Future of Engineering Education in a World Based on Design and Systems

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CSD&M Asia
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Basic Proposition:
All engineers should know something about systems and design and many engineers should know a lot
Why
What
Who*
How Much

*Undergrads, Masters, Phd, Continuing Ed
US National Academy of Engineering’s Greatest Achievements of the 20th Century
NAE Greatest Engineering Achievements of the 20th Century

1. Electrification
2. Automobile
3. Airplane
4. Water Supply & Distribution
5. Electronics
6. Radio and Television
7. Agricultural Mechanization
8. Computers
9. Telephone
10. Air Conditioning & Refrigeration
11. Highways
12. Spacecraft
13. Internet
14. Imaging
15. Household Appliances
16. Health Technologies
17. Petroleum & Petrochemical Technologies
18. Laser and Fiber Optics
19. Nuclear Technologies
20. High-performance Materials
Observations

• Many achievements are complex systems or create complex systems

• Almost all embedded in complex systems

• All result from product designs (none processes)

• Any identified with, or product of, education and research in engineering systems?
Today’s Major Societal Challenges (All Systems)

- Energy
- Environment
- Health
- Food
- Water
- Security
- Transportation
- Liveability
Undergraduate Education
SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
Established in collaboration with MIT
Singapore University of Technology and Design Mission

Through integrated multi-disciplinary curriculum and research, and a focus on Design, advance knowledge and nurture technology-grounded leaders and innovators who will create a better world.
**SUTD – An Overview**

<table>
<thead>
<tr>
<th>Global &amp; Relevant</th>
<th>University with technology &amp; Big-D design focus</th>
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<tbody>
<tr>
<td>Strong global partnerships</td>
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<tr>
<td>Outside-in Approach in research and education</td>
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<tr>
<th>Multi-disciplinary Culture</th>
<th>Broad footprint across Art &amp; Science of Design - Scholarship, Practice, Entrepreneurship</th>
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<tbody>
<tr>
<td>Unique interdisciplinary, no walls, cross boundaries structure</td>
<td>Research-intensive</td>
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| Unique Student Experience                                                      | Pedagogy, cohort-based, peer-support, Fifth Row                                          |
|--------------------------------------------------------------------------------| Diverse and inclusive student body (e.g. international students, high female ratios, etc) |
|                                                                                  | Engaging the world through research, industrial internships and entrepreneurship          |
Degree Structure
Outside-in approach

Grounding on Technology and Design
### An Outside-In Curriculum

<table>
<thead>
<tr>
<th>Senior</th>
<th>Capstone: Integrated Design Experience</th>
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<tbody>
<tr>
<td>Entrepreneurship, Management, Social Science, Economics, Humanities, Arts</td>
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<tr>
<th>Junior</th>
<th>Architecture Core</th>
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<tr>
<td>Energy &amp; Structures</td>
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<tr>
<td>Product Design Core</td>
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<td>Dynamics &amp; Control</td>
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<tr>
<td>System Design Core</td>
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<tr>
<td>Linear Signals &amp; Systems</td>
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<tr>
<td>Info Design Core</td>
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<th>Sophomore</th>
<th>Statistical Reasoning and Optimization</th>
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<td>Digital World</td>
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<tr>
<td>Physical World</td>
<td></td>
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<tr>
<td>Systems World</td>
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<tr>
<th>Freshmore</th>
<th>FOUNDATIONS</th>
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<td>Mathematics, Science, Introductory Humanities, Social Sciences in the context of Design</td>
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- Four 12-unit subjects per semester (x 8 semesters) 22% humanities courses

- Design projects
- Electives
Intro to Design 3.007
Idea Generation – Idea Development

Brainstorming
Mind-mapping
C-Sketch
S.C.A.M.P.E.R
Bio-inspiration
Sketching
Abstraction
Design Development – Design Specification

- Solid Modeling
- 3D Printing
- Laser Cutting
- Wood Work
- Metal Work
- Arduino Programming
- Electronics Fabrication
Pedagogy

- Cohort-based learning communities
- Project-based and hands-on learning throughout the curriculum
- Learning objectives and measurable outcomes for ALL courses
- Lecturelettes and videos
- OpenCourseWare
- Khan Academy type material and learning
- UROP, UPOP, UTOP
Active and Collaborative Learning

- Student-faculty ratio of 11:1
- Integrating lectures, recitations and laboratory sessions (Learn, Engage and Apply)
- Nurturing faculty, group learning & peer support
- Ready access to fabrication equipment
ESD Curriculum

**Fundamentals**
- Mathematics
- Physical sciences
- Biological Sciences
- Design
- Humanities

**Analytics**
- Optimization
- Probability & Statistics
- Simulation
- Network Science
- System Dynamics

**Economics, Management & the Social Context**
- Economics
- Financial Decision Making
- Operations Management
- Quality and Reliability
- Organizations & People
- Project Management
Course Sequence

1. Advanced Math I
   - Physics I
   - Chemistry
   - World Civilisations and Texts
2. Advanced Math II
   - Physics II
   - Introduction to Design
   - World Civilisations and Texts II
3. Modeling the Systems World
   - Engineering the Physical World
   - The Digital World
   - Biology
4. Internship
   - Engineering Systems Design
   - Probability
   - Optimization
   - Microeconomics
5. Operations Management
   - Statistics
   - Stochastic Modeling
   - Network Modeling
   - HASS
6. Internship
   - Decisions Analysis
   - Quality & Reliability
   - Simulation
   - System Dynamics
   - Elective
   - HASS
7. Capstone
   - Elective
   - Elective
   - Elective
   - HASS
8. HASS
Focus Tracks

**Business Analytics**
- Exploration of data to gain insights for business strategy and decision-making

**Economics & Operations Research**
- Use of operations research and economic theory to model and solve complex problems in economics and businesses

**Energy & Environment**
- Operations of energy/ environmental systems & sustainability of our natural and built environment

**Financial Services**
- Financial management, decision-making, trading, risk analysis and portfolio selection

**Healthcare**
- Health care delivery, hospital management, healthcare economics and public policy

**Supply Chain & Logistics**
- Design, planning and operations of supply chains

**Telecommunication**
- Design of wireless and wired systems that are cost effective, scalable, intelligent through optimum resource allocation
Masters, PhD, and Continuing Education
New Masters and PhD Programs
At MIT (as examples)

- **Masters**
  - Business Analytics (Operations Research Center)
  - Integrated Design and Management
    - Part of Systems Design and Management Program
- **PhD**
  - Doctoral program in Social and Engineering Systems
  - Long standing program in Operations Research
Continuing Education

MIT Example (Feb 18, 2016)

MIT News

MIT, Boeing, NASA, and edX to launch online architecture and systems engineering program

Four-course program will train professionals in latest practices on models and methods to manage complex systems
Opportunities & Challenges

- **Opportunities**
  - Importance: plenty of critical issues
  - Breadth: touches almost everything
  - Awareness: increasing recognition of importance
    - Design and systems everywhere, not only engineering

- **Challenges (for systems)**
  - Public and potential students lack awareness and understanding
  - Viewed as “soft” by many engineering faculty
  - Complexity and lack of closed form solutions
  - Often, no physical artifact
Your big opportunity might be right where you are now.

— Napoleon Hill