Towards Transforming Engineering Education

Welcome!

So let's begin:

. . . with a short quiz.

Question 1

- You walk into a room and notice that a picture is hanging crooked. As an engineer, you…
  a) Straighten it
  b) Ignore it
  c) Buy a CAD system - *spending the next 6 months designing a solar-powered, self-adjusting picture frame*

Question 2

- Which of the following lies might an engineer offer:
  a) *"I won't change anything without asking you first"*
  b) *"I'll return your really cool, hard-to-get cable tomorrow"*
  c) *"I need new equipment to do my job"*
  d) *"I'm not the least bit jealous of your new computer"*

Question 3

- What is your goal for attending this workshop and how would you measure its achievement? *(30sec)*

Setting the stage…

- **Caution:** *Most of the information presented represents the presenter's opinion and is not an official NSF position.*
- **Please Note:** *Some of the slides come from Carl Wieman's presentation at the 2011 TUES / CCLI PI meeting (1/27/11)*

Present Challenge

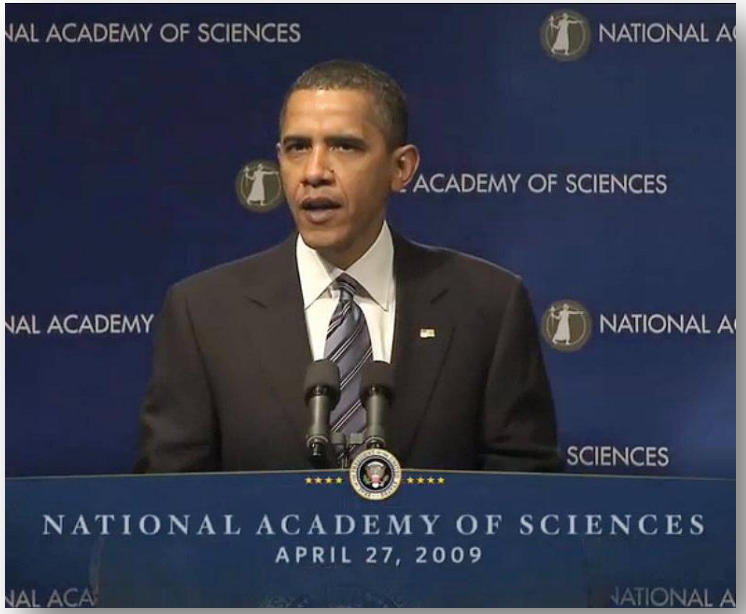
- Erosion of our national *"educational capital"* is occurring just when we need more college educated workers
- Baby Boomers retiring
- Increasing skill requirements are necessary for new engineering related jobs

The White House Perspective

- *"Maintaining our leadership in research and technology is crucial to America's success. But if we want to win the future* – if we want innovation to produce jobs in America and not overseas – *then we also have to win the race to educate our kids."*

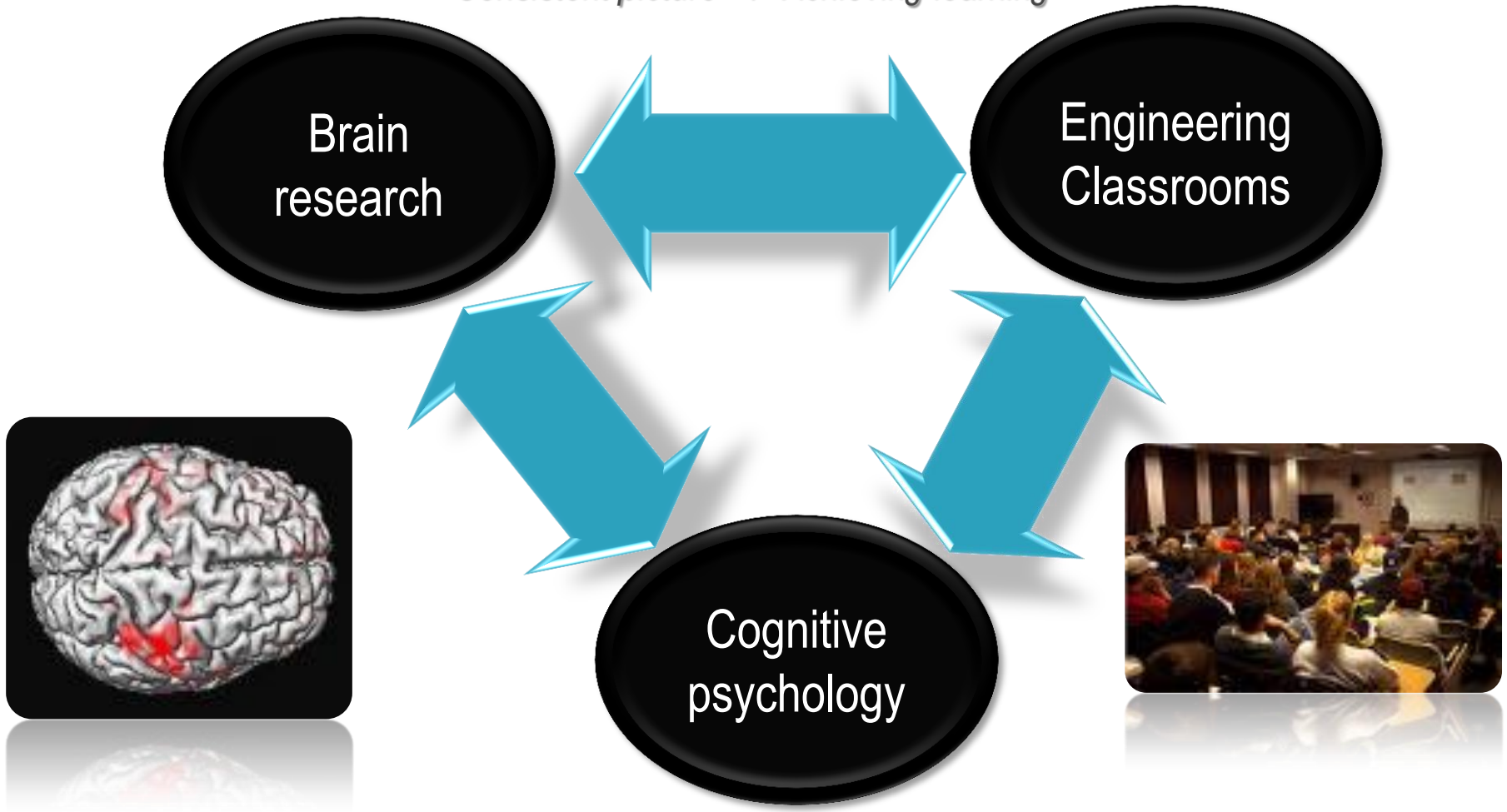
Major Policy questions:

- What is effective teaching, particularly in STEM?
- Can it be developed? How?
- How can we achieve better learning? (*evidence!*)



Major Advances Over Past 1-2 Decades

Consistent picture ⇒ Achieving learning



*Principles of learning help to design experiments and make sense of results - need to understand both what and **why***

Perceptions About Engineering*

Novice

Content: isolated pieces of information to be memorized

Handed down by an authority, unrelated to real world

Problem solving: simple "template matching" to memorized recipes

Expert

Content: coherent structure of concepts

Established by experiment, describes nature

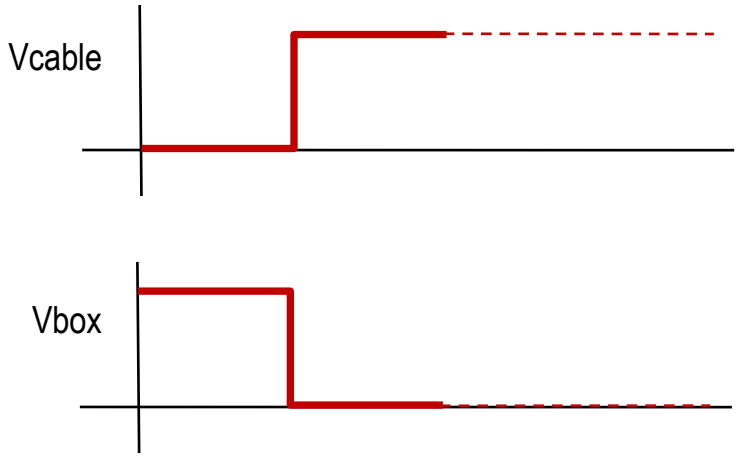
Problem Solving: systematic concept-based strategies; widely applicable

Note: consistent across engineers in a discipline

**C. Wieman adapted from David Hammer*

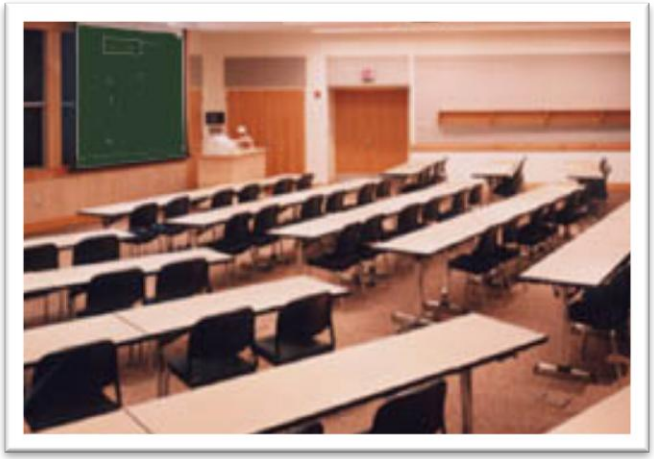
Relationship of Sense to Meaning

- Does this make sense?
  Based on experience
- Does it have meaning?
  Material relevant to the learner
- Meaning is more significant for longer-term storage



Engineering Education

- 1960's:

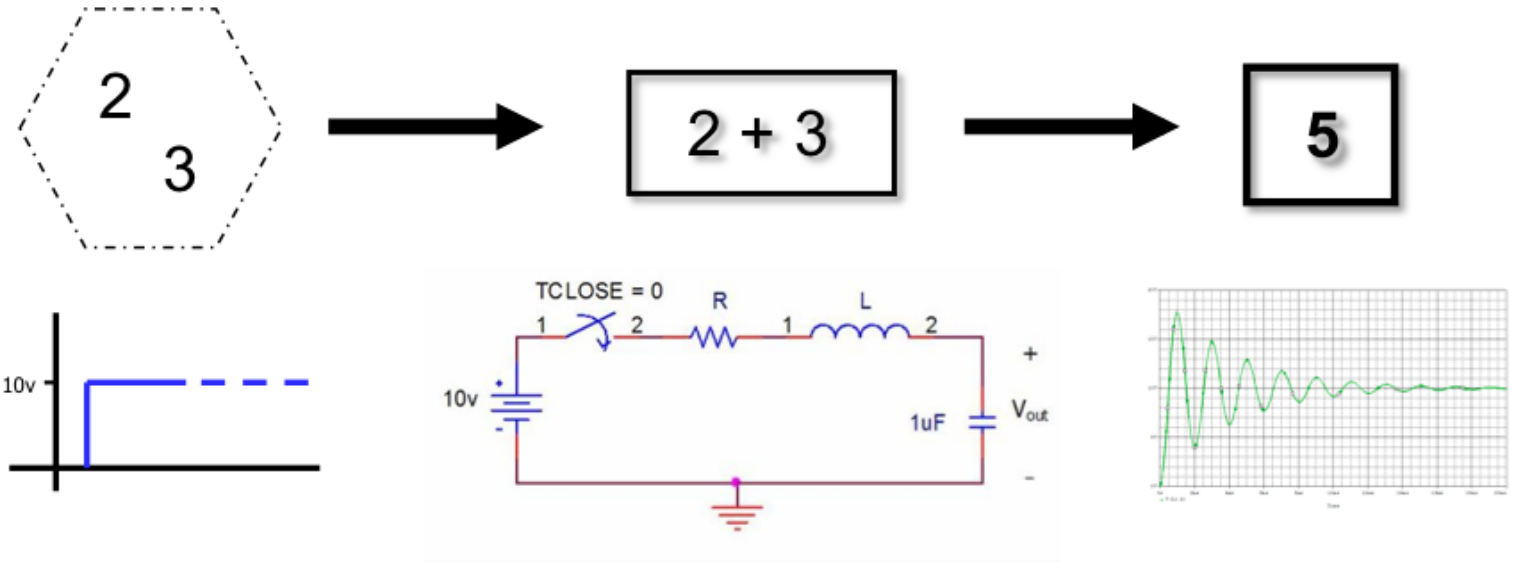


Engineering Education

- Today:


Rensselaer
MAXIM
Maxim Integrated Products
www.maxim-ic.com
IBM

K-12 Classroom

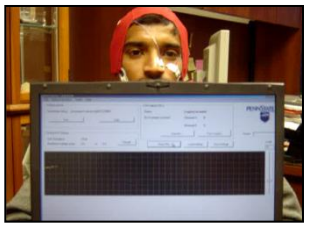


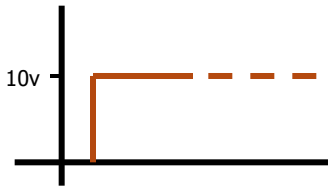
Given this input…

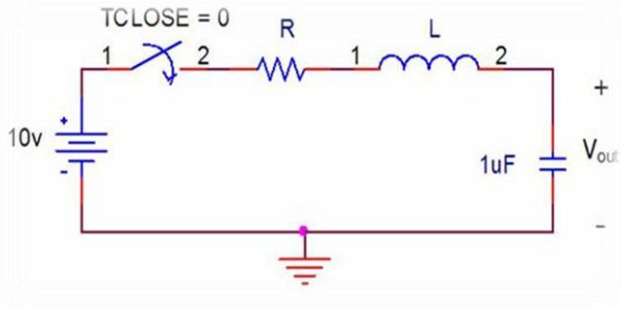
Analyze this system…

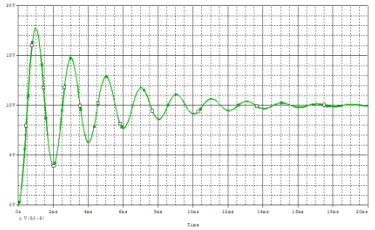
To get this output…

Engineering Career









Given this input…

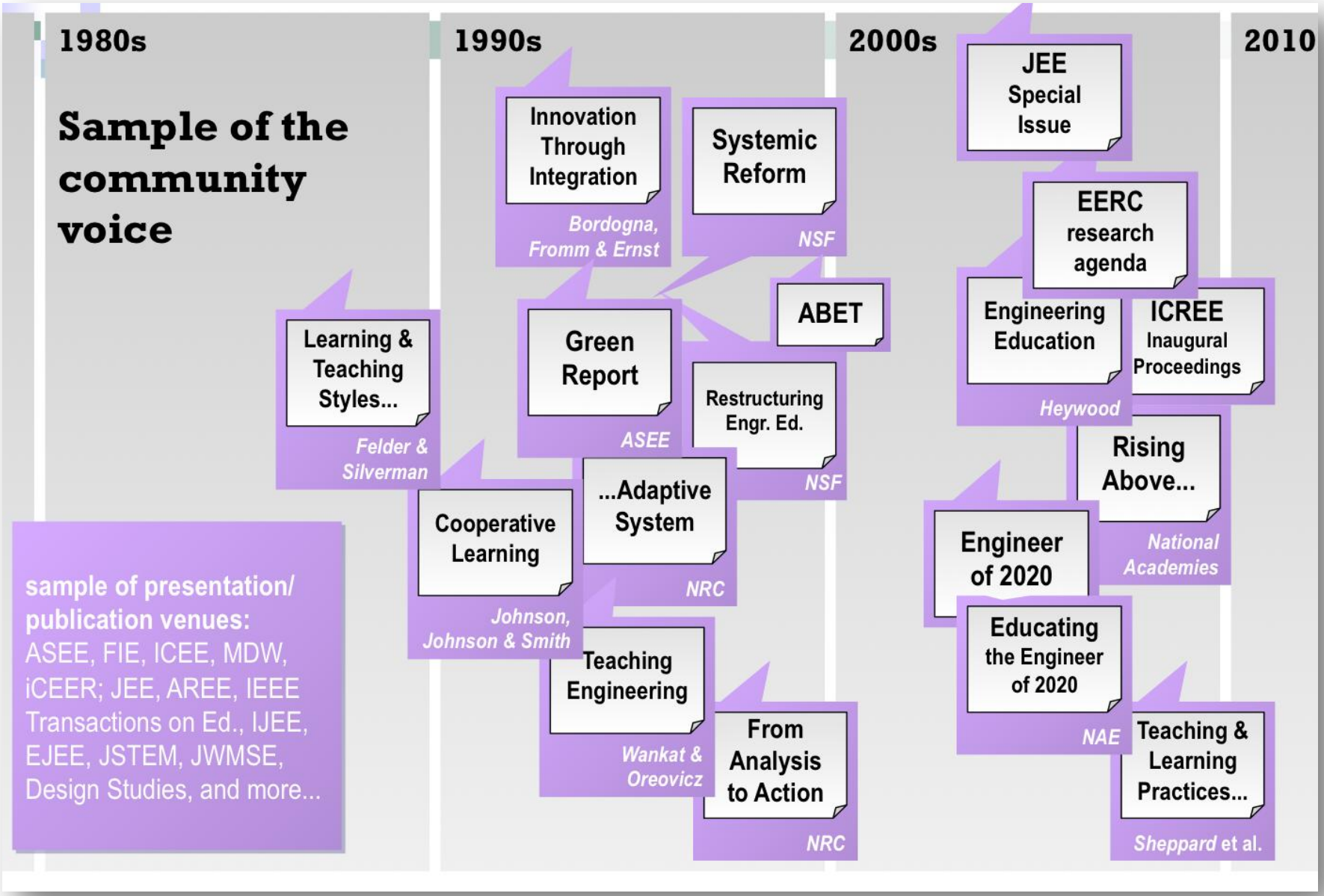
Design… this system

w/this desired output…

A Dichotomy

- ***In school***: problems almost always are clearly defined, confined to a single discipline, and typically have one right answer

- ***In the workplace***: problems are usually ill-defined, multi-disciplinary, and have several possible answers *(none of which are perfect)*



Acknowledgment: *Taken from Cindy Atman's talk to Danish Centre for Engineering Education Research and Development, June 8, 2007*

Historic Transformations in Engineering Education

- Science-based engineering
- Computers in the classroom
- Active, team-based learning
- Widespread internet access
- Jam-packed curricula…

What We've Learned

- Active classrooms trump passive classrooms
- Reflection fosters re-organization of thinking for deep learning
- Students will remember more if provided less at any given time *(average capacity of working memory is 7 chunks)*

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Creativity Definition Ranking

Topic	Industry	Academia
Problem identification or articulation	**1**	9
Ability to identify patterns of behavior or new combination of actions	2	3
Integration of knowledge across different disciplines	3	2
Ability to originate new ideas	4	6
Comfort with notion of "no right answer"	5	11
Fundamental curiosity	6	10
Originality and inventiveness in work	7	4
Problem solving	8	**1**
Ability to take risks	9	8
Tolerance of ambiguity	10	7
Ability to communicate new ideas to others	11	5

From: *D. Pink – "A Whole New Mind: Why Right-Brainers Will Rule the Future"*

Engineering Workforce Issues

- Need a combination of left/right brain thinking
- Eng jobs require good research, synthesis, and systems integration abilities
- China is trying to become more innovative, while the US is trying to be more rigorous (*it is better to be the US*)
- Need to stimulate, enable and foster creativity (*Why did Steve Jobs, Bill Gates & Mark Zuckerberg drop out of college?*)

Today's Realities

- Engineering schools are heavily influenced by academic traditions that don't always support the profession's needs
- We aren't very effective in preparing students to integrate/organize their knowledge, skills and identity as a professional

Why Engineering Students Leave

- Coursework too restrictive for students' varied interests
- Lack of role models – *especially for women and underrepresented minority students*
- Poor advising & teaching – combined with a lack of exposure to engineering early on…*leads to discouragement and departure*
- Fear of outsourcing
- Lack of connection between what is studied and perceived as exciting practice

Why Are We Here?

- What are the needs of industry?
- Skill set (hard/soft)?
- What is the “right” `mix for lifelong learning?

Charge

- What are the skills needed to do ENG today – different from ABET 2000...
- In a world with greater access and viability for lifelong learning (MOOCs, etc.) what might be the best college experience?
- With the advent of tools (Matlab, portable hardware, web resources, etc) what changes could be made?

In closing:

- Look to your left
- Look to your right
- Because…

You are the change agents for the future of engineering…

Thank you.

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