

Leveraging Engineering Education Innovation to Redefine Undergraduate Education

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Questions for Today

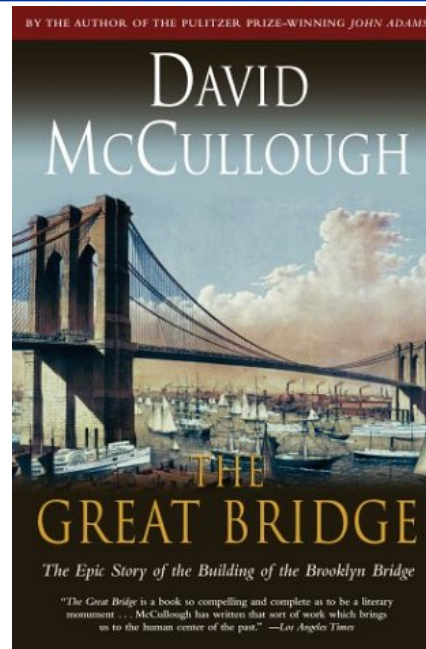
- *How did we get here?*
- *What are the data telling us?*
- *What are the desirable learning outcomes?*
- *Any reflections from Olin experience?*
- *Can engineering education innovation be a lever for rebalancing 21st Century education?*



This is not a new challenge – Washington Roebling graduated from RPI in 1857!



“...the terrible treadmill of forcing an avalanche of figures and facts into young brains not qualified to assimilate them...I am still busy trying to forget the heterogeneous mass of unusable knowledge that I could only memorize...”



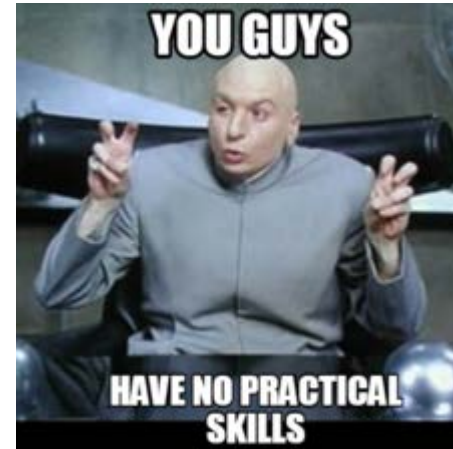
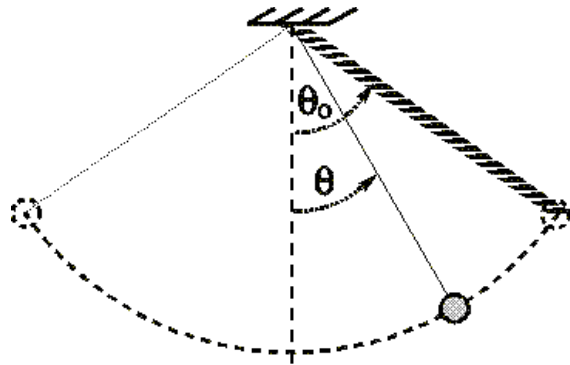
World War II, Cold War, Postwar Economy: Swing the pendulum from vocational to professional



*1945: “Science won the war.”
Engineering becomes Engineering Science.*



Pendulum swings too far, society and education change



30 years of calls for change follow...

Walker, E.A., Pettit, J.M., and Hawkins, G.A., Goals of Engineering Education: Final Report of the Goals Committee, 1968.

ASEE Engineering Deans Council and Corporate Roundtable, The Green Report: Engineering Education for a Changing World, 1994.



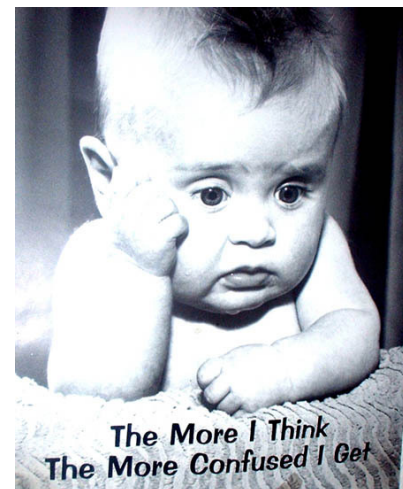
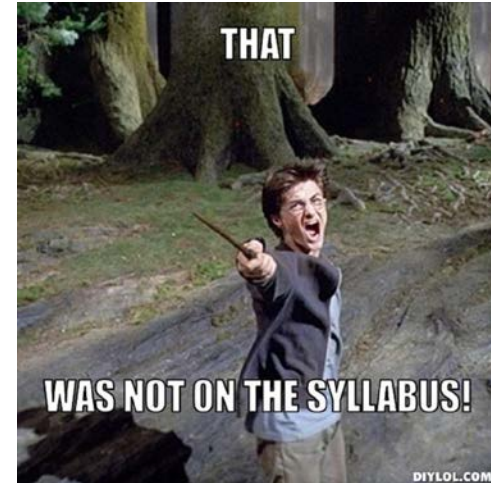
Current realities - rebalance content and process

- *There will never be enough time to 'cover' the material.*

- *We do not retain what we do not use.*

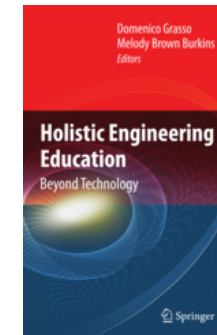
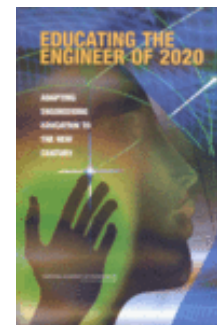
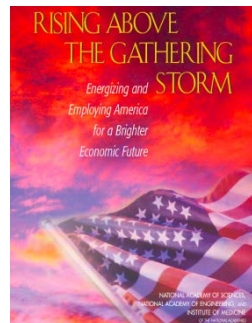
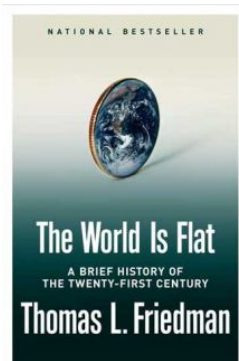


- *Information is a means not an end.*



Educating engineers beyond technology

Teamwork, communication, creativity, leadership, entrepreneurial thinking, ethical reasoning, global contextual analysis





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Current realities – who are our students?

- *Average of independence ~ 29 years old*
- *31M people have partially completed college*
- *>40% of undergraduate population is over 25*



Observations from USA undergraduate degree data (Department of Education)

- *Small percentage of engineering degrees*
- *Balkanization of American higher education – A&S vs Engineering vs Business rather than integrated*

<u>Total</u>	<u>2001</u>	<u>2015</u>
	1.24M	1.89M
<i>Engineering</i>	58k/4.7%	98k/5.2%
<i>Engr Tech</i>	14k/1.2%	17k/0.9%
<i>CS/IS</i>	44k/3.5%	60k/3.1%
	9.4%	9.2%
<i>Business</i>	264k/21.1%	364k/19.2%
<i>Biology</i>	61k/4.9%	110k/5.8%
<i>Health</i>	76k/6.1%	216k/11.4%



Implications - USA compared to the world (Department of Education)



- *Tipping point for impact – societal priorities, government policy, active and informed citizenship...*

	<u>Engineering</u>	<u>Physical Sciences</u>
USA	5%	11%
Poland	11%	10%
Japan	16%	7%
Finland	20%	9%
South Korea	24%	12%
China	32%	13%

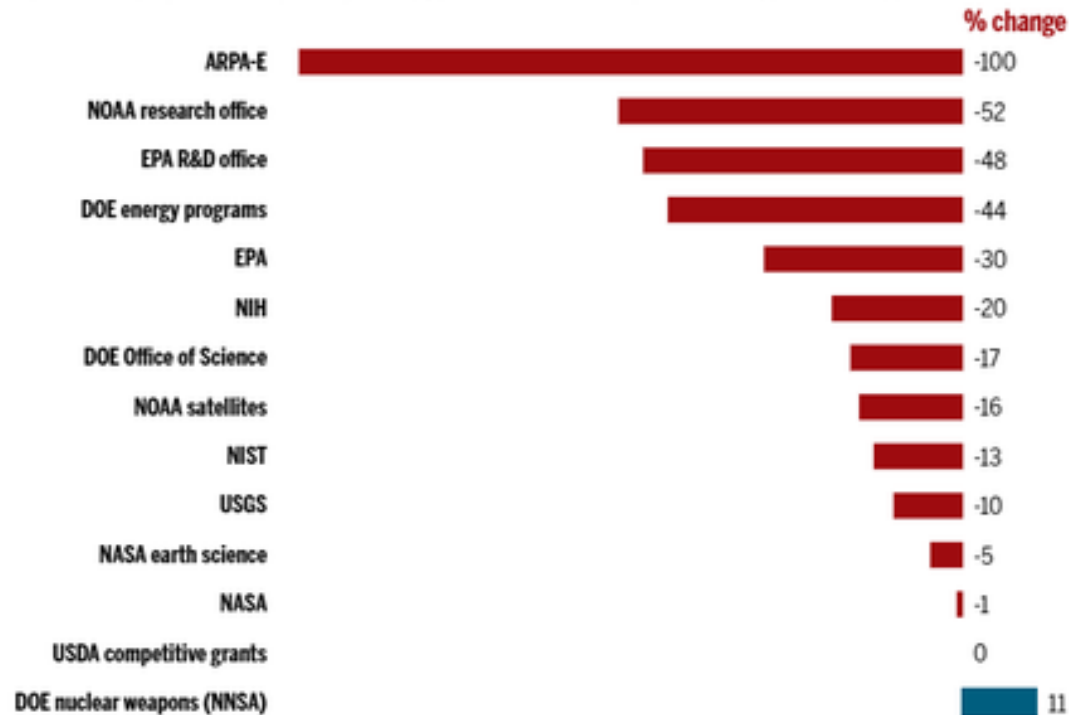


Sample implication – government policy

- **113th Congress (2015) – Engineers: 1.4%, No college: 5.0%**

The ax falls on research

Numerous federal science programs would see major cuts from 2016 levels under President Donald Trump's 2018 budget request, with the National Institutes of Health (NIH) getting a \$6 billion, 20% cut, a preliminary analysis suggests. Nuclear weapons funding would surge.



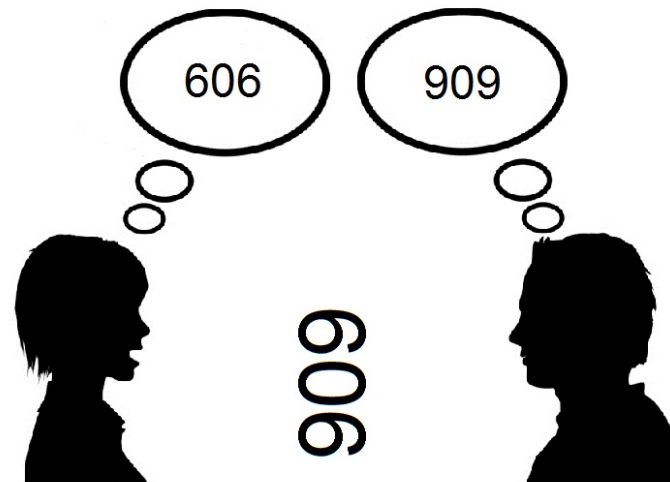
Graph: David Malakoff/Science

Data: Matt Hourihan, AAAS R&D Budget and Policy Program



Gallup data – *Disconnect of the academy and non-academic world*

- ***98% of Provosts/CAOs say their institutions effective/somewhat effective at preparing students for work life.***
- ***11% of business leaders strongly agree that graduating students have skills and competencies needed for success.***



Gallup data – Undergraduate experience affects quality of life

- *Purpose – what you do and how much you like it*
- *Social – relationships, love of life*
- *Financial – reduced stress, security*
- *Community – engagement with others*
- *Physical – health and well-being*





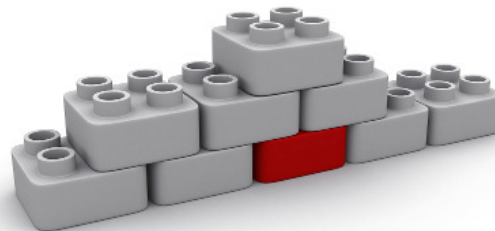
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Learning outcomes for Foundational Engineering Education(?)

- **Foundational** →
 - *Provide a strong platform upon which to build a career but more importantly*
 - *Prepare for an engaged life*
- **Engineering** →
 - *Leverage intrinsic motivation, technical skills and context to create and solve*
 - *Practice at engineering – (self-)empowerment of realization*
- **Education** →
 - *Convert information to knowledge (insight?)*
 - *Learn how to learn and to want to learn*

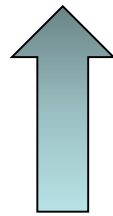


Goals of foundational engineering education

The Excitement of Engineering

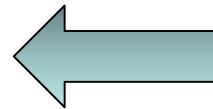
There Must be a Better Way!
(Analysis)

Why Not...?
(Idea)

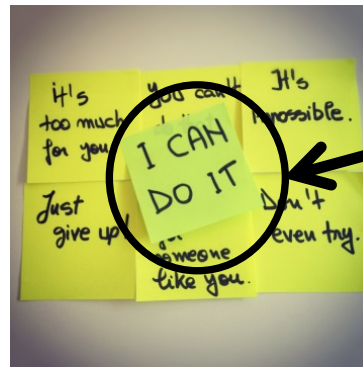


Why Doesn't it Work?
(Test)

Let's Try It!
(Prototype)



Empowerment



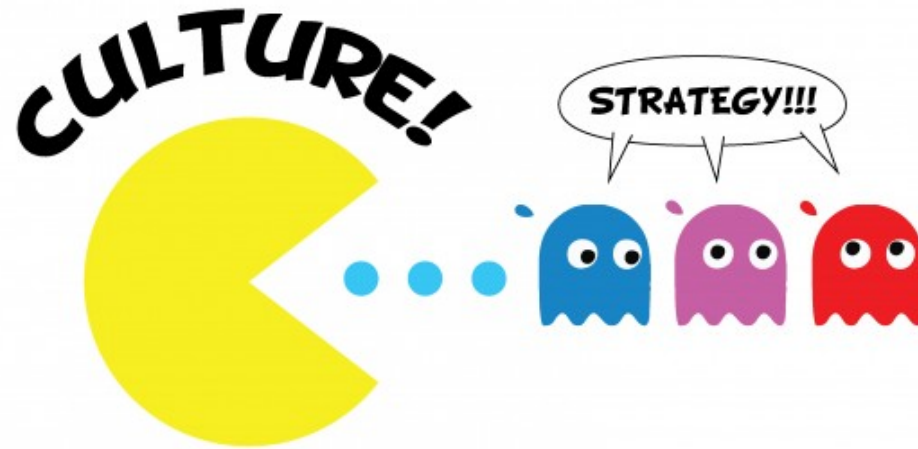
Curriculum → Culture

“Making universities and engineering schools exciting, creative, adventurous, rigorous, demanding, and empowering milieus is more important than specifying curricular details” ,

Charles Vest, NAE & MIT President emeritus



Culture trumps curriculum



- *Culture needs to have a scaffold*
- *Student as partners – engaged and intrinsically motivated*
- *Continuous curriculum innovation*
- *Connect educational theory and practice*
- *Broader (contextual) definition of engineering*

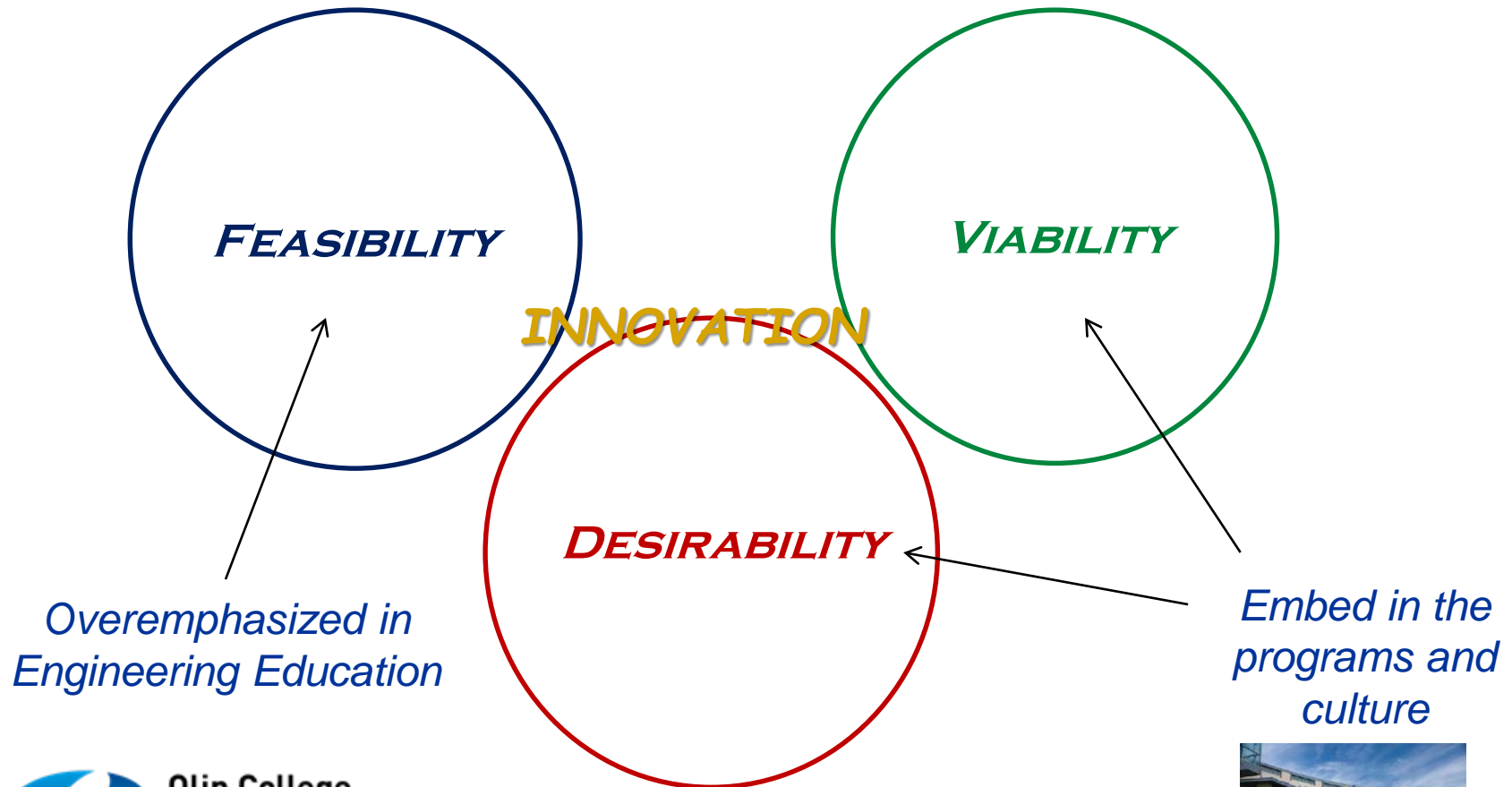


Attitudes and behaviors

- *Motivation – provide opportunities for students to do something (Felder & Silverman, 1988)*
- *PBL/PjBL courses...spark some significant changes in students' cognitive and behavioral strategy... (Lord et al., 2012)*
- *Students in lecture-only courses did not connect their perceived ability to do engineering with the outcomes they would experience as engineers (Atadero et al., 2015)*



Active learning better serves the meta-goals for success in the engineering profession





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A little bit of information about Olin (Needham MA near Babson and Wellesley colleges)



- *Founded in 1997, first graduates in 2006*
- *Total enrollment of about 350*
- *Nearly 50% women*
- *BS degrees in ECE, ME, E*
- *No academic departments*
- *~40 Faculty – renewable contracts*
- *Merit (50% for all) plus need blind aid*
- *100s of visitors and several collaborators*

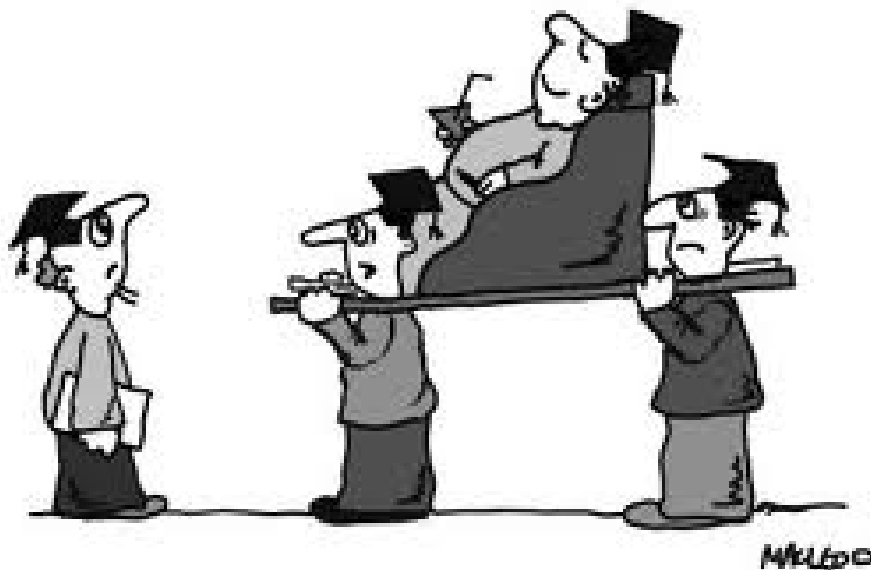


One faculty – one combined mission – one curriculum

Typical response:

No Tenure

No Departments



"He's been pretty much insisting on this ever since he got tenure."

The reality:

No Tenure

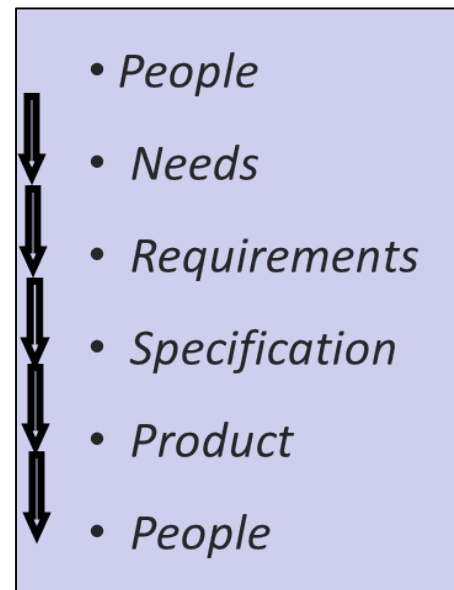
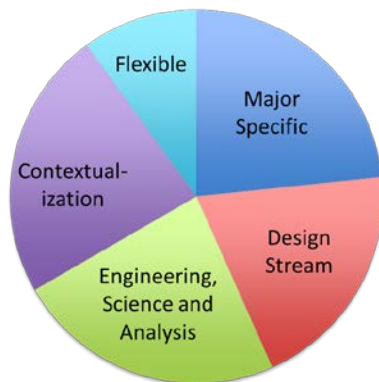
No Departments



Emphasize connectivity and why do we care

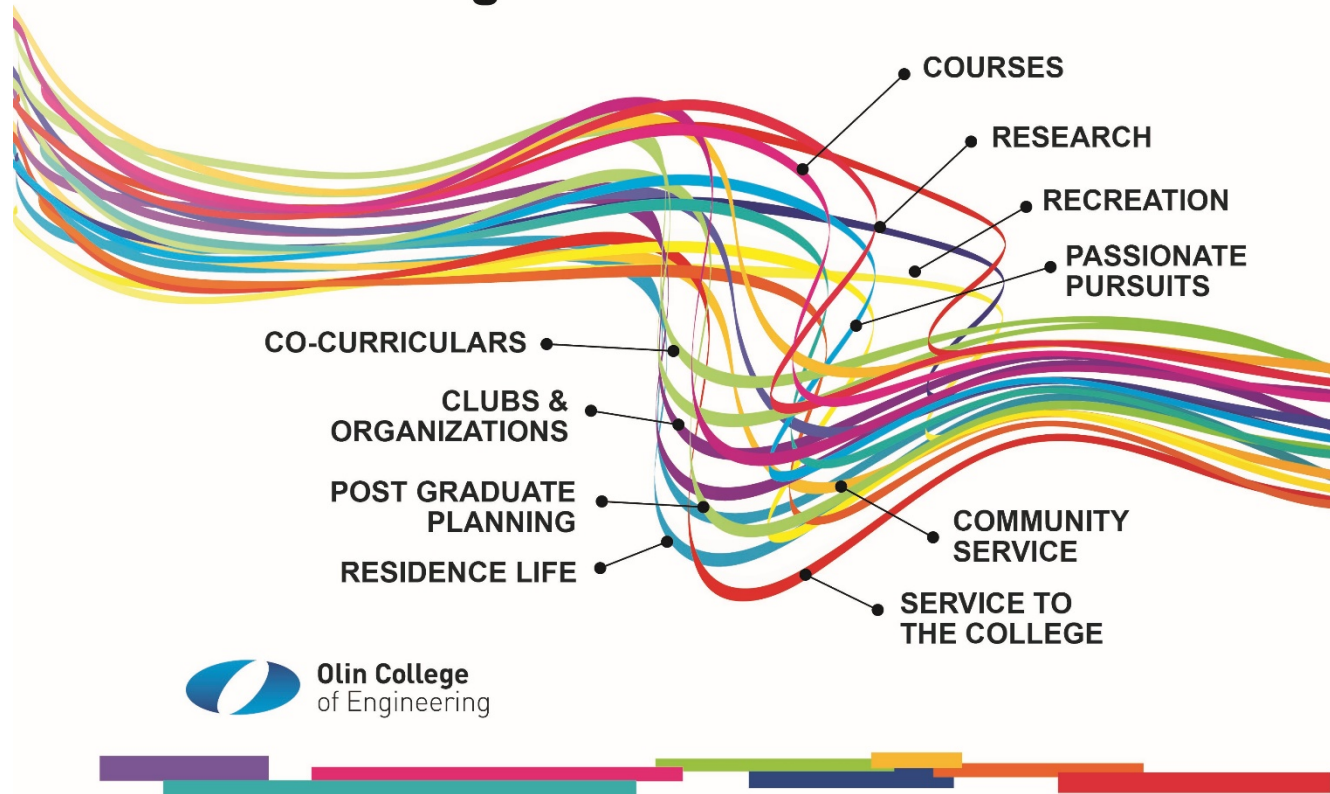
Just in time (not just in case) learning

Nearly 75% of the curriculum is independent of major.
Strong common technical foundation for all students.

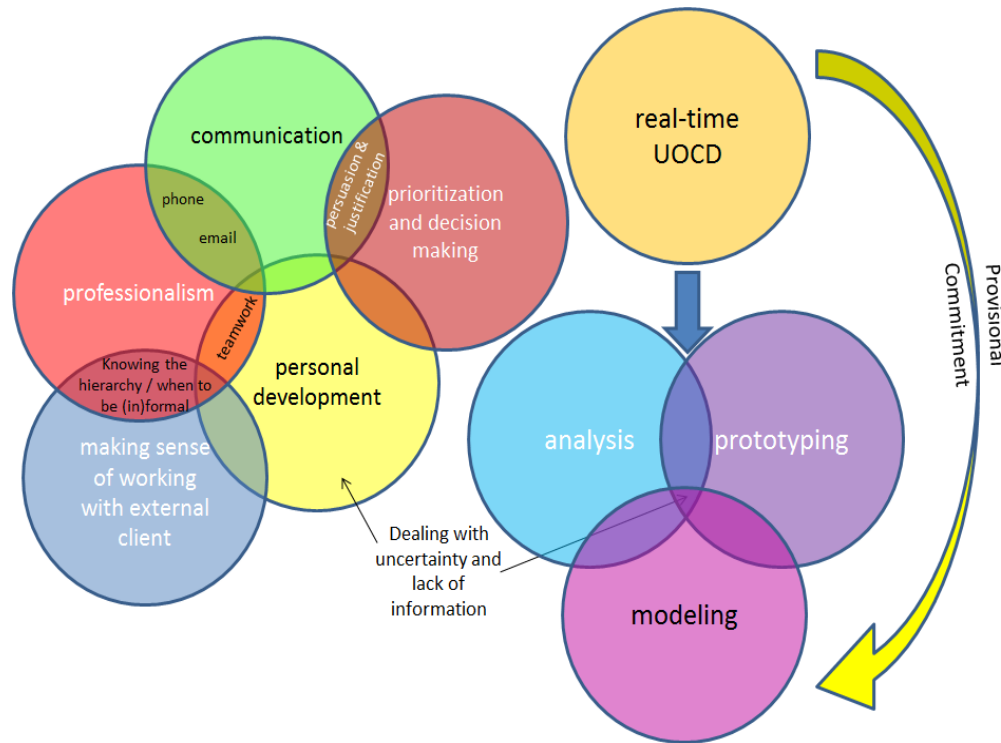


Academic affairs, student life → Academic life

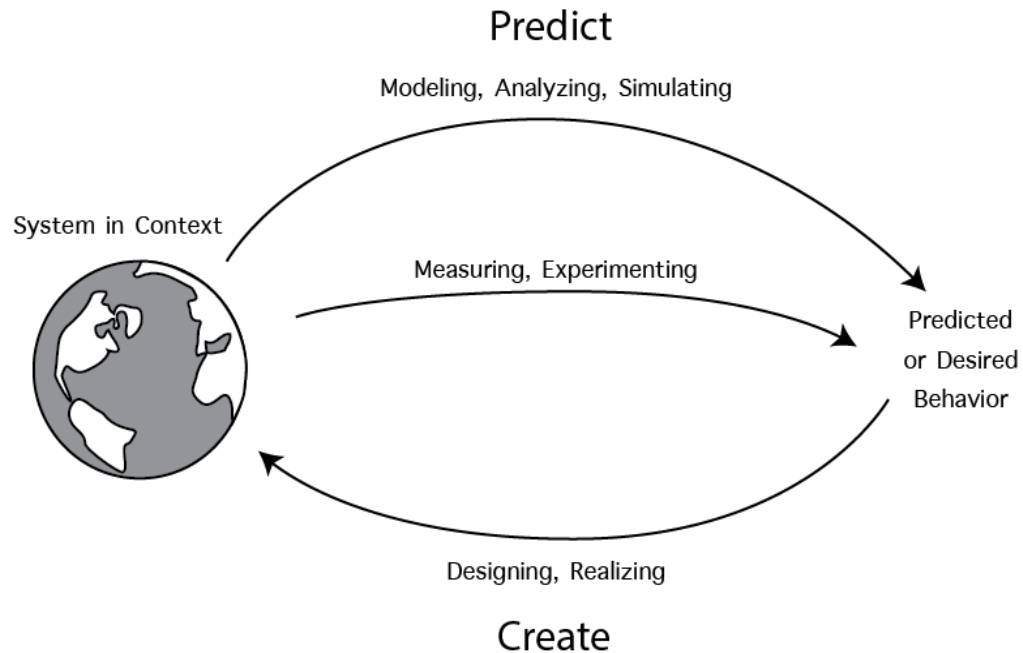
The Learning Continuum



Integrate practice at engineering and 'soft' skills → professional skills



Integrative learning - Competency and confidence to use 'power tools'



Desired Outcome:

Competence and confidence in choosing and using the “power tools”
(tools, concepts, ways of thinking) of **design and analysis.**



Integrative learning – e.g. Quantitative Engineering Analysis (QEA)

- ***Strengthen analysis through synthesizing math, physics and engineering science in a project-based environment***
- ***Alternative to disconnected courses embedded in the first years of engineering programs.***
- ***Two-semester, double-wide (i.e. eight credits each term) course sequence – launched January 2016***
- ***Created by a team of Olin faculty and students***



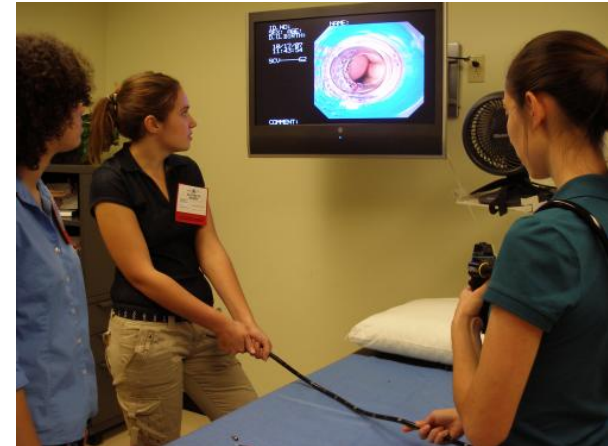
Substantive and 'real' experiences SCOPE or Affordable Design & Entrepreneurship (ADE)

SCOPE

- Sponsored
- Mid-burner project
- Professional mentor
- ~5 students
- No Olin IP claims/NDAs

SCOPE

Senior Capstone
Program in Engineering



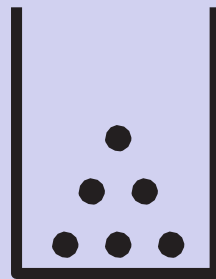
ADE

- Donations
- Non-profit – international
- People, impact, humility, justice
- ~5 students
- No Olin IP claims/NDAs

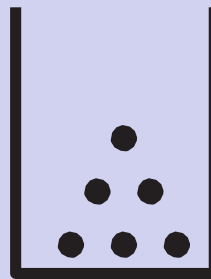


Faculty development and assessment: Internal and external impact – recognition and relevance

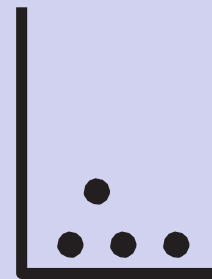
*(Elsewhere) **Tenure** based on demonstrated professional accomplishments in **teaching, research and scholarship, and service** ... will continue to contribute in all of these areas at a level of excellence ... through the **indefinite future**.*



Teaching



Research



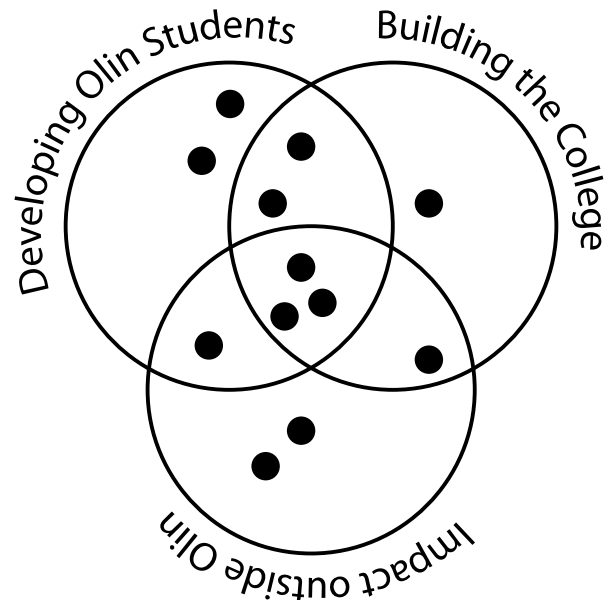
Service

- *Three Buckets – disconnected, size of each bucket?*
- *Individual not institution, separate not integrated, static not dynamic for the indefinite future*
- *No mention of mission - personal and institutional*



A new model – consensus developed by faculty and administration

- *Robust annual feedback, embedded faculty development*
- *Reappointment (looking forward) vs Promotion (retrospective)*
- *19 cases so far → case law and processes evolving*
- *Implications for institutions with tenure systems*

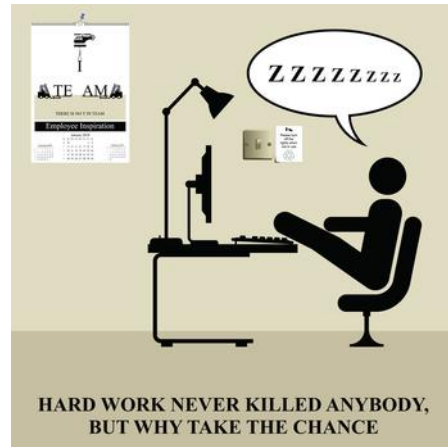
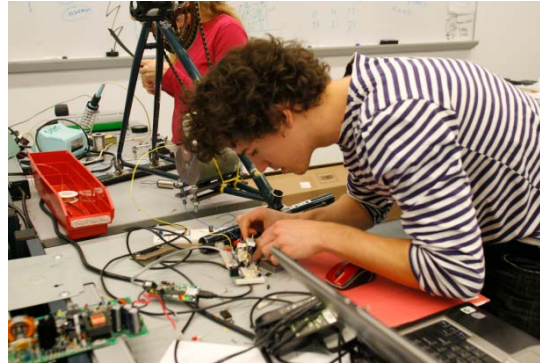


Can engineering education innovation be a lever for rebalancing 21st Century education?

- **YES**
- *Balanced and integrated education with a foundational engineering core is best positioned in the academy to be the driver of such a system.*
- *Important and positive impact on who studies engineering or who includes engineering in their studies - engineering profession, quality of life, society.*
- *What does this mean about educational models? Faculty responsibilities and competencies? Academic culture, reward system, priorities? Industry role? ABET?...*



Take-away 1 - Learning to learn is hard fun



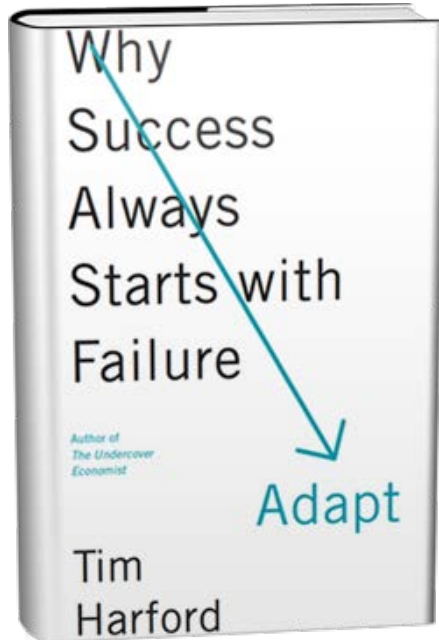
HARD WORK NEVER KILLED ANYBODY,
BUT WHY TAKE THE CHANCE



Take-away 2 – Students should have goals and take responsibility



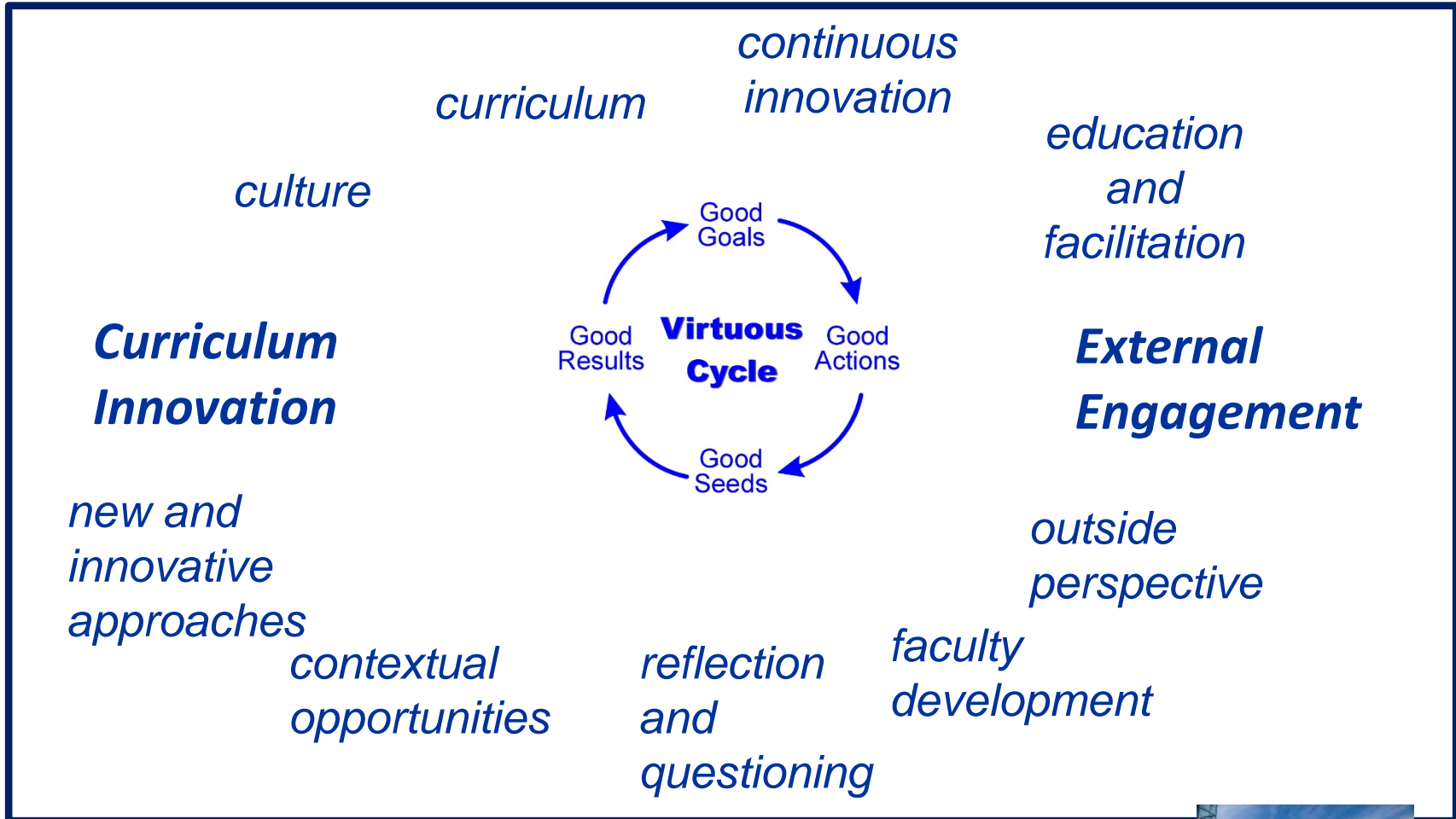
Take-away 3 - Failures will happen: Learn from them, control their size



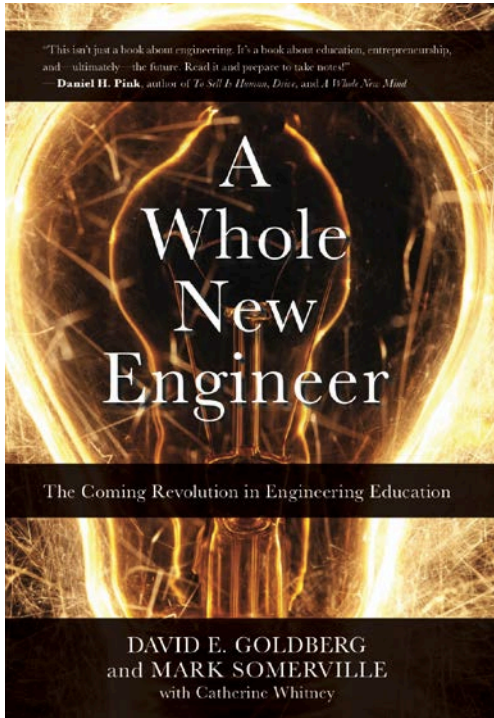
Take-away 4 - Practice being comfortable with discomfort (It's hard!)



We need to collaborate and co-create: Virtuous cycle and feedback loop



The time is now to build the right foundations – e.g. Purdue Polytechnic Summit 2017



*These choices are ours to make –
as educators, as students, as parents, as alumni,
as taxpayers, as schools, as companies, society...
They are the choices between the past and the future.
Goldberg & Somerville, 2014.*



*Thank you for inviting me.
What do you think?*

