UTeach Engineering & NASA Efforts in STEM Education Policy

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Presentation Overview

- Motivation for teaching engineering
- What is UTeach *Engineering*?
- UTeach *Engineering* high school course V2.0
- NASA involvement in UTeach *Engineering*
- NASA engagement in STEM education policy
The National STEM Conversation is Happening Now

- *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5 Report to the President – Prepare and Inspire: K-12 Education in STEM for America’s Future*
- *Change the Equation, a CEO-led initiative to cultivate widespread STEM literacy*
In the national STEM conversation, what is the role of engineering?

How can engineering be more than the “silent E” in “STEM”?

- Engineering in K-12 Education
  National Academy of Engineering (NAE), 2009

- Standards for K-12 Engineering Education?
  NAE, 2010

- Integrating engineering standards;
  To be reviewed & released, 2012
National Need

STEM Pipeline — Leaking Badly

In 2001, there were a bit more than 4 million 9th graders. Four years later, 2.8 million of them graduated and 1.9 million went on to two- or four-year college; only 1.3 million were actually ready for college work. Fewer than 300,000 are majoring in STEM fields and only about 167,000 are expected to be STEM college graduates by 2011.

Source: NCES Digest of Education Statistics; Science & Engineering Indicators 2008
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What is UTeach Engineering?

- Funded by the National Science Foundation through a $12.5M grant from the Math-Science Partnership program
- Grant period of performance: 2008-2013
- 1 of 3 NSF MSP grants to focus on K-12 engineering education
- A unique partnership
  - Respond to the current opportunity in Texas; 4x4 requirement (short-term)
  - Develop and evaluate a model for addressing national engineering needs (long-term)
What is UTeach Engineering?

- A model high school engineering course
- Teacher preparation
  - In-Service Teacher Programs
    - Engineering Summer Institutes for Teachers (ESIT)
    - Master of Arts in Science and Engineering Education (MASEE)
  - Pre-Service Teacher Programs
- Meaningful research in an emerging field
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UTeachEngineering
High School Course Development

Develop
- Develop Design Challenge Materials for Testing (V1.0)

Test & Refine
- Pilot, Assess and Evaluate V2.0 Materials in Texas Classrooms
- Refine into V 2.1

Test & Redevelop
- Pilot, Assess and Evaluate V1.0 Materials in Classrooms
- Develop Unified Course Framework and Design V 2.0

Finalize
- Pilot, Assess and Evaluate V2.1 Materials in Classrooms — Texas and other states
- Initiate teacher mentor model
- Generate Final Course Product

Red=NASA involvement
# UTeach Engineering V2.0 Course Framework

## Engineering and Its Role in the World

<table>
<thead>
<tr>
<th>Unit Title (V2.0)</th>
<th>Unit Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse Engineering Your World</td>
<td>2 weeks</td>
</tr>
<tr>
<td>From Pixels to Pixels: The Evolution of Imagery</td>
<td>5 weeks</td>
</tr>
<tr>
<td>Change Your World: Aerial Imagery</td>
<td>5 weeks</td>
</tr>
<tr>
<td>Thriving for a Better World: Wind Power</td>
<td>6 weeks</td>
</tr>
<tr>
<td>Moving Water from Source to Need</td>
<td>6 weeks</td>
</tr>
</tbody>
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### Fall Semester

- **Fundamentals of Engineering**
  - Engineering Impacts Our Everyday Lives
  - Engineering Has impacted Lives for Many Years: Engineers Work in Teams as Products Evolve in Parallel with Science, Technology and Societal Needs

### Spring Semester

- **Experiencing Design and the Breadth of Engineering**
  - Through Automation, Engineering Opens New Frontiers
  - Design
  - Special Topics in Engineering

## Key Skills

### What Do Engineers Design?
- Great Achievements
- Grand Challenges
- Practice (disciplinary, careers, multidisciplinary nature of practice)

### What Skills Do Engineers Use to Design (Engineering Habits of Mind)?

#### Systems Thinking
- System context and top-down perspective
- System decomposition (system, sub-system, element, component)
- Functional models, including input/output

#### Systems Understanding & Quantification
- Information gathering / Research (background, context, benchmarking)
- Understanding/application of domain-specific math/science knowledge (challenge-dependent)
- Data acquisition and analysis
- Modeling

#### Understanding & Application of Engineering Tools and Techniques
- Common engineering software tools (challenge-dependent)
- Instrumentation and experimentation
- Engineering project management

### Creativity
- New design, redesign, reverse engineering
- Techniques for concept generation and selection
- Innovation and design evaluation

### Collaboration
- Teamwork (e.g., types of teams, group dynamics, team composition)

### Communication
- Engineering notebooks and configuration management (cm)
- Specifications
- Data representation for decision making
- Formal documentation (e.g., reports, presentations)

### Ethics
- Engineering ethics and codes of practice (per engineering discipline)
- Engineering standards and regulations, including the role of government
- Legal aspects including intellectual property, patents, and trademarks

### Safety & Risk Analysis
- Safety considerations w/ respect to the system, the engineer & the user
- Understanding failure modes in system design

### What Process Do Engineers Use to Design?
- Identify
- Describe
- Generate
- Embody
- Finalize
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NASA involvement in the V2.0 Course

Unit 3 — Change Your World View: Aerial Imagery

Teamwork
System decomposition
Design at the subsystem level
Requirements
Operations planning
Remote sensing
Unit 5 — Robotics: The Search for Lunar Ice

Automation and control
Programming basics
Data acquisition
Specifications
Operations planning
Topography
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NASA involvement in the V2.0 Course

Unit 6 — Open Design Challenge: Mission to Mars

More complex unit; less structured
Uses all the engineering critical aspects
Introduces risk analysis
Introduces project management skills
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NASA involvement in the V2.0 Course

Supplemental materials

Basics of rocketry
Digital Learning Network units
e.g., Can a shoebox fly?
Engineering ethics lessons
Failure case studies
NASA involvement in UTeach Engineering

- Example of federal agency partnership
  - Math-Science Partnership (MSP) grants a viable mechanism for further partnerships
  - NSF, DoEd, and NASA

- Example of opportunity for NASA technical talent
  - Enable use of content in education curriculum
  - Mentor teachers

- Example of NASA education policy involvement
  - K-12 Engineering education; AP possibilities
  - Contribute to new FY13 Annual Performance Goals
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FY 13 Performance Goals and APGs

Outcome 6.2.1

Strategic Goal 6
Share NASA with the public, educators, and students to provide opportunities to participate in our Mission, foster innovation, and contribute to a strong national economy.

Outcome 6.2
Promote STEM literacy through strategic partnerships with formal and informal organizations.

Objective 6.2.1
Develop NASA’s leadership role in national STEM improvement efforts, as demonstrated by provision of meaningful educator professional development and student experiences, adoption of education technologies, and contributions to STEM education policies and strategies.

Performance Goal
Increase NASA engagement in national STEM education policy discussions to improve curricula, inform national standards in STEM subjects, and to ensure coordination and sharing of best practices across federal STEM agencies to avoid duplication.

APG
NASA will participate in no less than 20 STEM education advisory boards, STEM-related committees, or other events or activities related to national STEM education policy.
Recommendation 3 from Education Design Team

Participate in national and state STEM education policy discussions.

3.1. The Office of Education should develop an Agency position on STEM education topics such as the need for common core standards and the development of an engineering curriculum for high school students, to enable staff to consistently provide input to STEM policy discussions and debates.

3.2. The Office of Education should provide guidelines and training on how, when, and to what extent the Center education staff should engage in STEM education policy discussions.

3.3. The Office of Education should identify opportunities for NASA STEM subject matter experts to participate in key STEM education advisory boards, STEM-related committees, and other organizations addressing STEM education.
<table>
<thead>
<tr>
<th>National Role</th>
<th>Baseline Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HQ Education Leadership</strong></td>
<td><strong>Center Offices of Education</strong></td>
</tr>
<tr>
<td>Education policy coordination</td>
<td>Participate on WG with core staff from those Centers experienced and passionate about policy. Diversity of membership; not just education professionals. If available, always have an Einstein fellow (or equivalent quality teacher) assigned to the WG.</td>
</tr>
<tr>
<td>Education policy engagement</td>
<td>Engage at least one state in Center’s service region that is actively part of the specific policy implementation topic. Establish a liaison to each state within service region (i.e., networking).</td>
</tr>
<tr>
<td>Education policy connections</td>
<td>Seek opportunities to serve and connect with education leaders through Legislative Affairs. Ex. Space Day in Center’s resident state.</td>
</tr>
<tr>
<td>Education policy relationships</td>
<td>Extend education policy reach through NASA education projects and sponsored organizations (e.g., AESP; Space Grant).</td>
</tr>
<tr>
<td>Subject Matter Experts involvement in education</td>
<td>Identify/coordinate Center SMEs for assignments, possibly IPA opportunities.</td>
</tr>
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| Ex. | Communicate which states investing in virtual schools; or working next gen science standards. |
| Ex. | Co-STEM involvement; Dept of Ed & its Race-to-the-Top |
| Ex. | Extend education policy reach through organizations committed to STEM at national level, such as STEM Ed Coalition, STEM Connector. Enable NASA awards and grants to include STEM policy interests. |
Opportunities for Space Grant

STEM education policy

- Communicate to NASA how your state is responding to current STEM policy topics
  - E.g., K-12 engineering ed; next gen science standards

- Make state connections to extend NASA’s reach beyond field center states
  - With state education leadership; key STEM organizations; interested school districts

- Coordinate with MSP grant universities in your consortium
  - Example NSF MSP grantees for engineering ed: UT-Austin, Purdue, Steven’s, University of Cincinnati
  - Hot topics: teacher PD for engineering; implementation of next gen science standards; content for K-12 engineering
For more information

UTeach *Engineering* high school course — Engineer Your World

- [www.engineeryourworld.org](http://www.engineeryourworld.org)
- [Lisa.a.guerra@nasa.gov](mailto:Lisa.a.guerra@nasa.gov)
Back-up Slides
1. **Attract high school students** (including, particularly, those from historically underrepresented populations) to engineering and positively impact their interest in engineering.

2. Introduce students to **multiple disciplines** and a variety of career paths within engineering.

3. Enable students to make informed decisions regarding engineering as a profession.

4. Encourage engineering literacy by teaching the **engineering habits of mind**.

5. Encourage a growth mindset by highlighting that **engineering design and problem solving** are skills that can be learned, practiced, and improved.
What process do engineers use to design?
Engagement in Education Policy

Current Model:

- Ad hoc approach; no agency-wide coordination or discussion

- Centers choose to participate at the local, state or regional levels
  - 4 of the 10 NASA Centers are actively engaged in education policy (according to ECC survey distributed by the Policy Working Group)
  - Center concerns related to engagement: takes resources; lack policy expertise; should focus on workforce needs; work only at county level.