The Engineer of 2020: Motivating Curricula Change

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NAE Engineer of 2020 Project - Motivation

- Changes in engineering curriculum are often incremental
- Engineering practice often outpaces curriculum reform
  - E.g. interdisciplinary, team oriented environment
- Major curriculum reform typically motivated by a crisis


"All the News That's Fit to Print"

The New York Times.

LATE CITY EDITION

SOVIET FIRES EARTH SATELLITE INTO SPACE; IT IS CIRCLING THE GLOBE AT 18,000 M. P. H.; SPHERE TRACKED IN 4 CROSSINGS OVER U. S.

HOFFA IS ELECTED TEAMSTERS HEAD; WARNS OF BATTLE

COURSE RECORDED

Navy Picks Up Radio Signals—4 Report

560 MILES HIGH

Visible With Simple Binoculars, Moscow

- Time for **proactive** changes in engineering education

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Engineer of 2020 Project - Approach

- Phase I: Engineering Practice in 2020
  - Goal: Anticipate what the practice of engineering would be like in 2020
  - Phase I report published in Spring 2004

- Phase II: Action agenda to shape the future of engineering education
  - Goal: Recommendations for content, delivery, and structure of engineering education to meet needs of engineers and society in 2020
  - Phase II report published in Fall 2005

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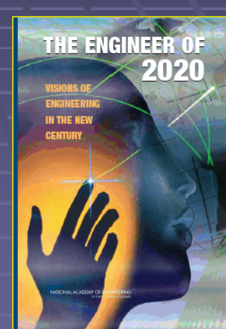
Results of Phase 1

- Context of Engineering Practice in 2020
- Technological Challenges in 2020
- Aspirations for the Engineer of 2020
- Expectations and Attributes of Engineers in 2020



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Context of Engineering Practice

- Population and Demographics
  - By 2015:
    - Majority of people in world will reside in urban centers
    - Mostly in countries that lack economic, social, and physical infrastructures to support burgeoning population
  - By 2020:
    - World population will approach eight billion people - greatest increase in underdeveloped countries
  - By 2050:
    - 50 percent of the world's population will be under 18 years old – most living in developing nations

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Context of Engineering Practice

- World will be intensely interconnected
- Scientific and engineering knowledge will continue to grow rapidly, especially in
    - Bioengineering, biotechnology & biomedical engineering
    - Miniaturization (MEMS, nanotechnology, advanced materials)
    - Information Technology
    - Complex and large-scale systems integration
- Technological problems will be complex and interdisciplinary

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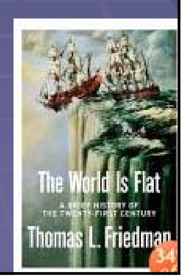
Context of Engineering Practice

- Engineering and public policy will intertwine as technology increasingly becomes engrained into every facet of daily life
  - Engineers need a stronger sense of how technology and public policy interact
  - Public servants need to recognize technological implications of policy decisions


Context of Engineering Practice

- Increasing pace of globalization
  - *The World Is Flat: A Brief History of the Twenty-first Century* by Thomas L. Friedman
    - Globalization 1.0 – **countries** collaborating and competing globally (1492-1800)
      - Driven by Europe
    - Globalization 2.0 – **companies** collaborating and competing globally (1800-2000)
      - Driven by U.S.
    - Globalization 3.0 – **individuals** collaborating and competing globally (2000 -)
      - Driven by China, India, etc.

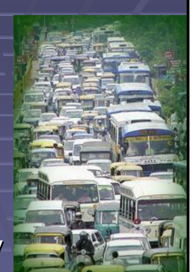


Context of Engineering Practice

- Impact of Globalization
  - Engineering practice varies due to different languages, cultures, customs, laws and legal systems, environmental, regulations and customer preferences
  - Increasing need for engineers with an international perspective, able to conduct business globally and deal with diverse business cultures and governmental regulations
  - Engineering teams will be multi-national, diverse in terms of culture and language and geographically distributed
  - Designs will take account both local and global cultural perspectives (e.g. environmental impact)

Technological Challenges in 2020

- Physical Infrastructure
- Information and Communications Infrastructure
- Environment and Energy
- Health Care Delivery and Aging Population
- Emergency Preparedness & Homeland Security
- Education



Physical Infrastructure

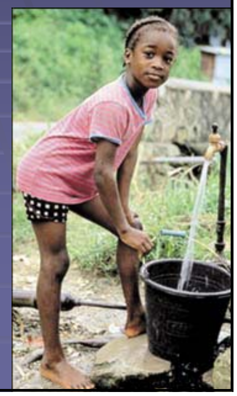
- Urban development principally driven by human services and private sector
- Inadequate focus on environmental impact and sustainability led to:
  - high levels of pollution
  - increased traffic problems
  - poor transportation infrastructure
  - decreasing greenery
- In many countries, including U.S., physical infrastructure (water treatment, waste disposal, transportation, energy facilities) in serious decline

Information and Communications Infrastructure

- World is increasingly dependent on interconnectedness
- Vulnerable to accidental or intentional events:
  - malicious attacks, i.e., computer viruses and denial of service
  - system overloads
  - natural disasters, e.g., hurricanes and earthquakes
- Disruptions can have a profound impact on economy, national security, lifestyle, personal security
- Solutions involve technical, legal, regulatory, economic, business and social considerations, e.g., privacy

Environment and Energy

- More than a billion people today have little access to clean drinking water; two billion live in conditions of water scarcity
  - Water tables falling in China, India and U.S.
  - Forty-eight countries containing a total of 2.8 billion people could face freshwater shortages by 2025
- Global per capita forest area projected to fall to 1/3 of its 1990 value by 2020
- In 2020 California will need 40 percent more electrical capacity, 40 percent more gasoline, and 20 percent more natural gas energy than needed in 2000



www.childinfo.org/ eddb/water/

Health Care Delivery

- Population growth and increased life expectancies will stress health care system
- Engineering applications (e.g., queuing methods, electronic medical records, computerized physician order-entry systems, six sigma approaches) have proven to improve health care delivery but not yet widely deployed
- Need technologies and tools that
  - overcome barriers to delivery of high-quality care
  - can be used to redesign care processes at various levels of the delivery system

Emergency Preparedness

- Need to anticipate and prepare for potential catastrophes (e.g., biological terror; water and food contamination; infrastructure damage to roads, bridges, buildings, and the electrical grid; and communications breakdown in the Internet, telephony, radio, and TV)

Expectations of the Engineer of 2020

- Undertakes "engineering" with consideration of societal repercussions and constraints
- Contends with changes in the nature and scale of the engineering workforce
  - Work in diverse teams of engineers and non-engineers to formulate solutions to yet unknown problems
- Addresses large-scale systems problems
  - Solve evermore difficult problems by forming revolutionary technologies or by applying existing solutions in unique ways

Attributes of the Engineer of 2020

- Strong analytical skills
- Practical ingenuity
- Creative
- High ethical standards and a strong sense of professionalism
- Dynamic/agile/resilient/flexible
- Good communication skills
- Business and management skills
- Leadership abilities
- Lifelong learner

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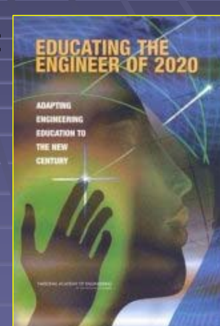
Phase II: Implications for Engineering Education

- Engineering education is a complex system involving a number of components:
  - Engineering practice
  - K-12 feeder system
  - Curriculum
  - Global economics
  - Public perception of engineering
  - Accreditation and Licensure
- Successful reform cannot focus on a single element



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Phase II: Implications for Engineering Education

- Engineering, including design, should be taught early
- Curricula flexibility should be enhanced
  - Move away from the “boot camp” approach
  - Minimize required core
  - Maximize elective (non technical) courses
- Knowledge will continue to grow rapidly
  - Half-life of engineering knowledge diminishing
  - Students must learn how to learn and to embrace lifelong learning
- Engineering “fundamentals” are changing, e.g. Biology

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Phase II: Implications for Engineering Education

- Students learning styles vary
  - Delivery styles should reflect different learning styles
  - Faculty training increasingly important
- Engineering curricula must better align with the challenges graduates will face in the workplace
- A BS degree may no longer be enough
  - MS as first professional degree
  - U.S. engineering schools must develop programs to encourage/reward domestic engineering students to persist through the MS and/or Ph.D. degree.

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Accreditation Considerations

From ABET's "Sustaining the Change" – 2004

- "…while the new, outcomes-based criteria finally provide the opportunity for innovation and program individuality, they also appear to leave much interpretation open to program evaluators and faculty, many of whom … have varying levels of sophistication and training in outcomes assessment."
- "There is serious concern … that inconsistencies exist between and among program evaluators, particularly regarding their evaluation of the objectives and outcomes components of the ABET accreditation criteria."

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Accreditation Considerations

- Design to support educational innovation
- Entice best faculty to engage in evaluation process
- Educate evaluators
  - Training for outcomes assessment
  - Encourage taking a broad view
  - Discourage bean counting
- Consider "peer to peer" evaluators

Addressing Globalization in Engineering Education

- Through increased exposure
  - Study abroad programs
  - Academic exchanges (faculty and student)
  - Internships abroad in multinational companies
- Through curriculum
- Through university partnerships
  - Cooperative degree programs
  - Joint research programs

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University of Michigan - Shanghai Jiao Tong University Partnership


Thank You!
谢谢!
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