# Shaping an Ideal Mechanical Engineer's Education

## *Implementing A New Curriculum*

Implementing the 5XME Workshop Recommendations

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# Engineering

Engineering bridges basic sciences and humans & society.

Modern engineering practices require a substantial understanding of technical and human-related issues.

# An Ideal Mechanical Engineer's Attributes

- Excited about what she does
- Able to understand the surrounding issues and the context to formulate (big) problems
- Competent enough to solve it and know the implications of the solution

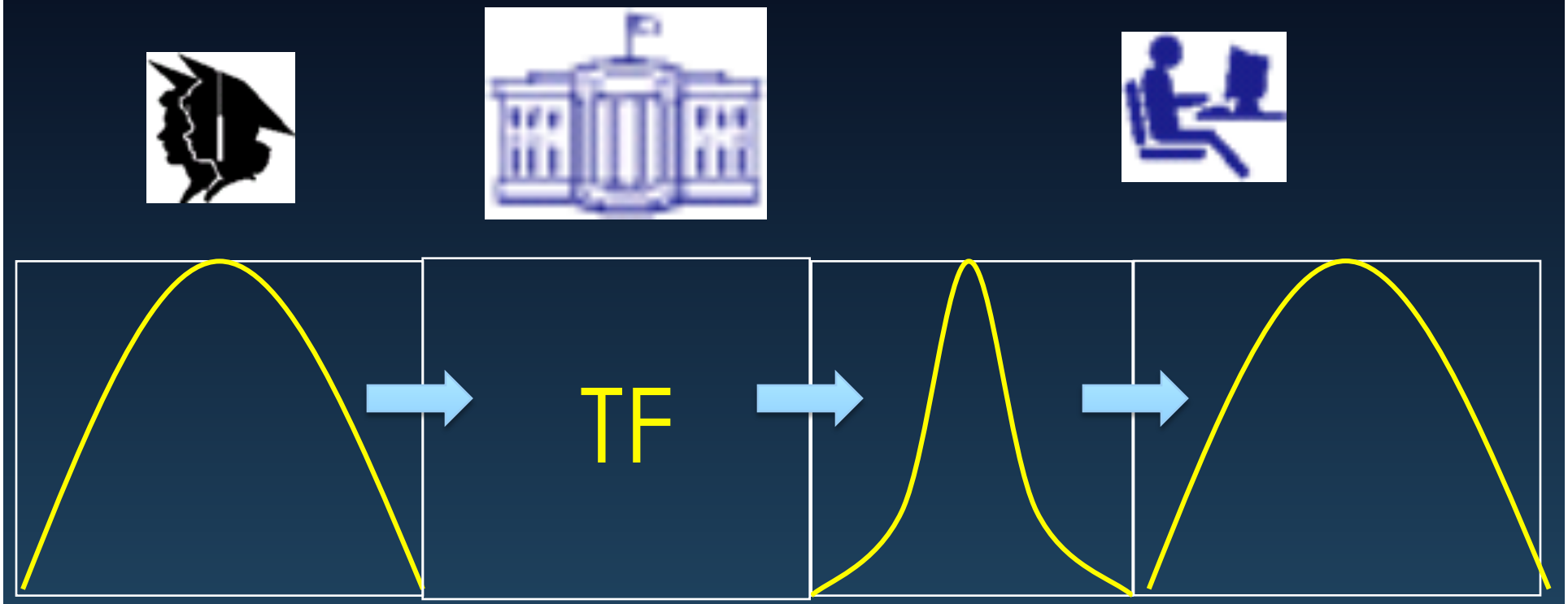
How does a university prepare
a modern engineer ?

# A FEW FACTS

- Students are not all the same
- Engineers are not all the same
- Universities are not all the same

- Learning has multiple dimensions
- People observe and learn differently

# Transfer Function




External **Forces**

# External Influences

- External forces
  - Technology
  - Economy
  - Business policies
  - Political climate
    - Berlin wall
  - Global
  - Many others,,,,,

# External Influences
## *An Engineer's* World is Connected

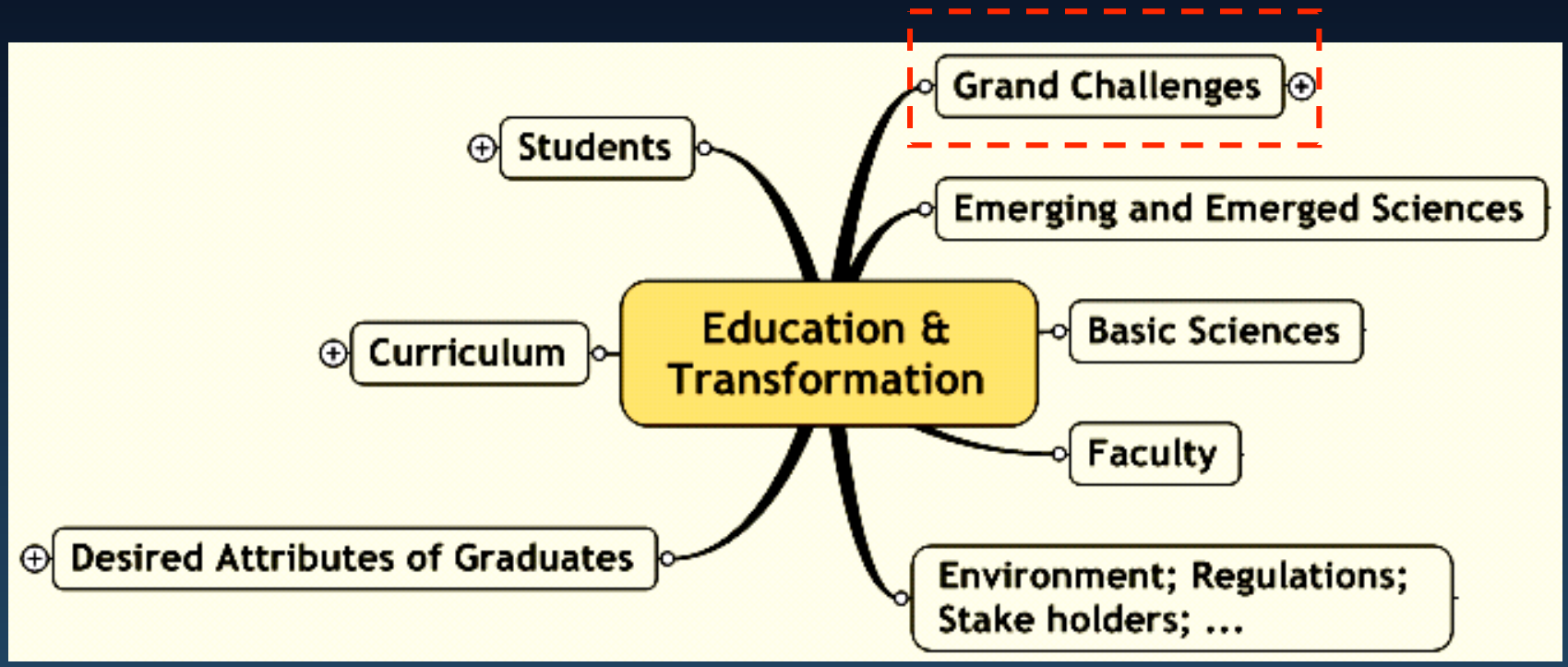
- Connections across the Globe
- Connections with Sciences & Technologies
- Connections with Individual and Societal Needs

# What are the Tools at Hand? (What can we shape?)

- Student
- Environment (Most impt for innovation)
  - Infrastructure
  - Faculty attitude
  - Other students
  - Hidden curriculum
- Learning/Teaching Programs
  - Curriculum, teaching & learning opportunities, technologies
- Faculty

TF

# A Good University Educates, A Great University Transforms




Underutilized resource: Students and their talents

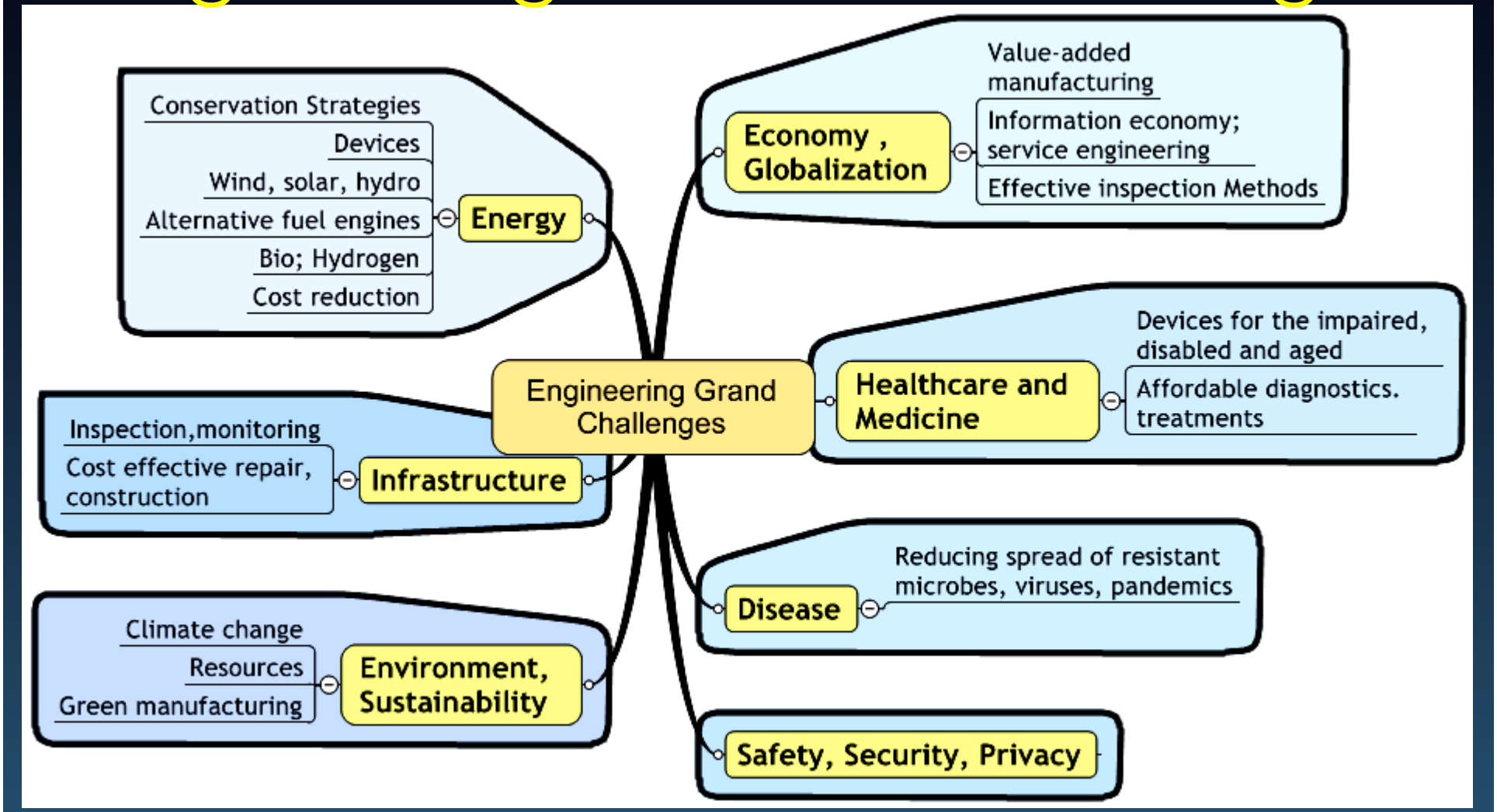
# Humanity's Top Ten Problems for next 50 years

1. Energy
2. Water
3. Food
4. Environment
5. Poverty
6. Terrorism & War
7. Disease
8. Education
9. Democracy
10. Population

## Grand Challenges

Richard Smalley, Nobel laureate

# Engineering & Grand Challenges




*Mechanical Engineering can contribute to each.*

*There is a need for a new kind of engineer.*

# Mechanical Engineering
## Traditional View

- Distinct from other engineering disciplines
- Energy conversion
- Power transmission
- Manufacturing
- Characterized by "engineering" length and time scales
- A certain subset of laws of science is emphasized (viz., 2nd Law of Thermodynamics)
- Design space – limited to traditional disciplines

# Mechanical Engineering Re-Defined

- Broadened basis of mechanical engineering
- Coverage of an increased number of scientific laws and principles

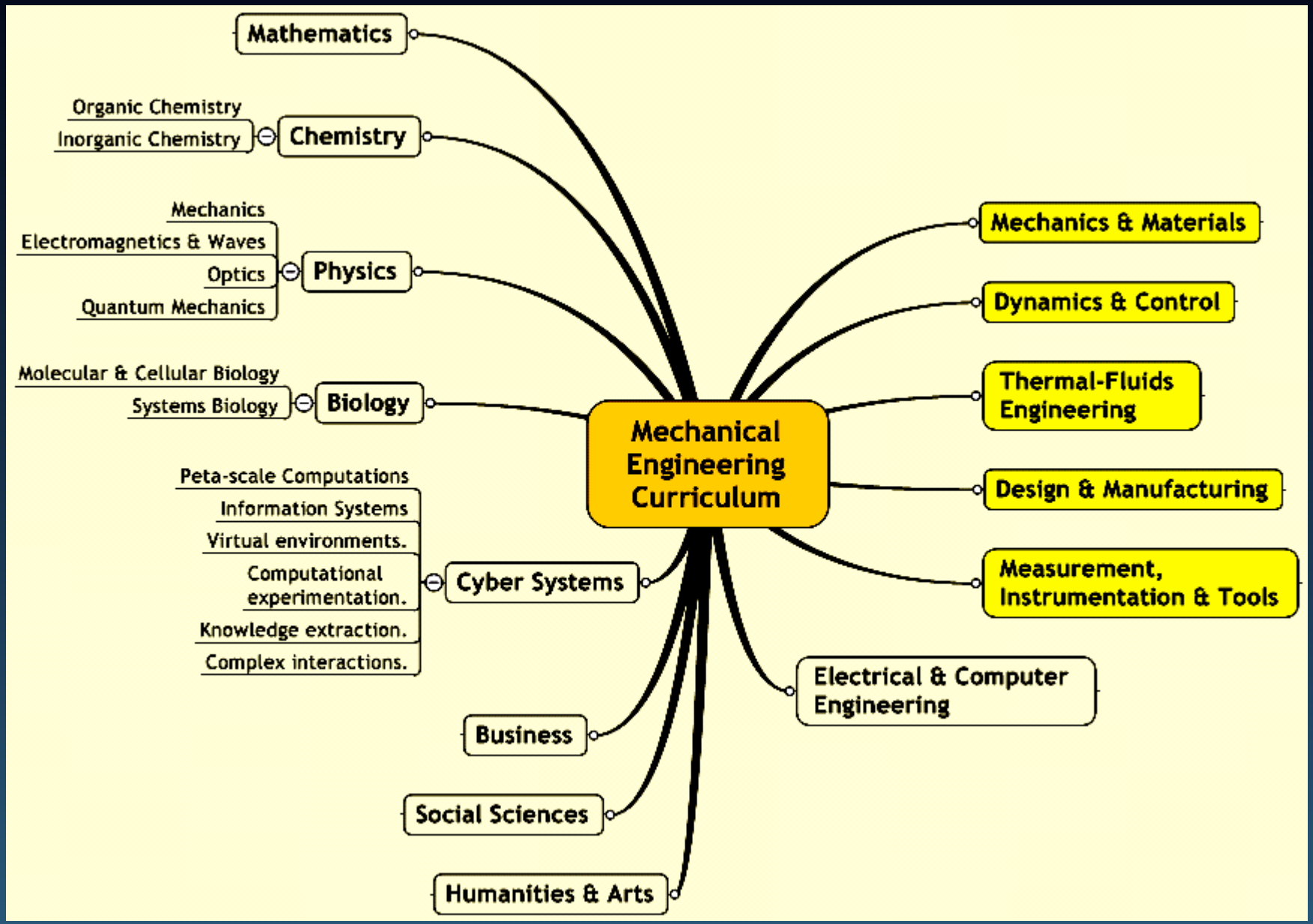
- Increased and deeper overlap with sciences
- Biology is an integral part of research and education

- Larger range of length and time scales

- Extension of traditional topics to new areas
  - Soft materials (viz., tissues)

- Design space – broader

# Mechanical Engineering



# High Expectations

- Too many subjects
- Information overload
- Advances in technologies and sciences at an exponential rate
- Design space has become boundless

Is it reasonable to expect the new engineer to meet all these expectations?

# Students
## *Diverse Individuals*

- Multiple Intelligences *
  - Musical intelligence
  - Bodily-Kinesthetic intelligence
  - Logical-Mathematical intelligence
  - Linguistic intelligence
  - Spatial intelligence
  - Interpersonal intelligence
  - Intra-personal intelligence
  - Naturalist intelligence
  - Existential intelligence
- Customized (individualized) education
- Flexibility in the curriculum

* H. Gardner

# Learning, Memory, and Individuality
## How Brain Processes Information

Acquired information remains in the short-term memory for a period; during transition to long-term memory its context may be stripped.

What are the implications for teaching/learning?

# Specialization vs. Breadth

- A contentious issue
  - Particularly for PhD education
- Tradition dictates that it is better to go into depth in an area of specialty
- Why not both?

## Depth and Breadth

Why should an engineer need to study and learn about arts, sciences and humanities?

# Cognitive Complexity

Capacity to observe, understand and see relationships among disparate fields of knowledge, referred as cognitive complexity, greatly increases the potential for making a major discovery. Major discoveries were made by scientists who were not highly specialized but "by those who internalized considerable scientific diversity."

Those scientists with high cognitive complexity tend to have different styles of research than those who did not have a high cognitive complexity, perhaps in part because those with high cognitive complexity understand a problem they study in multiple ways.

Cognitive complexity develops not so much through education but through a social and psychological process. Indeed, two such processes are observed by Hollingsworth are internalization of multiple cultures and having non-scientific avocations. This argues for consideration of new criteria in the selection of PhD students for research.

# Summary Engineering

- Undergraduate Engineering Education
  - Needs a Renaissance; more flexibility; new topics; embrace important problems; differences in learning
- Connected World Requires
  - Networks & Collaborations
  - National & International partnerships
  - Connections with other disciplines
  - Research and education inspired by social and human needs

# Summary
# Mechanical Engineering

- New directions in ME suggest a broadening of its traditional basis
  - Biology, nanotechnology, cyber technologies
- New directions require
  - Realignment with physics and chemistry (Atomic-scale engineering)
  - Inclusion of biology, life sciences
- Emphasis on simulations & their development
  - Computational thinking
- Sensing and control
- Human – machine & device – tissue interface
  - Biological systems
  - Cognitive sciences

*Faculty expertise from multiple disciplines and students with broad interests*

# Bilkent

Mechanical Engineering
Department

# Bilkent University

## (Bilim Kenti – City of Science & Learning)

- Ankara, Turkey
- The first private university in Turkey, est 1984
- Covers 1200 acres
- 12,000 Students (25% on Scholarship)
- 9 Schools 38 UG 27 G Programs; 2000 courses/yr
- 1000 Faculty; 1/3 from 40 countries
- BSO 100 musicians from 12 countries; performs 70 concerts each year
- Library open 365 days; 24 hrs; 400,000 books; 3000 periodicals; open to all
- Exchange programs with ~100 universities
- K-12, IB

# The ME Plan

- Expected demographics at steady-state
  - 15-16 Faculty
  - 80 UG Students/year
  - 80 – 100 MS, PhD
- Connections and collaborations
  - Nationally & internationally
- Research Centers of Excellence

# Curriculum Highlights

- Design & Manufacturing concepts years 1-4
- ME Fundamentals
- Systems Engineering
- Required:
  - Molecular Biology
  - Solid State Chemistry
  - Probability & Statistics
  - Physics – Quantum Mechanics
- Theory of Communication
- Integration of Topics, e.g. Thermo-Fluids
- 9 Electives – 4 ME, 2 ENG, 1 SCI, 2 HUM
- Required Summer Practice 2 Summers
- 137 credits

# MECHANICAL ENGINEERING

| | |
|---|---|
| Physics I & II<br>CS I & II<br>English I & II | Fundamentals of ME<br>Systems Engineering<br>Calculus I & II |
| Cultures, Civilizations & Ideas I & II<br>Turkish I & II<br>History of TR I & II | Linear Algebra<br>Differential Equations<br>Thermal Fluid Eng I & II<br>Mechanics & Materials I & II |
| Molecular Biology<br>Solid State Chemistry<br>Science, Technology and Society<br>Humanities & SS Elective<br>Theory of Communication | Probability & Statistics<br>Dynamics & Controls I & II<br>Electromechanical Systems<br>Measurement & Instrumentation<br>Design and Manufacturing<br>ME Elective |
| Humanities & SS Elective<br>Engineering Electives (2)<br>Science Elective | Design I & II<br>ME Electives (3)<br>Elective |

# MATHEMATICS

| | |
|---|---|
| Physics I & II<br>CS I & II<br>English I & II | Fundamentals of ME<br>Systems Engineering<br>Calculus I & II |
| Cultures, Civilizations & Ideas I & II<br>Turkish I & II<br>History of TR I & II | Linear Algebra<br>Differential Equations<br>Thermal Fluid Eng I & II<br>Mechanics & Materials I & II |
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| Humanities & SS Elective<br>Engineering Electives (2)<br>Science Elective | Design I & II<br>ME Electives (3)<br>Elective |

# SCIENCE

| | |
|---|---|
| Physics I & II<br>CS I & II<br>English I & II | Fundamentals of ME<br>Systems Engineering<br>Calculus I & II |
| Cultures, Civilizations & Ideas I & II<br>Turkish I & II<br>History of TR I & II | Linear Algebra<br>Differential Equations<br>Thermal Fluid Eng I & II<br>Mechanics & Materials I & II |
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# HUMANITIES & COMMUNICATION

| | |
|---|---|
| Physics I & II<br>CS I & II<br>English I & II | Fundamentals of ME<br>Systems Engineering<br>Calculus I & II |
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# CHOICES

| | |
|---|---|
| Physics I & II<br>CS I & II<br>English I & II | Fundamentals of ME<br>Systems Engineering<br>Calculus I & II |
| Cultures, Civilizations & Ideas I & II<br>Turkish I & II<br>History of TR I & II | Linear Algebra<br>Differential Equations<br>Thermal Fluid Eng I & II<br>Mechanics & Materials I & II |
| Molecular Biology<br>Solid State Chemistry<br>Science, Technology and Society<br>Humanities & SS Elective<br>Theory of Communication | Probability & Statistics<br>Dynamics & Controls I & II<br>Electromechanical Systems<br>Measurement & Instrumentation<br>Design and Manufacturing<br>ME Elective |
| Humanities & SS Elective<br>Engineering Electives (2)<br>Science Elective | Design I & II<br>ME Electives (3)<br>Elective |

# Humanities

- The Iliad, Homer/trans. Fagles, *Penguin USA*, 1990
- Civilization and its Discontents, Sigmund Freud, *Norton*, 1961
- The Republic, Plato/ed Grube Reeve, *Hackett*, 1992
- Gilgamesh, A new English Edition, Mitchell (tr.), *Free Press*, 2006
- The Theban Plays, Sophocles, *Penguin*, 1974
- The Prince, Machiavelli
- Hamlet, Shakespeare
- Discourse on Method and Meditations on First Philosophy, Descartes
- A Room of One's Own, Woolf
- Discipline and Punish, Foucault

# Summary of Courses

| | # | Cr | % |
|---|---|---|---|
| MATH | 5 | 17 | 12.4 |
| SCIENCE | 5 | 17 | 12.4 |
| ME | 17 | 55 | 40.1 |
| ENG | 4 | 13 | 9.5 |
| | | | |
| HUM | 5 | 14 | 10.2 |
| ELECTIVE | 1 | 3 | 2.2 |
| ENGLISH | 3 | 9 | 6.6 |
| HISTORY | 2 | 4 | 2.9 |
| GEN ED | 1 | 1 | 1 |
| TURKISH | 2 | 4 | 2.9 |
| | | | |
| TOT | 45 | 137 | 100 |

# Inaugural Year

- 80 Students Enrolled
  - 50 Students in English Language Prep School
  - 30 Students 1st Year (9 Women)
- 22.5% (of 80) Women Students

You are invited to come for a visit.

Tack så mycket.

Credit: iStockphoto