Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS)
Creating smart systems that sense, respond and adapt to the environment
One NSF
NSF

Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21)

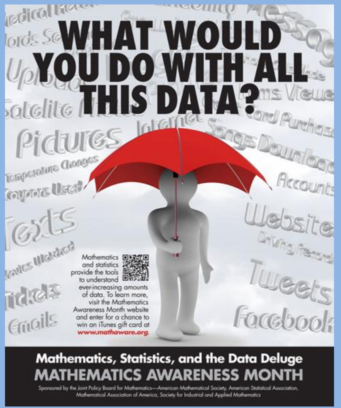




Addressing grand challenges in computing, computational modeling and simulation, and big data

Scientists are:

- Collaborating across vastly different disciplines on compelling problems
- Inventing and using computational techniques and algorithms to deal with massive data sets
- Building and using infrastructure and instruments to gather new data
- Accessing more data than they can possibly analyze in a lifetime, using shared datasets
- Networking around the globe in orchestrated ways to solve specific problems
- Formulating new problems that could not have been approached without current technologies

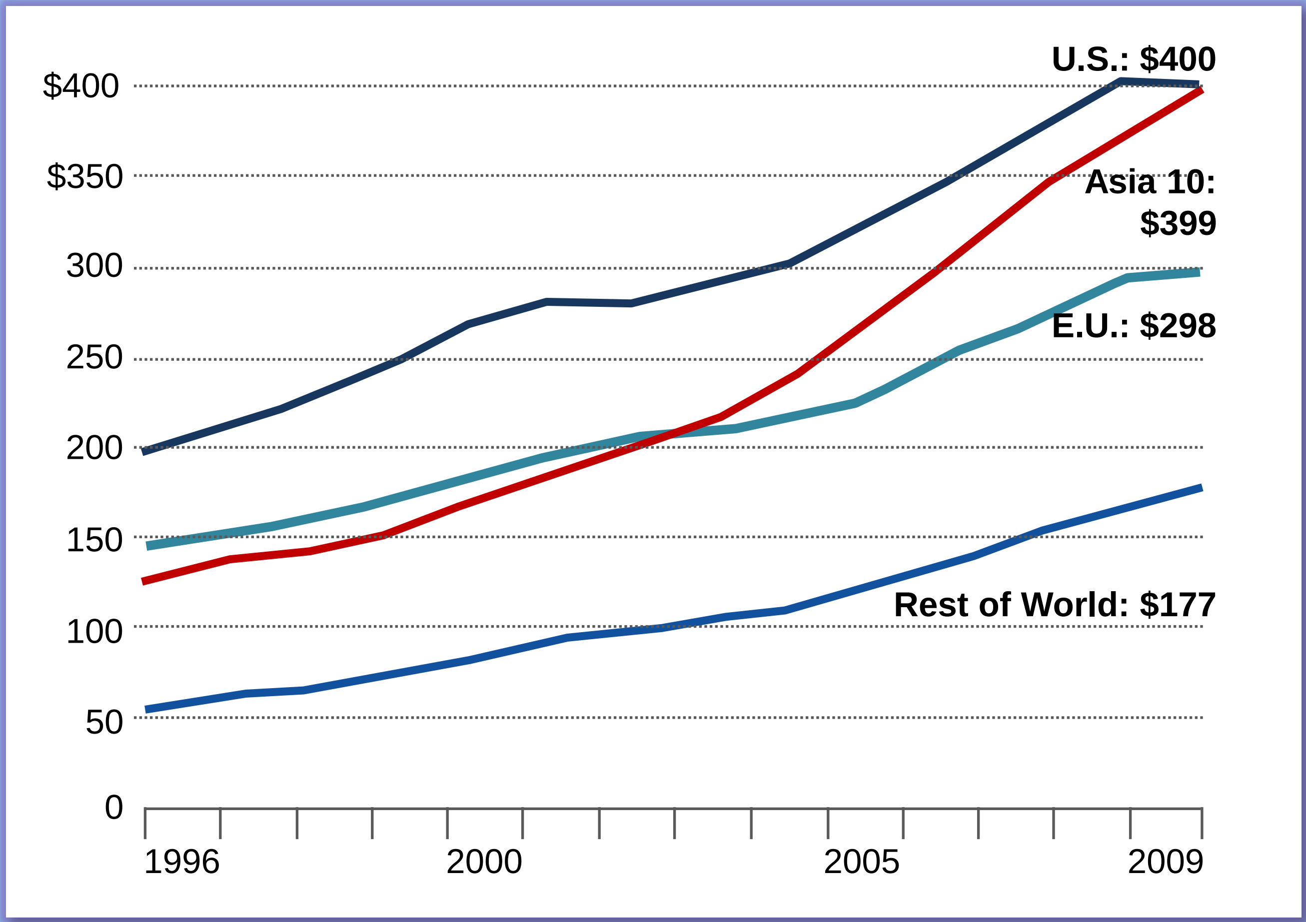


"The scientific community benefits from diversity. Innovation, creativity, and novel discoveries are accelerated by a diversity of ideas and perspectives. While the scientific method provides a crucible for testing and validating these ideas, a diverse research community with many perspectives affords a rich environment for new theories and hypotheses."

Schultz, P.W., et al. (2011). Patching the pipeline: Reducing educational disparities in the sciences through minority training programs. *Educational Evaluation and Policy Analysis*, 33 (1).

The Case for NSF Funding

Research-and-development expenditures,
In billions of U.S. dollars

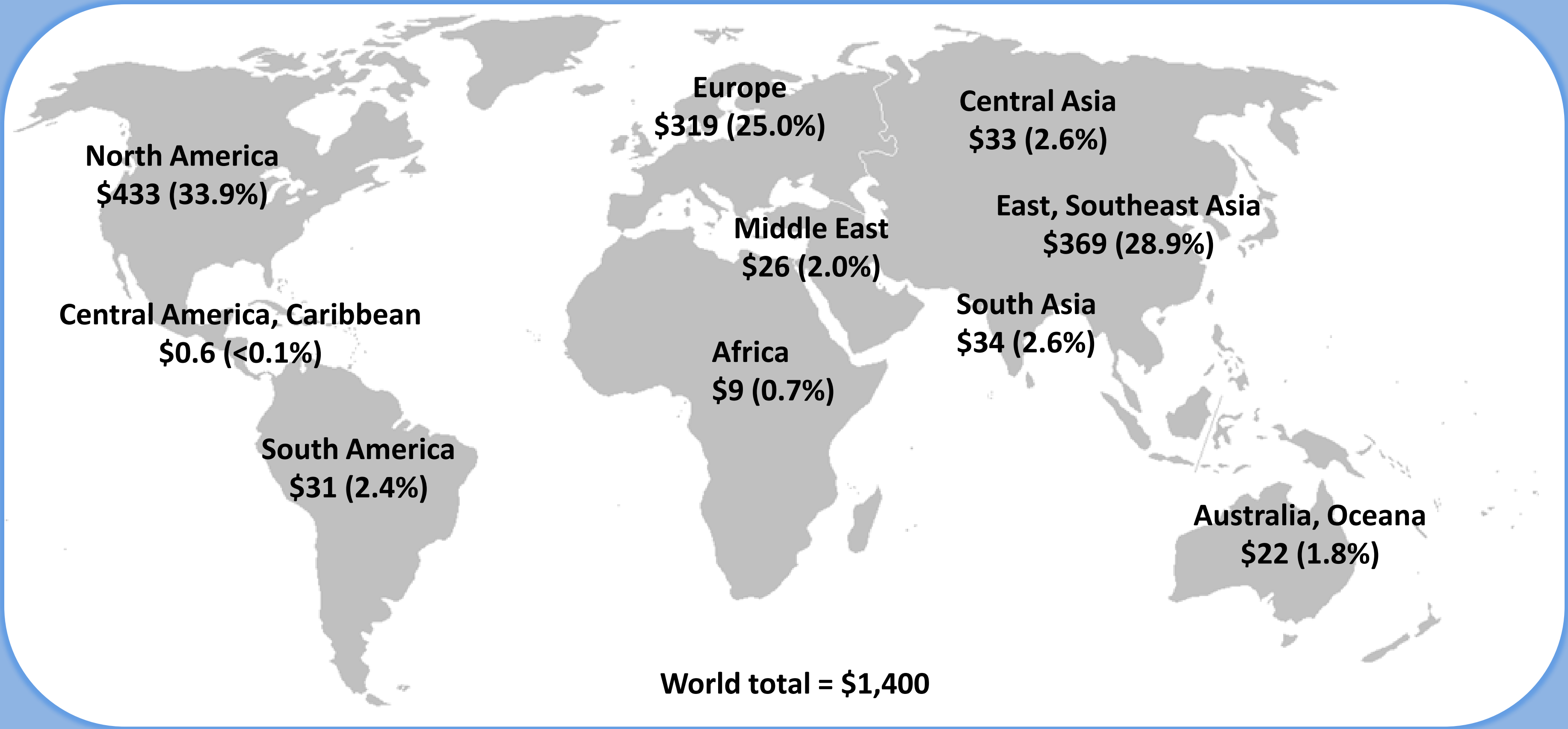


The Asia 10: China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan and Thailand

OneNSF

Global R&D Expenditures and Share of World Total by Region

(Billions of 2009 U.S. Purchasing-Power-Parity Dollars)



National Science Board, *Science and Engineering Indicators 2012*

The Big Picture

NSF FY 2013 Budget

TOTAL: $7.373 billion

Increase: $340 million

4.8% over FY 2012 enacted

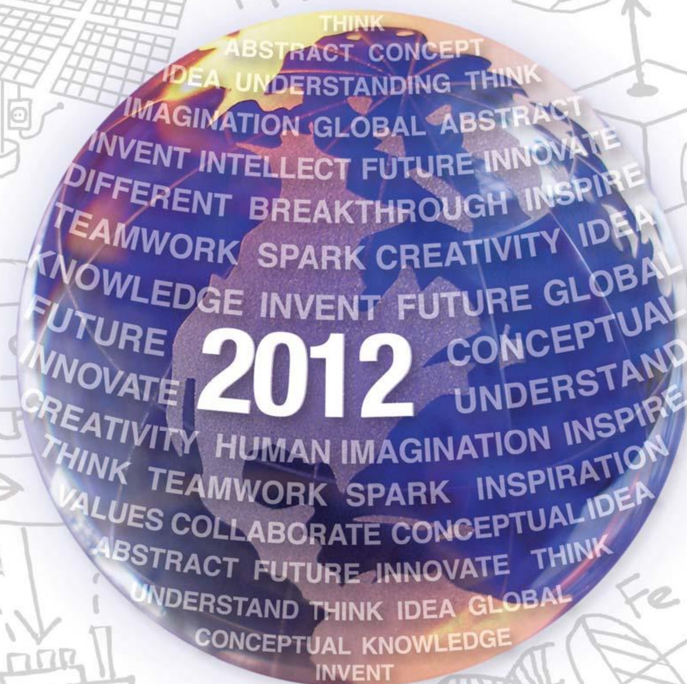
2. WHY DOES NSF FUND EDUCATION?

"Basic scientific research is scientific capital…How do we increase this scientific capital? First, we must have plenty of men and women trained in science, for upon them depends both the creation of new knowledge and its application to practical purposes."

Bush, Vannevar (1945) *Science: The endless frontier* (Washington, D.C.) accessed April 19, 2012 at http://www.nsf.gov/about/history/vbush1945.htm#transmittal

National Science Board

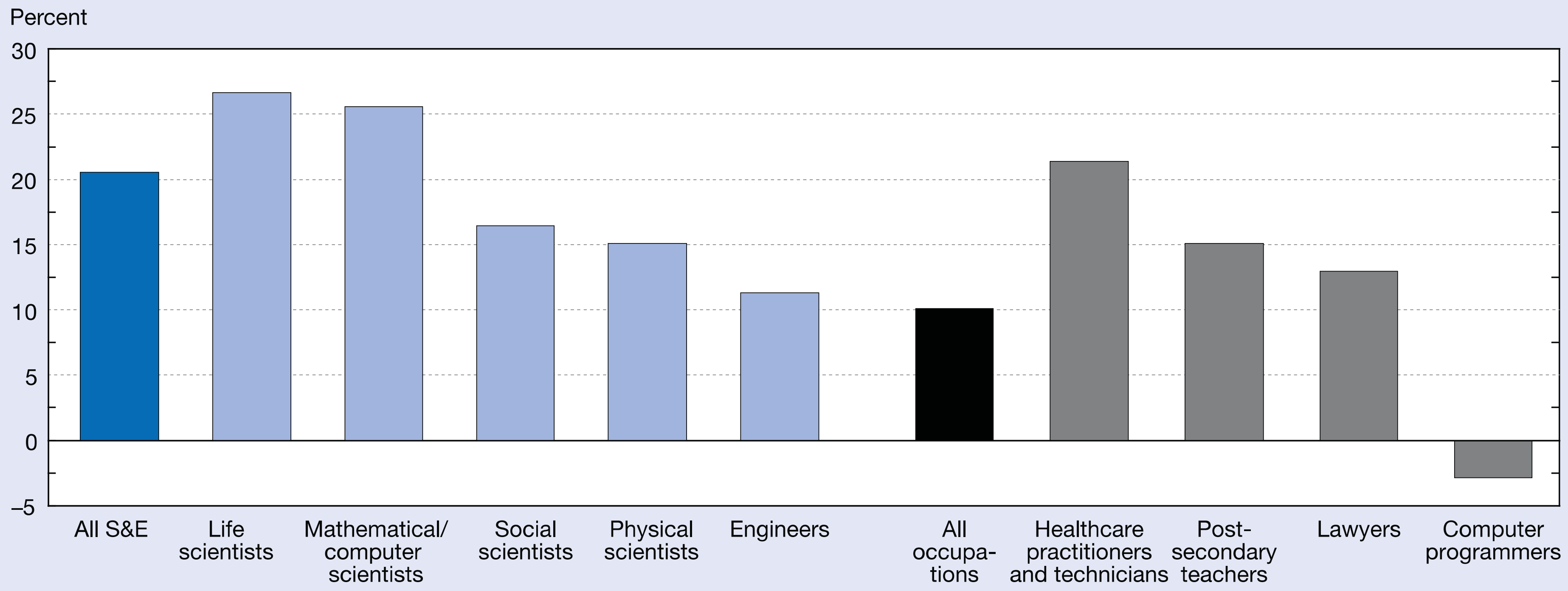
SCIENCE AND ENGINEERING INDICATORS



NATIONAL SCIENCE FOUNDATION

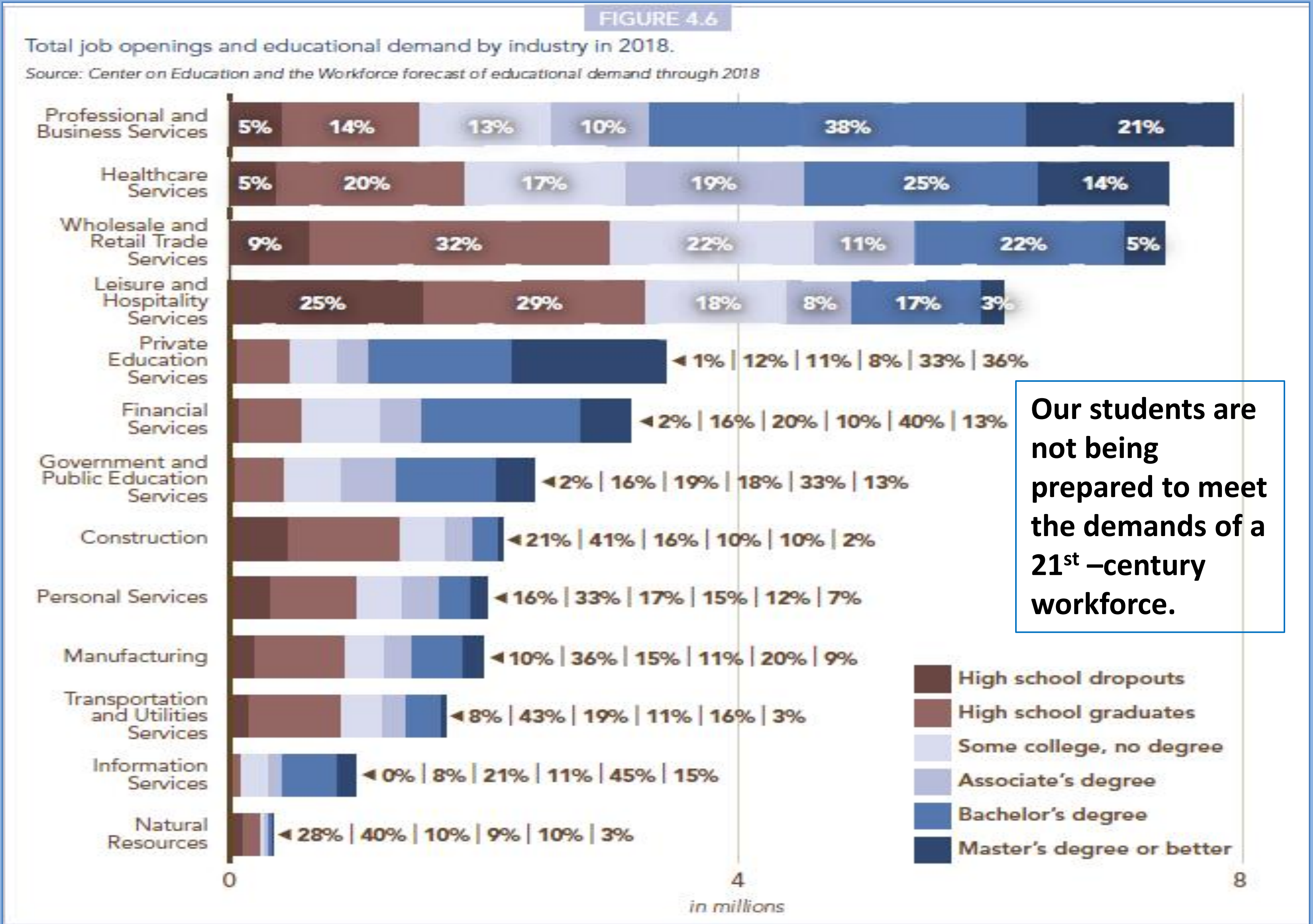
Figure 3-A

Bureau of Labor Statistics projected increases in employment for S&E and selected other occupations: 2008–18



SOURCE: Bureau of Labor Statistics, Office of Occupational Statistics and Employment Projections, National Industry-Occupation Employment Projections 2008–18. See appendix table 3-1.

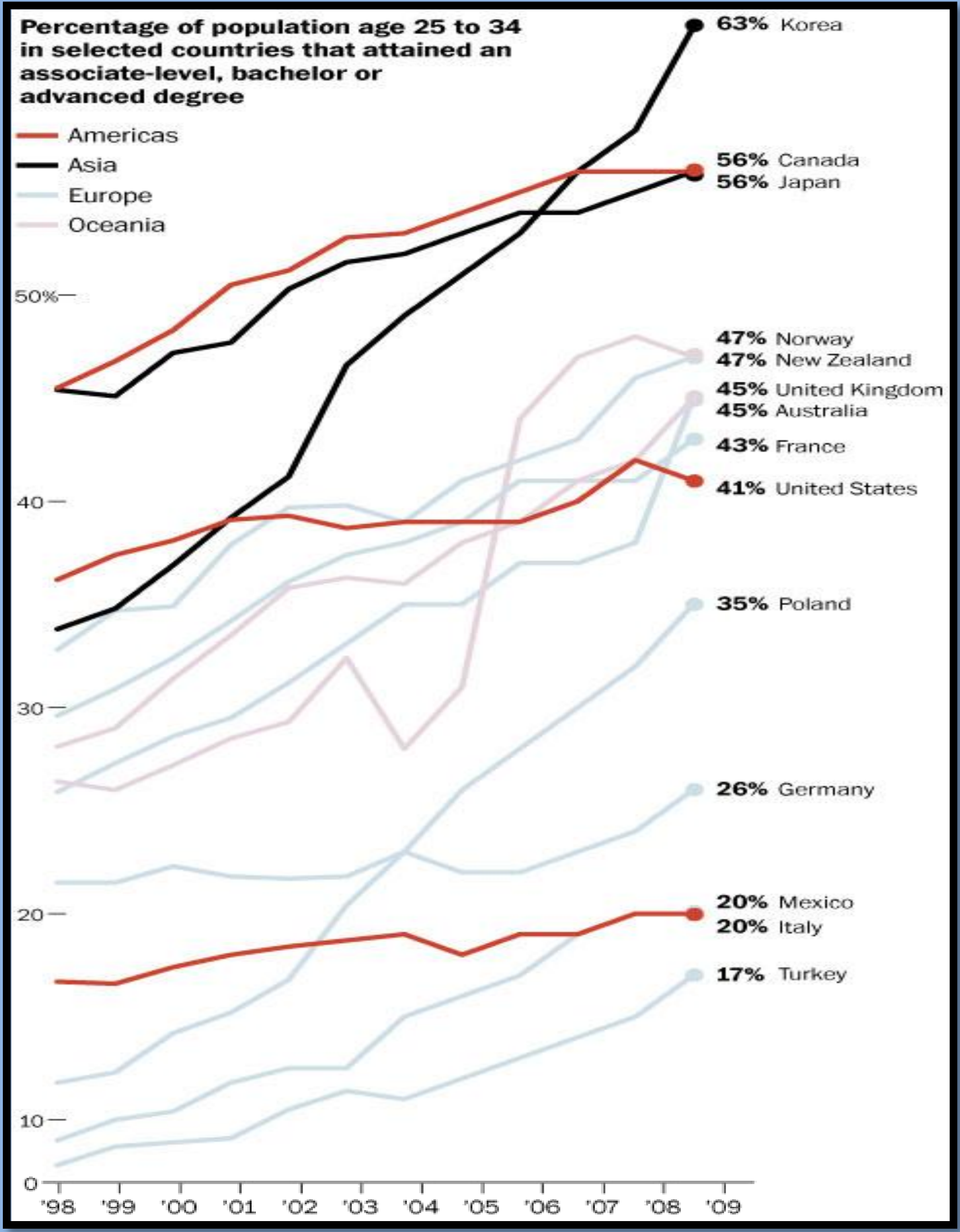
Science and Engineering Indicators 2012



Our students are not being prepared to meet the demands of a 21st –century workforce.

Carnevale, Anthony P., Smith, Nicole, Strohl, Jeff. (June 2010). *Help wanted: Projections of jobs and education requirements through 2018.* Center on Education and the Workforce, Georgetown University: Washington, DC., pg.71

The US trails much of the developed world in college attainment among young adults, a key measure of global competitiveness.

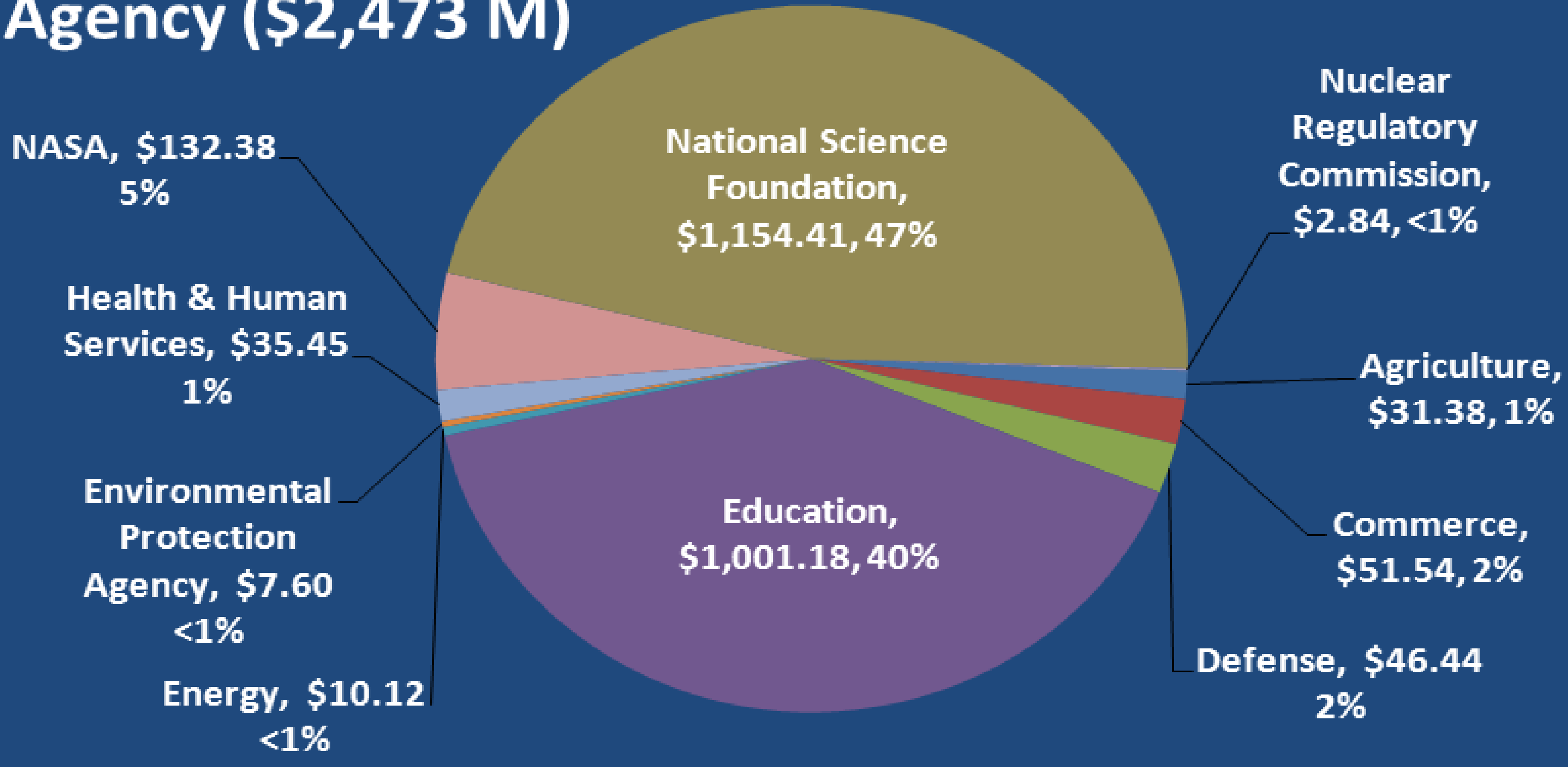


Source data and image prepared by OECD: http://www.washingtonpost.com/local/education/playing-catch-up-in-college-completion/2011/09/12/gIQAegt6NK_graphic.html accessed September 12, 2011.

"In the United States, fewer than 40% of the students who enter college with the intention of majoring in a STEM field complete a STEM degree. Most of the students who leave STEM fields switch to non-STEM majors after taking introductory science, math, and engineering courses."

PCAST, 2011, *Engage to Excel*, p. 5.

Funding for Broader STEM Education by Agency ($2,473 M)



The Federal Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio, December 2011, p. 12

3. WHAT'S NEXT?

Discovery Research K-12 Program Strands

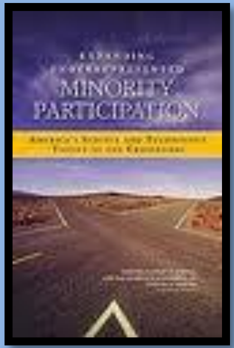
- Learning
- Teaching
- Scale-up and sustainability
- Assessment

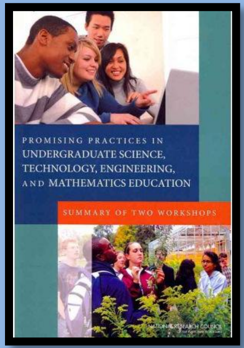
A family participating in a workshop funded by the NSF project "Be a Scientist." Award #1008309, NSF *Informal Science Education* program.

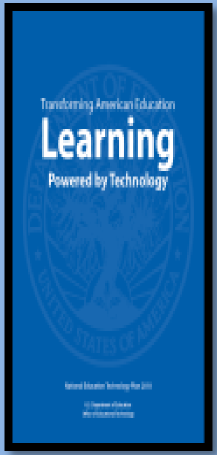
Image used by permission of the Investigator: Dr. Tara Choklovski

Grand Challenges in Education: Driving Questions

- How does the nation train and develop its science and engineering workforce?
- How should we teach and learn science in the 21st century?
- How does the nation create a science-literate citizenry?
- How can we broaden and deepen participation in science and engineering?
- How does NSF most effectively deploy its resources to transform the frontiers in STEM education and learning?







Disruptive innovation, a term of art coined by Clayton Christensen, describes a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves ‘up market’, eventually displacing established competitors. An innovation that is disruptive allows a **whole new population of consumers** access to a product or service that was historically only accessible to consumers with a lot of money or a lot of skill.

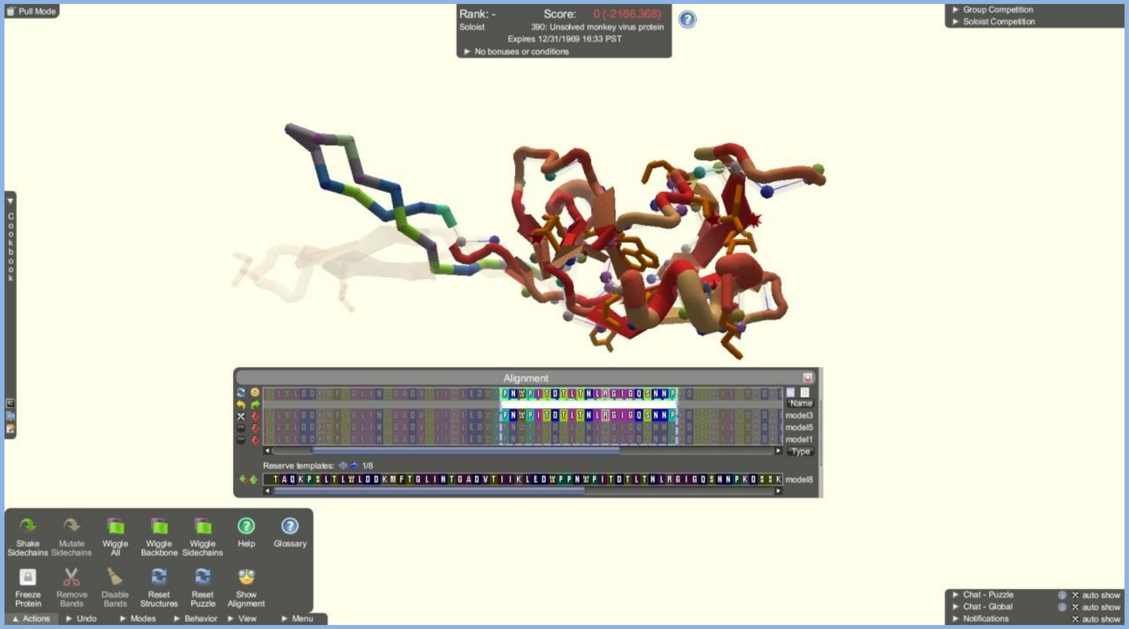
And….

- Cyberlearning
- Lifelong/life wide learning
- New modes of research on learning
- New kinds and uses of data
- Data analytics
- Rapid-cycle improvement
- Citizen science to solve scientific problems
- Designing for scale

"Think about the year when your findings or resources will reach STEM learners and teachers for full scale implementation? What will the environment look like?"

Social Networks Solving Complex Problems

Networks of human minds are taking citizen science to a new level



In 2011, players of Foldit helped to decipher the crystal structure of the Mason-Pfizer monkey virus (M-PMV) retroviral protease, an AIDS-causing monkey virus. Players produced an **accurate 3D model** of the enzyme **in just ten days**. The problem of how to configure the structure of the enzyme had **stumped scientists for 15 years**.

The "unsolved monkey virus protein" Foldit puzzle, highlighting the tool used by online gamers. Credit: University of Washington

Expeditions in Education- E^2

Engage, Empower, Energize

- Make frontier science central
- Use theory and research on STEM learning
- Aim for bold learning outcomes
- Commit to common metrics
- Design for scale
- Involve all NSF directorates and offices

Expeditions in Education (E^2)

Focus Topics for 2013:

- Transforming Learning for STEM Undergraduates
- Sustainability Science
- Cyberlearning and Big Data

FY 2013 Budget- NSF Total:	$49 Million
EHR Contributions	$20.50 Million
R&RA Contributions	$28.50 Million

Innovation Corps (I-Corps)

Accelerating innovations from the laboratory to the market

Or….

evolutionary improvements?

Figure 1: U.S. 15-Year-Old Performance Compared with Other Countries

Programme for International Student Assessment (PISA)

Average is measurably higher than the U.S.

Average is measurably lower than the U.S.

Mathematics (2006)

Rank		Score
1	Finland	548
2	Korea	547
3	Netherlands	531
4	Switzerland	530
5	Canada	527
6	Japan	523
7	New Zealand	522
8	Belgium	520
9	Australia	520
10	Denmark	513
11	Czech Republic	510
12	Iceland	506
13	Austria	505
14	Germany	504
15	Sweden	502
16	Ireland	501
17	France	496
18	United Kingdom	495
19	Poland	495
20	Slovak Republic	492
21	Hungary	491
22	Luxembourg	490
23	Norway	490
24	Spain	480
25	United States	474
26	Portugal	466
27	Italy	462
28	Greece	459
29	Turkey	424
30	Mexico	406
	OECD average	498

Science (2006)

Rank		Score
1	Finland	563
2	Canada	534
3	Japan	531
4	New Zealand	530
5	Australia	527
6	Netherlands	525
7	Korea	522
8	Germany	516
9	United Kingdom	515
10	Czech Republic	513
11	Switzerland	512
12	Austria	511
13	Belgium	510
14	Ireland	508
15	Hungary	504
16	Sweden	503
17	Poland	498
18	Denmark	496
19	France	495
20	Iceland	491
21	United States	489
22	Slovak Republic	488
23	Spain	488
24	Norway	487
25	Luxembourg	486
26	Italy	475
27	Portugal	474
28	Greece	473
29	Turkey	424
30	Mexico	410
	OECD average	500

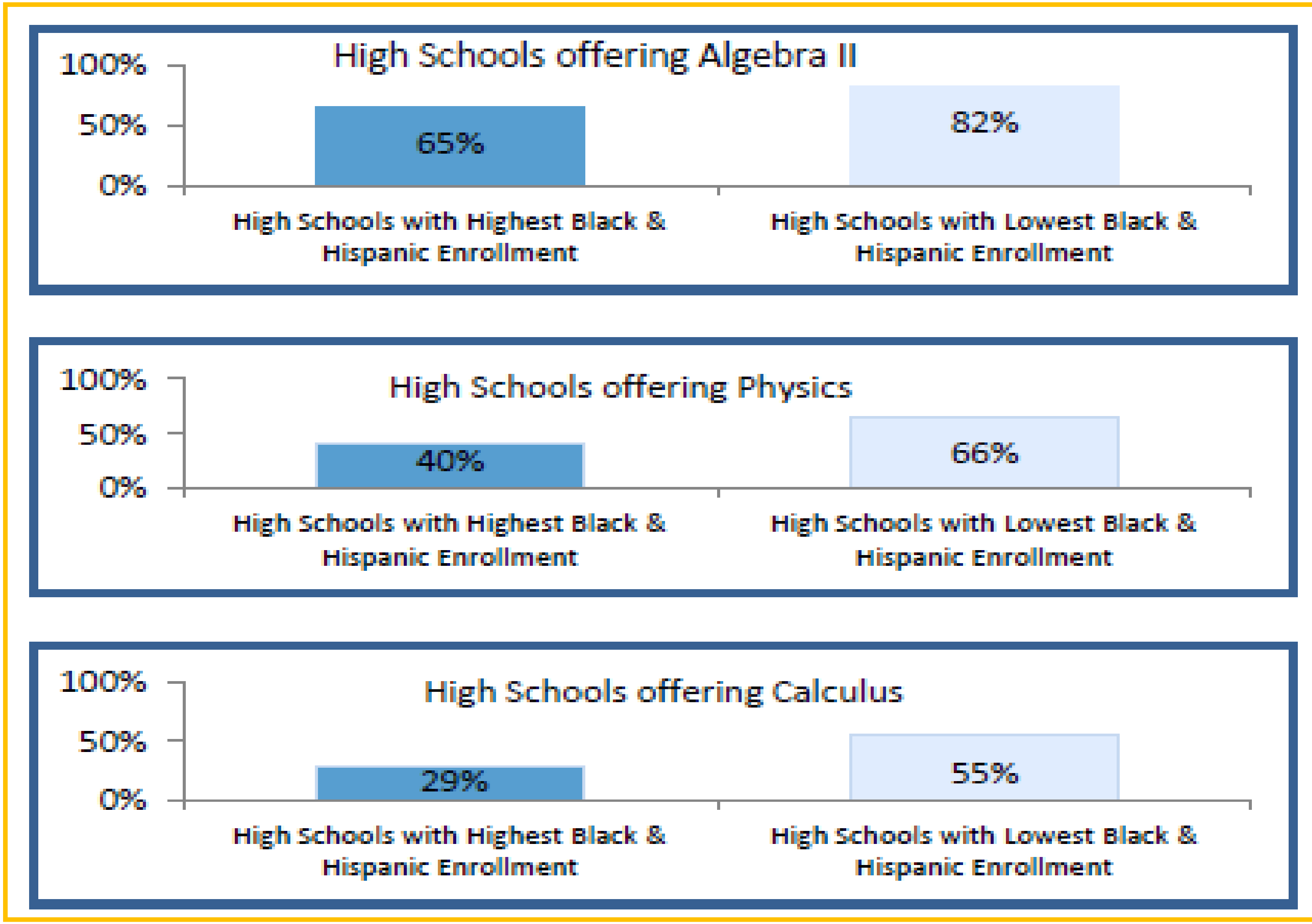
Reading (2003)

Rank		Score
1	Finland	543
2	Korea	534
3	Canada	528
4	Australia	525
5	New Zealand	522
6	Ireland	515
7	Sweden	514
8	Netherlands	513
9	Belgium	507
10	Norway	500
11	Switzerland	499
12	Japan	498
13	Poland	497
14	France	496
15	United States	495
16	Denmark	492
17	Iceland	492
18	Germany	491
19	Austria	491
20	Czech Republic	489
21	Hungary	482
22	Spain	481
23	Luxembourg	479
24	Portugal	478
25	Italy	476
26	Greece	472
27	Slovak Republic	469
28	Turkey	441
29	Mexico	400
	OECD average	494

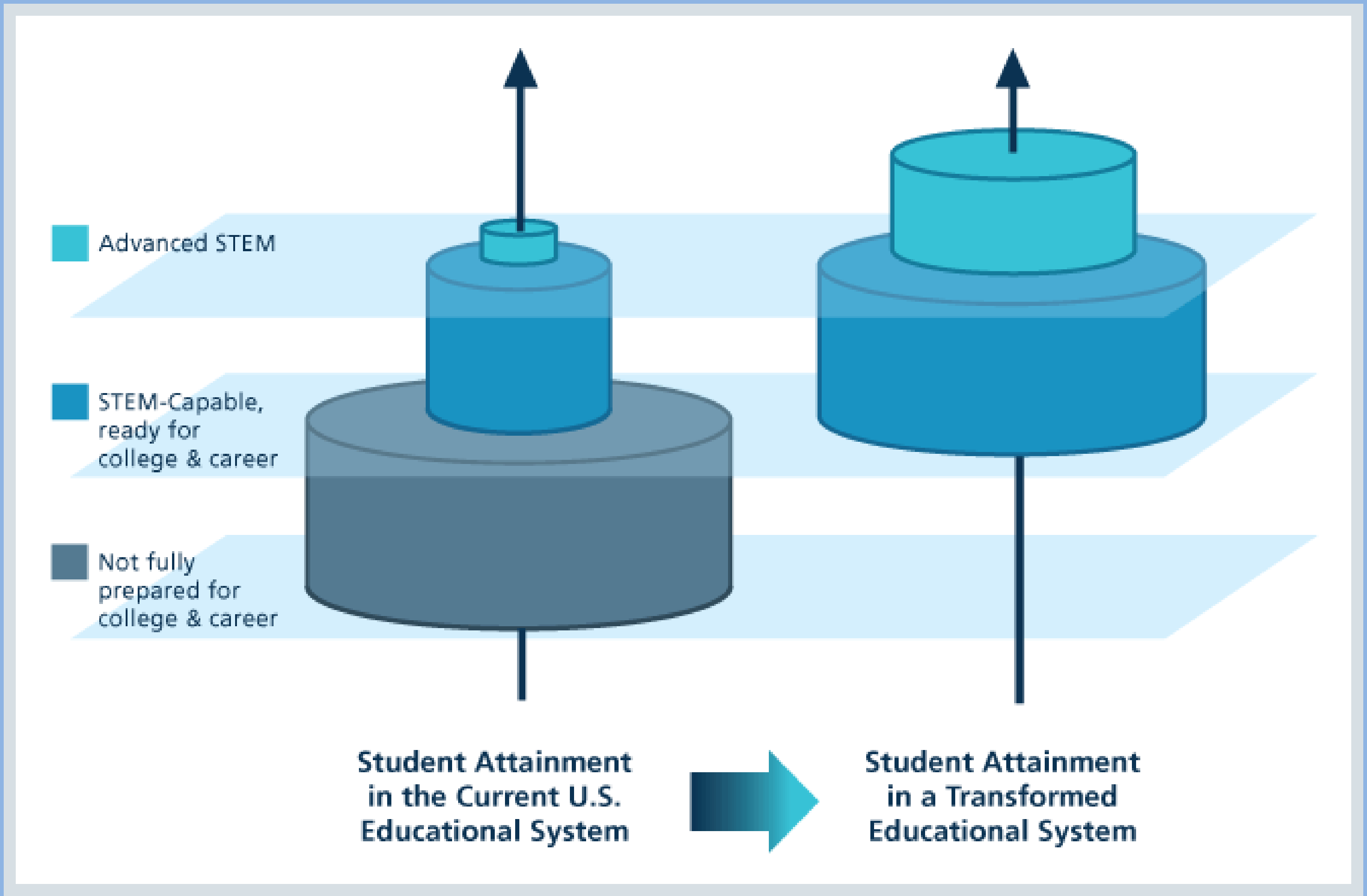
Problem Solving (2003)

Rank		Score
1	Korea	550
2	Finland	548
3	Japan	547
4	New Zealand	533
5	Australia	530
6	Canada	529
7	Belgium	525
8	Switzerland	521
9	Netherlands	520
10	France	519
11	Denmark	517
12	Czech Republic	516
13	Germany	513
14	Sweden	509
15	Austria	506
16	Iceland	505
17	Hungary	501
18	Ireland	498
19	Luxembourg	494
20	Slovak Republic	492
21	Norway	490
22	Poland	487
23	Spain	482
24	United States	477
25	Portugal	470
26	Italy	469
27	Greece	448
28	Turkey	408
29	Mexico	384
	OECD average	500

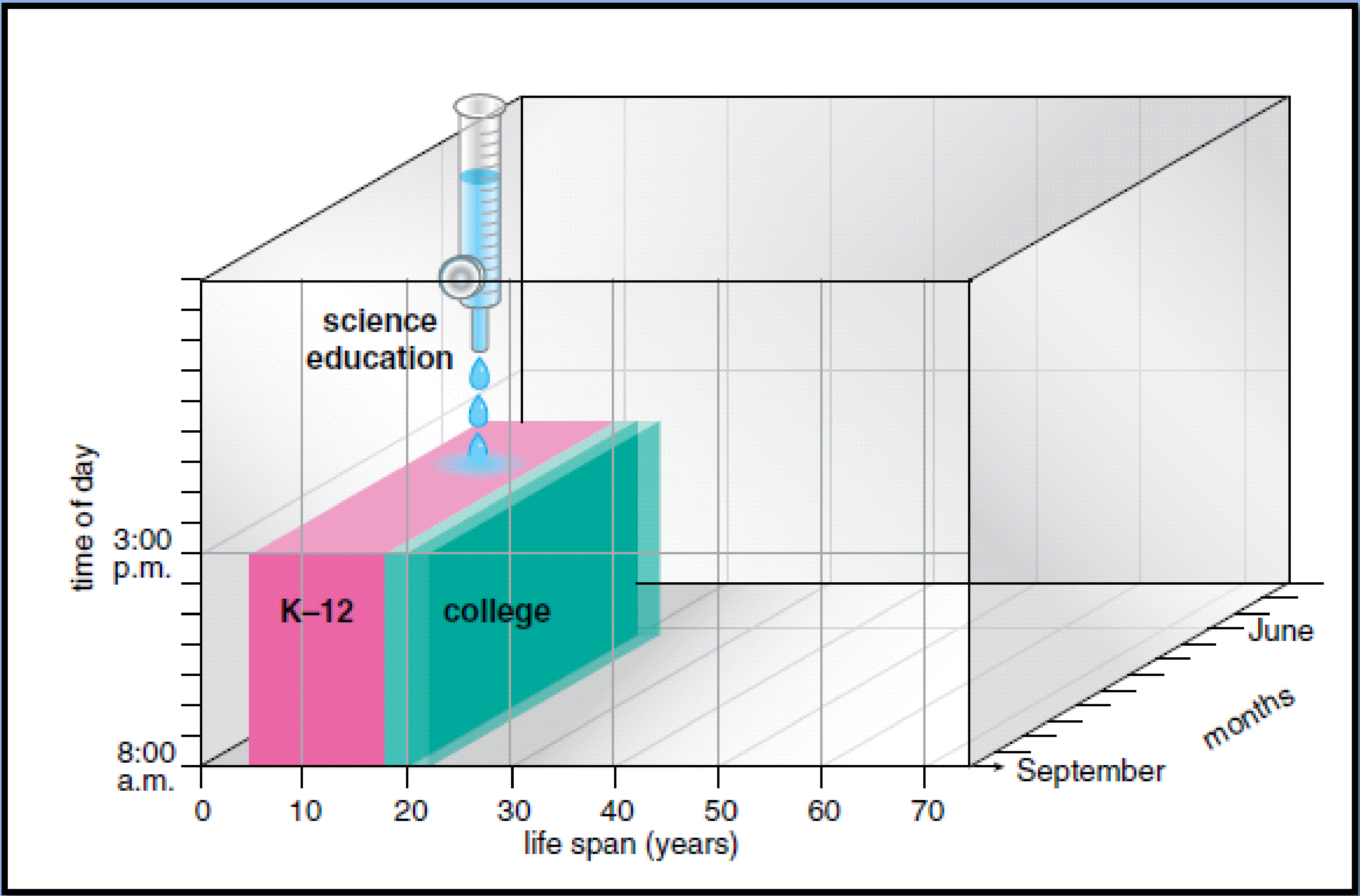
Source: Organisation for Economic Co-Operation and Development and U.S. Department of Education.



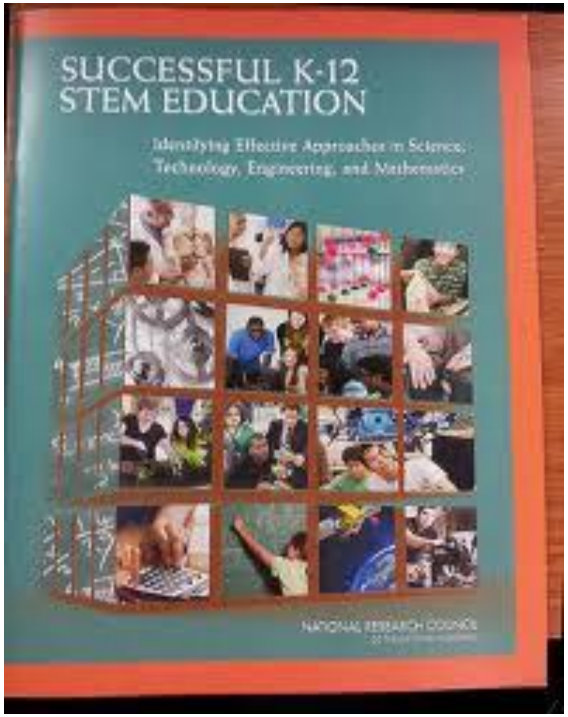
http://www.ed.gov/news/press-releases/new-data-us-department-education-highlights-educational-inequities-around-teacher



Carnegie Corporation of New York. (2009). *Visualizing Change*. Retrieved from: http://opportunityequation.org/report/visualizing-change



Falk, John H. and Dierking, Lynn D. (2010). The 95 Percent Solution, p. 488. *American Scientist, 98*.



"Effective instruction capitalizes on students' early interest and experiences, identifies and builds on what they know, and provides them with experiences to engage them in the practices of science and sustain their interest."

National Research Council, 2011.
Successful K-12 STEM Education, p.18

NSF Award #1063495 (Division of Research on Learning in Formal and Informal Settings), *Highly Successful Schools or Programs for K-12 STEM Education: A Workshop, PI:* Martin Storksdieck. National Academy of Sciences

K-16 Mathematics Education Initiative

Moving successful education programs from early research to widespread use

Credit: Thinkstock (left); Amy Snyder, © Exploratorium, Exploratorium.edu (right)

EHR Moving Forward: FY 2013 Request

Research & Development

Leadership & Capacity

Expeditions & Collaborations

Research & Development

Core Launch

- ✓ STEM Learning
- ✓ STEM Learning Environments
- ✓ Broadening Participation and Institutional Capacity in STEM
- ✓ STEM Professional Workforce Preparation

Challenges

- High quality evidence of impact
- Use of NSF-funded resources at scale
- Effective partnering
- Telling the story of DRK-12 successes

Discovering What Works

"Knowing that a program *can* work is not good enough; we need to know *how to make it work* reliably over many diverse contexts and situations.

Anthony Bryk, President of the Carnegie Foundation for the Advancement of Teaching (2009), page 298 [as cited by Paul Cobb, February 2, 2012]

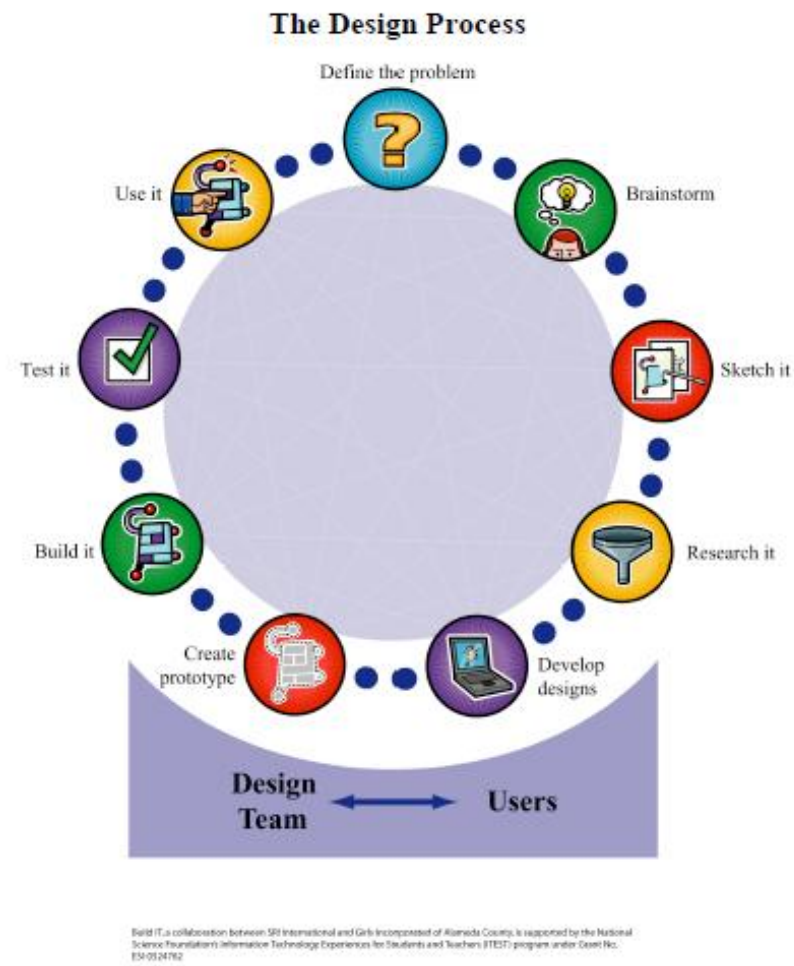
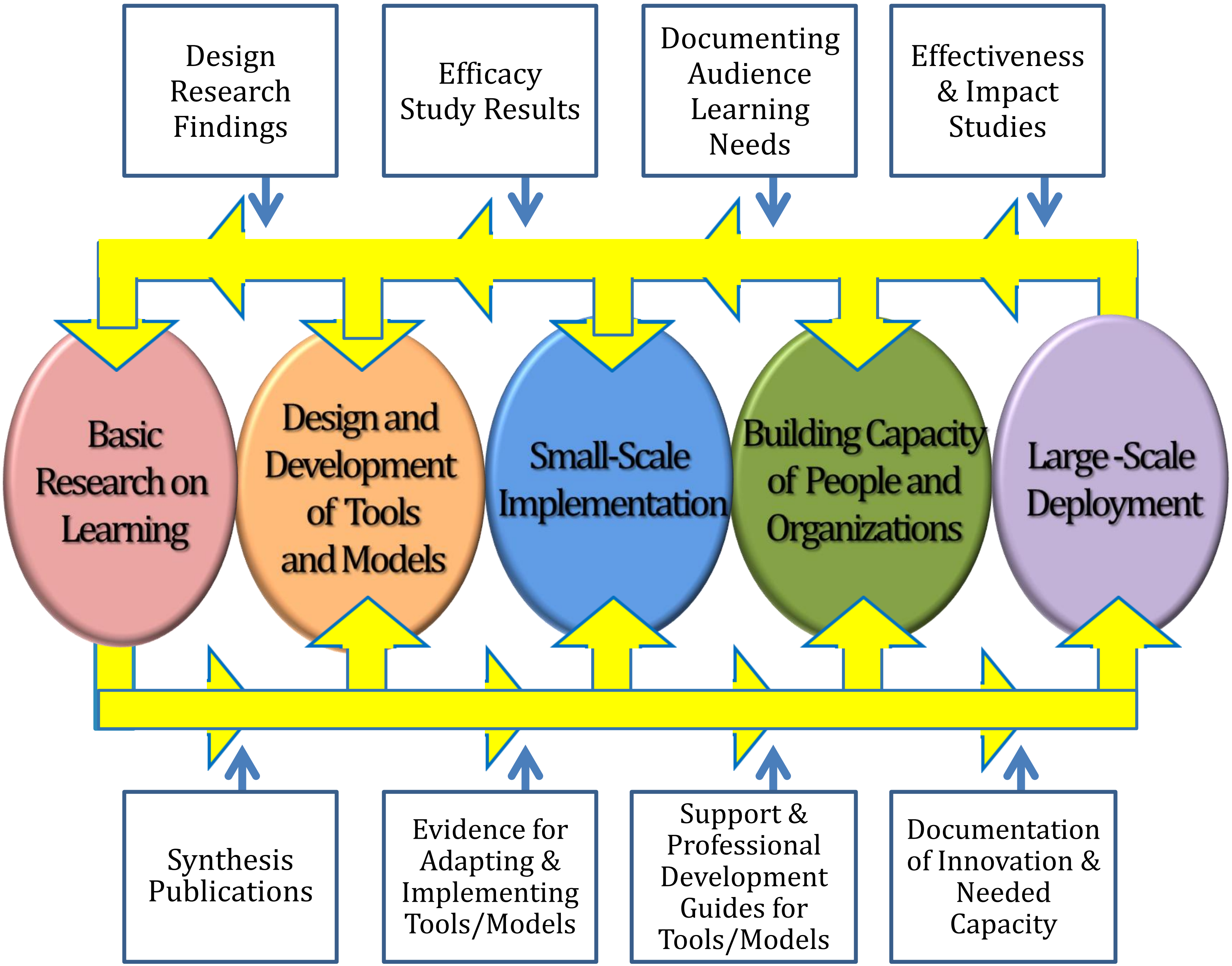


Figure 1. The Design Process poster used in the Build IT curriculum.

Koch, Melissa, et al (2005). Build IT: Girls building information technology fluency through design. Retrieved from the Build IT website: http://buildit.sri.com/curric/design.html


Design Research Findings
Efficacy Study Results
Documenting Audience Learning Needs
Effectiveness & Impact Studies
Basic Research on Learning
Design and Development of Tools and Models
Small-Scale Implementation
Building Capacity of People and Organizations
Large-Scale Deployment
Synthesis Publications
Evidence for Adapting & Implementing Tools/Models
Support & Professional Development Guides for Tools/Models
Documentation of Innovation & Needed Capacity

One NSF

Thank You!

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