From the Ground Up:
A Comprehensive Systems Approach to the Redesign of Engineering Education

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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 achievements will you use today? A
Explore our list of the top 20 achievements that engineering shaped a century and change

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. Nuclear Technologies
12. High-performance Materials

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NAE Grand Challenges for the 21st Century

Sustainability, Health, Security, Joy of Living

The 2010 NAE Grand Challenges National Summit will bring together leading scientists and engineers, educators, policy leaders, innovators and corporate executives to address the 14 challenges articulated by the National Academy of Engineering. The discussions will be organized around the four thematic threads of the challenges, namely sustainability, vulnerability, health and the joy of living, which represent key societal issues of the 21st Century.
The Pale Blue Dot

• NASA, 1990 - Voyager 1

• 3.8 billion miles (41 AU)

• Carl Sagan - address at Cornell University, Oct 13, 1994
Educating Engineers Beyond Technology: The Increasing Need for Non-technical Education for Engineers

- Minimizing Unintended Consequences

- Systems Architects of Complex Systems with Technical, Economic, Political, Social, even Religious Dimensions

- Conceiving, Creating, and Managing the Technologies of the Grand Challenges

- Engineering Innovators Who Make a Positive Difference in the World
Feasibility

Viability

Desirability

All other subjects

Feasibility

Viability

All other subjects

No Uniformly Accepted Standards For Feasibility or Viability
Creativity & Cognition

YOUTUBE:
Sir Ken Robinson
(TED 2006)

- All people have at least 7 “intelligences”
  - Linguistic
  - Logical/mathematical
  - Spatial
  - Bodily-kinesthetic
  - Musical
  - Interpersonal
  - Intrapersonal

**Academic Intelligence (IQ, SAT, etc.)**

**Artistic Intelligence**

**Persuasion, Management**
A New Culture of Learning

Traditional

Knowledge Transfer

“Can’t Do”

Follow Orders

Learn in Class

Learn Alone

Problem-based

New

Construct Knowledge

“Can Do”

Follow Your Passions

Learn 24 x 7

Learn in Teams

Design-based

Pedagogy like Graduate School

“For most of the twentieth century our educational system has been built on the assumption that teaching is necessary for learning to occur.”
What We Teach vs. What They Need to Know

• Engineering alumni report that engineering science is not as useful in their careers as design, communication, teamwork, and entrepreneurial thinking (Kristen Wolfe, “Understanding the Careers of the Alumni of the MIT Mechanical Engineering Engineering Department,” SB Thesis, June, 2004, MIT (supervised by Prof. Warren Seering)).


YouTube: Prof. Woodie Flowers on Education Reform
The Need for Change in Engineering Education

- Thomas L. Friedman, *The World is Flat: A Brief History of the Twenty-first Century*
- Council on Competitiveness, *National Innovation Initiative*
- National Academy of Engineering, *Rising Above the Gathering Storm*
- National Academy of Engineering, *Educating the Engineer of 2020*

- Teamwork, communication, creativity, leadership, entrepreneurial thinking, ethical reasoning, global contextual analysis
What Is An Engineer?

• Applied Scientist

• noun: “a person who carries through an enterprise by skillful or artful contrivance,” (Merriam-Webster Dictionary)

• Designer/Architect of a System, Process, or Device

• Project/Team Leader

• “To Engineer is to Make” (D. Chapman-Walsh)

• “An Engineer is a person who envisions what has never been, and does whatever it takes to make it happen”

“Scotty”
The Process of Engineering Design

There Must be a Better Way! (Analysis)

Why Doesn’t it Work? (Test)

Let’s Try It! (Prototype)

Why Not…? (Idea)

Engineering is a Process, not a Body of Knowledge!
The Process of Scientific Discovery

Wow! Did You See That? (Observation)

Maybe It’s Because… (Hypothesis)

What Can We Conclude? (Analysis)

If so, Then You Should See… (Test)

Science is also a Dynamic Process, not a collection of Static Facts!
F.W. Olin Foundation

• 1997 – Establish “an entirely new paradigm for engineering education”
• No tenure, no departments, no tuition, continuous improvement
• Founding precepts: Olin College is “…to become an important and constant contributor to advancement in engineering education in America and throughout the world…”

• Where do you begin?
  • Leadership, finances, governance, facilities, faculty, staff, students, public image, academic partnerships, academic program, government relations, accreditation, marketing, etc.

• Project management:
Simple Strategies

• Truly student centered, not faculty centered

• “I’ll take the ‘A’ team with a ‘B’ idea over the ‘B’ team with an ‘A’ idea every time” (Desh Deshpande)

• “There is no more powerful force for conservatism, than having something to conserve” (Joe Platt, Harvey Mudd)

• Key reading:
  • Jim Collins and Jerry Porras, Built to Last
  • Tom Kelly, The Art of Innovation
  • Stephen Covey, The 7 Habits of Highly Effective People

• Job One: Core Values
• Undergraduate residential engineering education
• Total enrollment of about 350
• Nearly 50% women
• BS degrees in ECE, ME, Engr only
• 9-to-1 student/faculty ratio
• Founded in 1997, first graduates in 2006
• 75 acres and 400,000+ sq. ft. new buildings
• Endowment > $1 million/student
• Research expenditures ~ $1 million/yr
• Adjacent to Babson College, Wellesley College
• No academic departments
• No tenure
• Low tuition
• Continuous improvement
Olin College Campus
Needham, MA
Blurring Boundaries

FEASIBILITY

VIABILITY

DESIRABILITY

Franklin W. Olin College of Engineering

Babson

Wellesley College
Some Features of the Olin Curriculum

- **Candidates’ Weekend**: interviews required for admission
- **Extensive DESIGN** core required
- Multiple Team design projects required in 6+ semesters
- **SCOPE** senior project: corporate sponsored, year-long ($50k/project)
- **EXPO** at end of each semester: “stand and deliver”
- **Olin Self Study** self-directed independent research required for graduation
- **AHS/E! Capstone** project required for graduation
- Study Away in Junior year
- Summer internships: REU and corporate experience
- Business and entrepreneurship:
  - **all students must start and run a business** for a semester
- Continuous improvement: **expiration date on curriculum every 7 years**

- **BUT, the learning culture** is far more important than the curriculum!
Reflections

Overall, Greatly Exceeded Our Expectations

Positives
• very successful alumni
• intense student engagement
• increased motivation and autonomy
• strong leadership potential
• entrepreneurial “disease”
• very high levels of teamwork
• faculty commitment to lead change in education
• students ability to “stand and deliver,” manage projects, and work with ill-structured problems
• strong engagement with Wellesley and Babson Colleges

Negatives
• concerns about balance: design vs. advanced theory, qualitative vs. quantitative design, etc.
• student interest grows beyond engineering to include leadership, policy, management, etc.
• alumni preference for small start-up companies
• assessment challenges: metrics?
• scalability?
• growing resistance to change(!)
Student Engagement and Learning Outcomes

- Educational research shows that the more students are enthusiastic and personally engaged in their studies, the more they learn, and the more they want to continue learning. (G. Kuh, E. Pascarella, A. Astin, etc.)

- National Survey of Student Engagement (Indiana University)
  - More than 500 universities and 500,000 students in the US
  - Five major areas:
    1. Level of Academic Challenge
    2. Active and Collaborative Learning
    3. Student-Faculty Interaction
    4. Enriching Educational Experiences
    5. Supportive Campus Environment

→ Results for Olin College exceed 90%-ile level in 9 of 10 metrics
First year Student Engagement (NSSE 2009)

Mean Score (in Std Dev from Global Mean)

- Level of Academic Challenge
- Active and Collaborative Learning
- Student-Faculty Interaction
- Enriching Educational Experiences
- Supportive Campus Environment

Legend:
- Olin College
- Engineering
- Liberal Arts
- All Unvs.