Towards Transforming Energy Systems Education

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Welcome!

Intent

1) Set the stage for reforming Electric Energy Systems (EES) education
2) Offer a brief perspective of emerging trends in education
3) Provide some background that should be considered - *to transform EES education*

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1) Setting the stage…

Caution: *Most of the information presented represents the presenter's opinion and is not an official NSF position.*

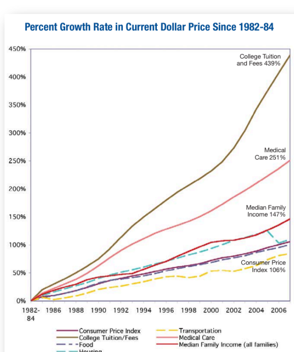
Please Note: *Some of the slides come from Carl Wieman's presentation at the 2011 TUES / CCLI PI meeting (1/27/11)*

Our Story…

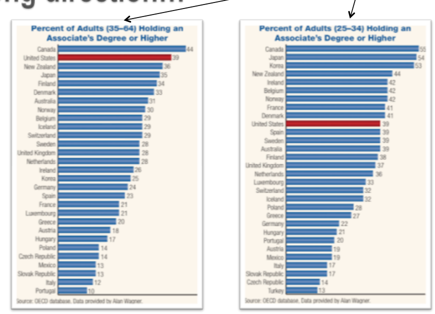
Family Income: ~1.5x

Medical Costs: ~2.5x

College: ~**4.4x**

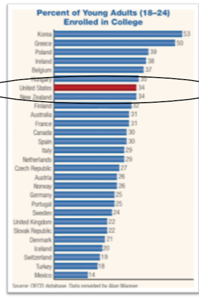


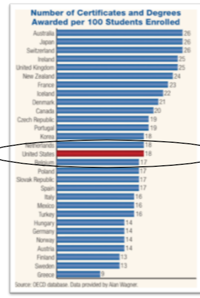
Wrong direction…



From: "*Measuring Up 2008*"

It is getting worse…





From: *"Measuring Up 2008"*

Present Challenge

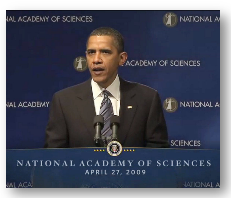
- Erosion of our national *"educational capital"* is occurring just when we need more college educated workers
- Baby Boomers retiring
- Increasing skill requirements are necessary for new electric energy/power systems related jobs

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:

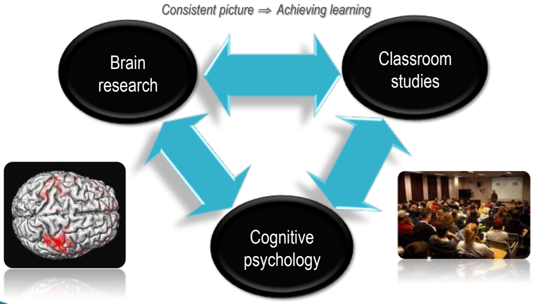
- What is effective teaching, particularly in STEM?
- Can it be developed? How?
- How can we achieve better learning? *(evidence!)*



2) Emerging trends in education…

Major Advances Over Past 1-2 Decades

Consistent picture ⇒ Achieving learning

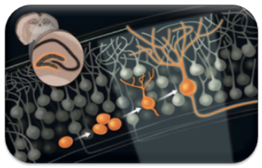


*Principles of learning help to design experiments and make sense of results - need to understand both what and **why***

Brain Research

MRI data related to learning

- *Significantly changes the brain*, doesn't just add bits of knowledge
- Building proteins, growing neurons ⇒ enhance neuron connections...
- Does the brain operate similar to a muscle? More exercise, more wiring?



Cognitive Psychology

Perceptions About Science/Engineering*

Novice	Expert
Content: isolated pieces of information to be memorized	*Content:* coherent structure of concepts
Handed down by an authority, unrelated to real world	Established by experiment, describes nature
Problem solving: simple "template matching" to memorized recipes	*Problem Solving:* systematic concept-based strategies; widely applicable

Note: consistent across scientists/engineers in a discipline

**C. Wieman adapted from David Hammer*

"Expert" Competence Research*

athletes, scientists, musicians, doctors,...

Expert competence equals:

- Factual knowledge
- Mental organizational framework ⇒ retrieval and application

or ?

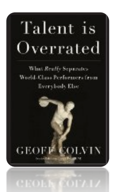
patterns, relationships, scientific concepts

- Ability to monitor own thinking and learning ("Do I understand this? How can I check?")

New ways of thinking: *requires MANY hours of intense practice to develop*

**Cambridge Handbook on Expertise and Expert Performance*

Developing Expertise



"Deliberate practice" (Anders Ericcson)

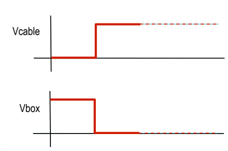
- Do a challenging (but achievable) level task that requires explicit expert-like thinking and intense engagement
- Reflection and guidance on result
- Repeat & repeat & repeat . . .
- 10,000 hours later . . . *very high level expertise*

Brain changes; develops with "exercise"

- "Constructivism", "formative assessment", "self-regulated learning" - *all contained in "deliberate practice" framework*

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



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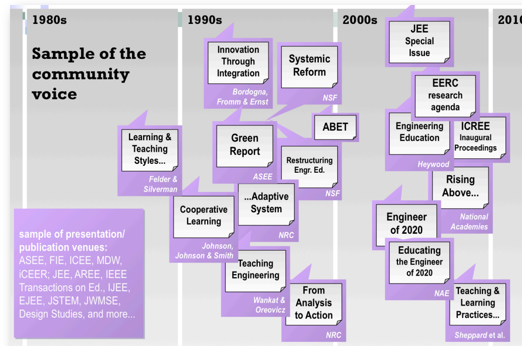
Classroom Studies



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

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Historic Transformations in Engineering Education

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

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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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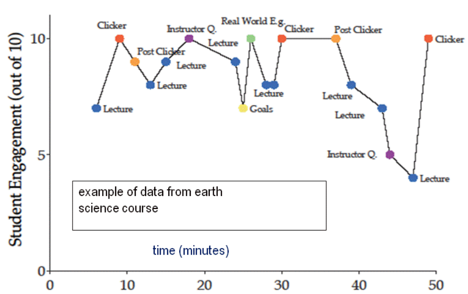
Student Engagement



A Potential Class

1. Pre-class intro/exploration activity *(research)*
2. On-line assessment → JIT in-class planning
3. Preliminary in-class reflective question to stimulate discussion and develop coherence *(Concept Inventory)*
4. Inquiry-based, guided interactive/hands-on activity
5. Response system-based, open-ended question to foster restructuring *(clickers)*
6. Post-class concept assessment/reinforcement

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3) Background considerations…

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"*

Energy Systems Workforce Issues

- Industry needs a combination of left/right brain thinking
- EES 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?*)

Why Engineering Students Leave

- Poor performance in intro math/science courses
- Coursework too restrictive for students' varied interests
- Perception that other majors have easier classes and more fun – *view engineering as a competitive and uncaring field*
- A feeling of isolation from rest of the university – *due to the workload, lack of cross disciplinary opportunities*

Why Engineering Students Leave

- 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

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

An Opportunity

NSF Impact

- NSF uses merit review to select about 10,000 new awards each year from more than 42,000 competitive proposals submitted annually

Solicitation → Proposal → Review → Award → Project

NSF TUES Program (formerly CCLI)

- Title changed to emphasize the special interest in projects that have the *potential to transform* undergraduate STEM education
- Emphasizes:
  - Materials, processes, or models that ***enhance student learning***
  - Widespread adoption of best classroom practices
  - Adaptation at many sites
  - Exploration of cyberlearning

A Successful Proposal

- Good idea + need
- Right people + infrastructure
- Assessment of outcomes that measure effect on student learning (with goals/objectives linked to evaluation)
- Active dissemination plan
- Efforts to broaden participation of underrepresented groups

Answer Reviewers' Questions

What are you trying to accomplish?
What will be the outcomes?
} *Goals*

Why do you believe that you have a good idea?
Why is the problem important?
Why is your approach promising?
} *Rationale*

How will you manage the project to ensure success?
How will you know if you succeed?
} *Evaluation*

How will others find out about your work?
How will you interest them?
How will you excite them?
} *Dissemination*

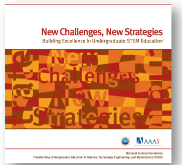
Promising Strategies

This is not a comprehensive list!

What Works

- Guided inquiry
- Concept inventories
- Peer-led team learning

- Problem-based learning
- Active recall of information
- Effective use of technology



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Process-Oriented Guided Inquiry Learning

- Work in teams to complete specially designed worksheets that guide them through the inquiry process of learning
- Students are given data/information followed by leading questions
- Discuss material - rather than just hear about it
- 3 Phases: *Exploration, Concept Invention, Application*
- Instructor serves as facilitator, observing and periodically addressing individual and class needs

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Peer-Led Team Learning

- Students who do well are trained as "peer leaders" - to guide the efforts of 6-8 students
- Groups meet weekly (outside of class) to work together on challenging problems that help build conceptual understanding and skills
- Problems that can't be solved easily on one's own
- PLTL sessions replace traditional recitation sections
- Dept/Institutional support is essential, including logistics and finance

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Problem/Service-Based Learning

- Instructor led/facilitated
- Complex problems - *open-ended, real world, deliberately vague*
- Problems drive concept discovery on a need-to-know basis
- Ideal class size < 30 students (groups of 4-5)
- Concepts will be understood and remembered longer when learned, explored, discussed, applied and tested in a practical context

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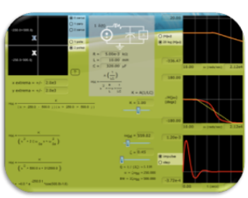
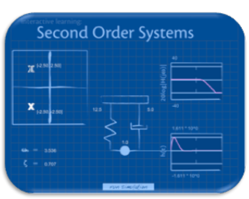
Technology Example





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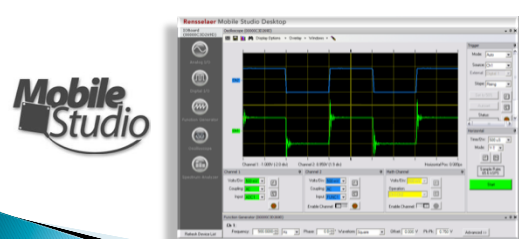
Engagement



Towards Reform/Transformation…

- *3C's:*
  1) Core (teaching/learning)
  2) Culture (communication/adoption)
  3) Community (local/global)

Why Are We Here?

- Engage
- Educate
- Expand the community
  1. *Faculty → Faculty*
  2. *Admin → Faculty*
  3. *Faculty → Admin*

In closing:

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

You are the change agents for our future energy systems…

Thank you.

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