Engineering and the Liberal Arts

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Keller Center for Innovation in Engineering Education

• Address issues in Engineering Education that are beyond the scope or resources of any one of our departments.

Issues than cross the boundary between the school and the rest of campus.
Liberal Arts Education

College or university curriculum aimed at imparting general knowledge and developing general intellectual capacities in contrast to a professional, vocational, or technical curriculum. In the medieval European university the seven liberal arts were grammar, rhetoric, and logic (the trivium) and geometry, arithmetic, music, and astronomy (the quadrivium). In modern colleges and universities the liberal arts include the study of literature, languages, philosophy, history, mathematics, and science as the basis of a general, or liberal, education. Sometimes the liberal-arts curriculum is described as comprehending study of three main branches of knowledge: the humanities (literature, language, philosophy, the fine arts, and history), the physical and biological sciences and mathematics, and the social sciences.

Source: Encyclopedia Britannica
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Source: Encyclopedia Britannica
Undergraduate Degrees at Princeton

- Bachelor of Arts
  - ~80% of the class
  - Humanities, Social Sciences, Sciences and Math
- Bachelor of Science in Engineering
  - ~20% of the class
Liberal Arts Education

... the education you have received at Princeton -- an education that we rightfully claim does not prepare you for one job but for many jobs -- puts you in remarkably good stead in an uncertain time. The skills and traits that we strived to instill in you -- critical thinking and writing, a finely tuned moral compass, a disciplined work ethic, a commitment to excellence in whatever you choose to do, compassion for those less privileged and a devotion to service -- will serve you well whatever comes next.

President Shirley Tilghman, Commencement speech, June 2, 2009.
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What this means for BSE Students

• A stronger understanding of engineering in the world through
  – Significant flexibility in the curriculum
  – Significant breadth requirements
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A coherent program of courses in the humanities and social sciences, combining breadth and depth, is an essential part of every B.S.E. student’s program of study. B.S.E. students must complete a minimum of seven courses in the humanities and social sciences. B.S.E. students are required to take one course in four of the following six areas: epistemology and cognition, ethical thought and moral values, foreign language (at the 107/108 level or above), historical analysis, literature and the arts, and social analysis (see pages 56–60) for full descriptions of these distribution areas). The remaining three required courses and additional courses may be taken in any fields in the social sciences and humanities.

Source: Undergraduate Announcement
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Source: Undergraduate Announcement

10-12 courses is typical!
What this means for BSE students

- Don’t necessarily think of themselves as professional engineers

- A greater range of analysis and synthesis capabilities
  - Enables them to see a better interaction of engineering and society
  - Enables them to be problem/issue framers and not just problem solvers

<table>
<thead>
<tr>
<th>Post-Graduation Option</th>
<th>% of Class of 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering/Sciences Grad School</td>
<td>17.5</td>
</tr>
<tr>
<td>Other Grad School</td>
<td>2.4</td>
</tr>
<tr>
<td>Job in Engineering</td>
<td>23.2</td>
</tr>
<tr>
<td>Job in Finance/ Management Consulting</td>
<td>26</td>
</tr>
<tr>
<td>Unknown/undecided</td>
<td>22</td>
</tr>
</tbody>
</table>
Taking this further...

• A tighter integration
  – Societal context in engineering courses
    • Critical to tackle emerging societal challenges in energy and the environment, security, global health and poverty
      – Make problems less abstract, solution envelopes clearer
      – Better engage and motivate students
  • Complex knowledge organization
    – Challenging for texts and faculty

COS 432 Information Security
Security issues in computing, communications and electronic commerce. Goals and vulnerabilities; legal and ethical issues; basic cryptology; private and authenticated communication; electronic commerce; software security; viruses and other malicious code....

E. Felten

Princeton University
Taking this further...

Greentrofit Team

- Project Based Courses
- Engineering Projects in Community Service
  - Originated at Purdue
  - Jamieson and Coyle
- Teams work on technology problems with local non-profits
- Multidisciplinary – engineering and non-engineering students
- Vertically integrated – mix of sophomores through seniors

- Partner: Isles community development and environmental organization
- Project: HEAT (Home Energy Action in Trenton); to address needs of energy efficiency in low-income houses in Trenton, NJ
- Technical learning: study extent of energy efficiency and effectiveness of various retrofitting strategies

Challenges in scaling.
Taking this further...

- Gaps in a traditional liberal arts curriculum
  - Entrepreneurship
    - Critical way for engineers to make an impact in society
    - Challenging without a business school
What this means for AB students

• Technology deeply enmeshed in all aspects of society
  – A liberal arts education emphasizing general knowledge and general intellectual capabilities must have a strong technology component

• Yet - asymmetry in requirements
  Technology related requirements
  – Quantitative Reasoning (QR)—one course
  – Science and Technology, with laboratory (ST)—two courses
  Easy to fulfill these using science/math courses familiar to the students
What this means for AB students

• About 40% of the students do not take an engineering course
• <10% take more than 2 courses

Number of AB Students vs. Number of Engineering Courses Taken
Barriers to doing more...

- Everyone needs to step out of their comfort zones
  - Engineering courses
    - Need to make them more accessible
      - Emphasize fundamental principles, rather than detailed analysis and synthesis needed for students in the majors
      - Show how this discipline interacts with societal issues

ELE 206 Introduction to Logic Design

- Boolean algebra and digital logic gates
- Combinational and multi-level combinational logic
- Basic memory elements, latches, flip-flops, SRAM and DRAM cells
- Timing methodologies
- Synchronous and asynchronous designs
- Counters
- Finite-state machines
- Designs with programmable logic
- Basic computer organization
- Three lectures, one laboratory

Prerequisite: an introductory programming course, or equivalent programming experience.
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      - Show how the technical material impacts societal issues

ELE 222B The Computing Age

The past several decades have seen an exponential growth in computing as reflected in modern computers as well as consumer products such as music/video players and cell phones. This course will explore the reasons for this growth through studying the core principles of computing. It will cover representation of information including video and music, the design of computers and consumer devices, and their efficient implementation using computer chips. Finally, it will examine the technological factors that will likely limit future growth and discuss the societal impact of this outcome.
Broad Access Engineering Courses

• Other Examples
  – Energy Solutions for the Next Century
  – Introduction to Biomedical Innovation and Global Health

• Challenges
  – Knowledge organization
  – Texts, teaching geared towards building deep expertise, not general knowledge and intellectual growth!
Barriers to doing more...

- Everyone needs to step out of their comfort zones
  - Students
    - Very risk averse
  - The rest of the academy
    - Advisors are from non-engineering majors
      - Do not necessarily see the value of the technology component
    - Need strong institutional commitment

Requires a change in culture!
Summary

• Engineering Students benefit in a liberal arts setting
  – Increases their breadth of analysis and synthesis
  – But we need to do more
    • Increase societal context in engineering courses that reflect emerging societal challenges

• Technology component a critical part of any liberal arts education
  – But we aren’t there yet
  – Several changes needed in many parts of the university
    • Engineering education
    • Cultural change with AB students and faculty