The NAE Grand Challenge Scholars Program: Update on a White House Call to Action

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Looking Back to the 20th Century:

Greatest Engineering Achievements of the 20th Century

Welcome!
How many of the 20th century’s greatest engineering achievements will you use today? A car? Computer? Telephone?
Explore our list of the top 20 achievements and learn how engineering shaped a century and changed the world.

1. Electrification
2. Automobile
3. Airplane
4. Water Supply and Distribution
5. Electronics
6. Radio and Television
7. Agricultural Mechanization
8. Computers
9. Telephone
10. Air Conditioning and Refrigeration
11. Highways
12. Spacecraft
13. Internet
14. Imaging
15. Household Appliances
16. Health Technologies
17. Petroleum and Petrochemical Technologies
18. Laser and Fiber Optics
19. Nuclear Technologies
20. High-performance Materials
NAE Grand Challenges for the 21st Century

- Make solar energy economical
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery
Implications of the Grand Challenges

• Don’t fit within any one discipline, or even within engineering

• Describe engineering in human-facing terms:
  – Sustainability, Health, Security, Joy

• Powerful tool for “Changing the Conversation”
Learning about NAE challenges enhances perceptions of importance and interest in engineering.

% saying engineering issues/problems are more interesting/important than those of medicine, business, and law

- Before hearing
- After hearing

**Men**
- 21% much more
- 29% much more
- 46% total
- 58% total

**Women**
- 15%
- 26%
- 33%
- 53%

**High school or less**
- 19%
- 29%
- 41%
- 59%

**Some college**
- 18%
- 31%
- 37%
- 55%

**College graduates**
- 15%
- 22%
- 39%
- 54%

**Postgrad education**
- 16%
- 25%
- 38%
- 51%

Solving Grand Challenges will require I-Shaped Engineers

- Solutions must be Feasible, Viable, Desirable
  - Feasible → Engineering fundamentals
  - Viable → Economics and business knowledge
  - Desirable → Context of culture and social policy

A couple of stories...
Goals of the Grand Challenge Scholars Program

• Create a generation/community of engineers with the skillset and mindset to solve Grand Challenges
  – “The 300” of ancient Sparta → today
• Attract diverse students to engineering
• Retain “
• Incent students to stretch
• Integrate co-curricular and curricular education into a whole greater than the sum of its parts
Grand Challenge Scholars

- To prepare UG engineering students with the skillset and mindset to address GCs over the course of their careers

- Five critical components
  1. Project or research activity engaging a Grand Challenge
  2. Interdisciplinary curriculum
  3. Entrepreneurship
  4. Global dimension
  5. Service learning

Simon GC Scholar Maggie Hoff working on potable water project in Peru

Courtesy Martha Absher
Reinventing the pit latrine
Human waste digested to biogas, then used to heat sterilize effluent.
6 seat prototype in Togo

Biogas combustion to generate electric power and revenue
Project Example: Sustainable fishery in Kenya
Teaching wave mechanics to protect fragile shallow water reefs
Project Example: Exoskeleton controlled by Brain-Machine Interface

Courtesy M. Nicolelis, Duke
HIV+ Women who give birth at home
• 20-50% have HIV+ children [1]
• Majority transmitted during delivery [1]
• 3TC, NVP and/or AZT can prevent transmission
• Drugs expires quickly out of the bottle (<1mos)

Project Example: Pratt Pouch


Duke Pouch 12 mos NVP
Duke Pouch 12 mos AZT
Duke Pouch 12 mos 3TC

Clinical Trials
Ecuador
Zambia
Tanzania
Namibia

Courtesy: Bob Malkin
The End Game: Not just education but solutions to Grand Challenges

• Some expected and some unexpected advances since 2007...
Provide Clean Water

Dean Kamen’s Slingshot and Stirling generator

>1,000 liters/day
<.001 cent per liter
Less electricity than a hairdryer

AIC-Chile Plasma Water Sanitization System
2010: Watson wins on Jeopardy

2013: IBM Watson as an AI Physician
2010: Make Solar Energy Economical
Algae?

May 20, 2010
First synthetic life form

• FUEL
• FOOD
• VACCINES

Algae: 10,000 gal/acre/year

250M Cars $\rightarrow$ $\sim$0.0048 of US landmass
Carbon Sequestration

• Ca. 2012: Advent of fracking drives down natural gas costs, replaces coal in fixed power generating plants
• C emissions reduced 50% from US electricity
• Can we engineer the environmental risk out of fracking?

Don't sign the wrong fracking petition

By TomKatsonleas, Dean of Duke University’s Pratt School of Engineering. "I was a Chair of the National Engineering’s Advisory Engineering Grand Century.

Activists deliver 150,000 signatures against fracking (Photo Credit: CREDO-farming).
Personalized Learning

2011: First MOOC reaches > 100,000

2013

With Duolingo you learn a language for free while helping to translate the web

900,000 learners + Machine Learning → surpassing Rosetta Stone
Laser and beam-driven plasma wakefields can miniaturize a large particle accelerator:

- **RF structure accelerator**
  \[ \lambda \sim 30\text{cm} \]

- **Plasma wakefield**
  \[ \lambda \sim 100\mu\text{m} \]

0-42 GeV in 3km
42-85 GeV in 1m

Blumenfeld et al, Nature ‘07
Grand Challenge Scholars Programs
5 years out

- 115 GC Scholars graduated to-date
- 15 institutional GCSPs in the US
- 51 institutions stated interest in developing a GCSP
- National Steering Committee:
  - Martha Absher, Duke
  - Lynn Stein, Olin
  - Louise Yates, USC
  - Jenna Carpenter, Louisiana Tech (Chair)
- National GCSP Workshops (Olin College 2010, AMD Campus in Austin 2011) and Panels (ASEE 2011, 2013, 2014)
Grand Challenges: More than a list... 
...a call

• Easily appreciated by engineers and 3\textsuperscript{rd} graders (and politicians)
A STRATEGY FOR AMERICAN INNOVATION: DRIVING TOWARDS SUSTAINABLE GROWTH AND QUALITY JOBS

Catalyze Breakthroughs for National Priorities
- Unleash a clean energy revolution
- Support advanced vehicle technology
- Drive breakthroughs in health
  - Address the “grand challenges” of the 21st century

Promote Competitive Markets that Spur Productive Entrepreneurship
- Promote American exports
- Support open capital markets that allocate resources to the most promising ideas
- Encourage high-growth and innovation-based entrepreneurship
- Improve public sector innovation and support community innovation
“The Grand Challenge Scholars Program Currently has 14 schools participating, would be great to increase this number and set a collective goal of number of students”
Announcing a Special Workshop

EDUCATING ENGINEERS TO MEET THE GRAND CHALLENGES

APRIL 30-MAY 1, 2014
National Academy of Engineering
in Washington, D.C.

Leaders of engineering service-learning organizations, associations, industry and academia will gather in the nation’s capitol next spring for a workshop focused on how the U.S. can best prepare future engineers to meet the NAE Grand Challenges for Engineering.

The goal of the workshop is to develop a consortium of 50 universities and organizations committed to incenting students to integrate specific curricular and co-curricular experiences that prepare them to address the Grand Challenges over the course of their careers. Attendance by invitation only.

Learn more at
nae.edu/grandchallengesworkshop
What we are asking you to do...

- Take the Survey by April 11:
  surveygizmo.com/s3/1586877/Grand-Challenges-Workshop-Attendee-Survey
  (link in March 30 email from William Kelly)

- Let me know if you would like an invitation to the April 30 workshop

- Endorse the MOU/letter to Pres. Obama when it comes to you (after May 1)

- Submit a GCSP Program proposal
Submitting a GCSP Proposal

6. **Submitting a GCSP Proposal.** Schools that join the GCSP Community through the GC Scholars web site will be invited to submit a proposal for an institutional program. These proposals should be concise descriptions of the following information.

1. Cover page with the name of the candidate school, name and signature of the engineering dean, name and signature of the GCSP director, and the GCSP director contact information.

2. Describe the GCSP vision for your school, noting GC-related activities.

3. Describe how GC scholars will be selected, including anticipated number of students involved.

4. Describe how the five GC curricular components will be met at your school.

5. Describe how GC scholars will be assessed and tracked at your school. Also include in this section how you will promote early student engagement in GC-related activities, as well as how you will foster intramural and extramural networking among GC scholars.

Examples of approved institutional GCSPs can be viewed at http://www.grandchallengescholars.org/.
Special Thanks

• Yannis Yortsos, USC
• Rick Miller, Olin
• Louis Martin-Vega, NCSU
• Tom Byers, Stanford
• Wayne Davis, UTenn
• Leah Jamieson and Bill Oakes, Purdue
• Randy Atkins, NAE
• Cathy Leslie, EWB
• +Grand Challenge Scholars partner universities:
  – ASU, LaTech, Iowa, Lafayette, Bucknell, W. NE, St. Louis, UT, Utah, Ohio St
• ASEE Bill Kelly, Jeff Goldberg, Paul Johnson
"As we think about the challenges ahead, it is important to remember that students are driven by passion, curiosity, engagement, and dreams. Although we cannot know exactly what they should be taught, we can focus on the environment in which they learn and the forces, ideas, inspirations, and empowering situations to which they are exposed."

Charles M. Vest  
NAE President 2007-2013
Providing Water in Ugandan Village
Single...
...To multi