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)
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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
Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS)

Creating smart systems that sense, respond and adapt to the environment

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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.”

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

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

- North America: $433 (33.9%)
- South America: $31 (2.4%)
- Europe: $319 (25.0%)
- Middle East: $26 (2.0%)
- Central Asia: $33 (2.6%)
- East, Southeast Asia: $369 (28.9%)
- Africa: $9 (0.7%)
- South Asia: $34 (2.6%)
- Central America, Caribbean: $0.6 (<0.1%)
- South America: $31 (2.4%)
- Australia, Oceana: $22 (1.8%)

World total = $1,400

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.”

Figure 3-A


Science and Engineering Indicators 2012
Our students are not being prepared to meet the demands of a 21st-century workforce.
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:
“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.”

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

- National Science Foundation, $1,154.41, 47%
- Education, $1,001.18, 40%
- NASA, $132.38, 5%
- Health & Human Services, $35.45, 1%
- Environmental Protection Agency, $7.60, <1%
- Energy, $10.12, <1%
- Nuclear Regulatory Commission, $2.84, <1%
- Agriculture, $31.38, 1%
- Commerce, $51.54, 2%
- Defense, $46.44, 2%

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?”
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**.
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

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Expeditions in Education (E²)

Focus Topics for 2013:

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

FY 2013 Budget- NSF Total: $49 Million

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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.

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OECD average: 498
OECD average: 500
OECD average: 494
OECD average: 500


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“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
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

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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]


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Synthesis Publications

Evidence for Adapting & Implementing Tools/Models

Support & Professional Development Guides for Tools/Models

Documentation of Innovation & Needed Capacity

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

DRK-12 June 2012
Thank You!

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