Engineering Education: A Paradigm Shift into High Gear

A talk by Dr. Cliff Davidson

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McGill TISED Trottier Institute for Sustainability in Engineering and Design

Engineering Education:
A Paradigm Shift into High Gear

CSE

Center for Sustainable Engineering

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Outline of the Talk

1. Introduction: What is “sustainable development”?
2. What are the most important challenges in changing engineering education to include sustainability?
3. Overcoming these challenges: Developing a community and sharing educational materials

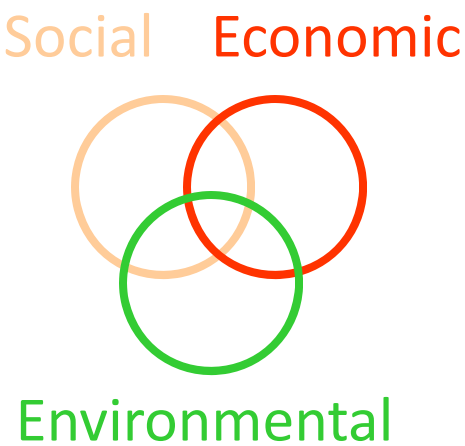
What is Sustainable Development?

First publicized by the World Council on Environment and Development (WCED) in 1987:

"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

Intended to reduce conflict between economic development and environmental preservation

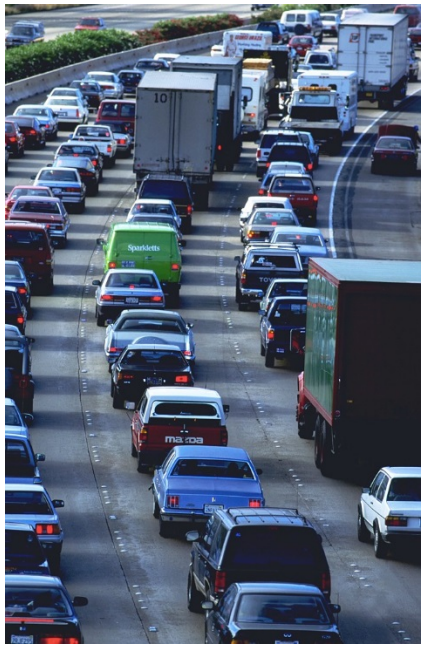
Now, 27 years later…



- Over 350 published definitions
- Some emphasize social sustainability, others emphasize purely environmental preservation
- Example of different definitions:
  - **Social sustainability implies egalitarianism (EU)**
  - **Social sustainability implies equal opportunity (US)**
- "Sustainability" has been used by different groups to further their own agendas

Despite its drawbacks, sustainability is an important concept that is here to stay.

A few other notes about Sustainability



It is a relatively new concept

It is immature: experts don't agree

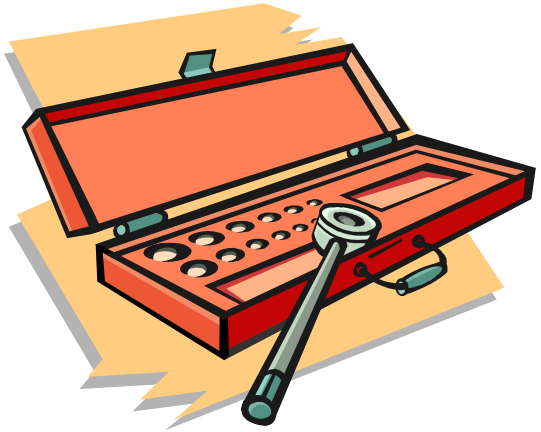
It is heavily "value-laden"

It generates a lot of media attention

Thus sustainability cannot be a technological or scientific construct – rather it is a *cultural construct.*

What are the characteristics of Engineering?

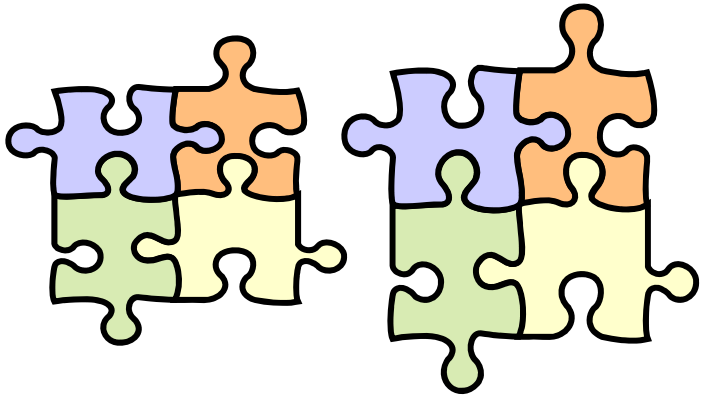
- Applied problem solving
- Pragmatic
- Depends on structured heuristics
- Highly quantitative



Thus we have a mismatch

- **Sustainability is a cultural construct that depends on societal values and requires assumptions about the future**

- **Engineering is a technological construct that must provide precise solutions to problems today, and may be sensitive to assumptions about the future**



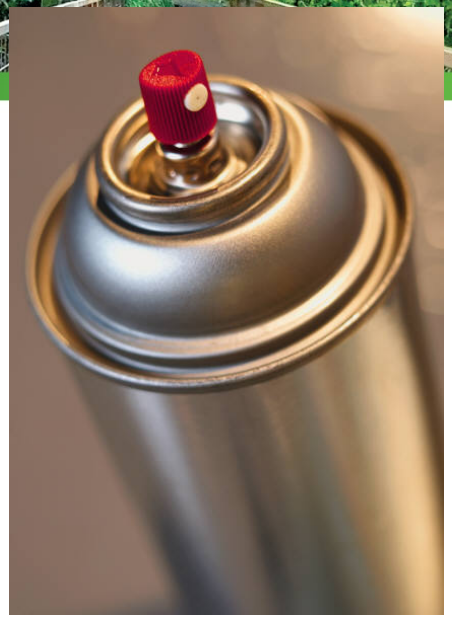
So engineers attempting to solve societal problems in a sustainable way can run into trouble if they:

-- don't account for social and cultural issues

-- don't consider global scale implications and long-term future

-- handle unpopular decisions inappropriately, e.g., they don't do their homework to learn the details, don't bring all stakeholders together to discuss options, or make a poor decision

-- convince themselves that the world fully understands implications of most engineering decisions



Examples of Sustainable Engineering Principles

- **Materials and energy used in products and processes should be:**
  - **-- as nonhazardous as possible**
  - **-- renewable to the maximum degree**
  - **-- reusable to the extent possible**
  - **-- used as efficiently as possible**

- **Design choices should be**
  - **-- based on local conditions**
  - **-- consistent with targeted durability, not immortality**
  - **-- taking advantage of embedded energy and entropy**

- **Assessing environmental damage should include all stages of a product's life cycle**

2. Challenges in Implementing Sustainability in Engineering Courses

- **Barrier #1: Sustainable Engineering is highly interdisciplinary**
- **Barrier #2: The discipline of Sustainable Engineering is largely undeveloped**
- **Barrier #3: Reward and incentive structure works against faculty trying to "do the right thing"**

Barrier #1 The field is interdisciplinary

- **Sustainable Engineering is interdisciplinary**
  - **-- Interacting natural systems**
    - **Hydrosphere, lithosphere, atmosphere, biosphere, …**
  - **-- Interacting human-made systems**
    - **Economic, political, legal, transportation, building systems, …**
- **Academic institutions are disciplinary**
  - **-- Individual departments in individual colleges**
  - **-- Faculty are independent!**

Barrier #2: The field is largely undeveloped

- **There are only limited educational materials on Sustainable Engineering available to use in courses**
- **There is little guidance available on incorporating Sustainable Engineering into courses in a pedagogically sound manner**
- **The community of engineering educators committed to Sustainable Engineering is scattered, with little sense of community**

Barrier #3: Incentives do not promote SE

- Tenure and promotion system at most universities is based mainly on research results, less emphasis on teaching
- Little money available for educational pursuits in SE
- Power structure at universities does not encourage innovations in education
- Making major changes in courses or curricula is hard work – there need to be incentives or change will not occur

3. Overcoming the Challenges:

Developing a Community

Center for Sustainable Engineering

- **Sustainable Engineering information is becoming available**

  -- Life Cycle Assessment software

  -- Industrial Ecology and Green Engineering textbooks

  -- Topic-specific courses based on recent research

- **Center for Sustainable Engineering Workshops**

  -- CSE is a partnership between Syracuse University, Georgia Institute of Technology, and Arizona State University

  -- Workshops include sessions on principles of sustainability, sources of educational materials, networking with others teaching in the field, and specialty topics

- **CSE Electronic Library at http://www.csengin.org**

Questions for Discussion

How can we overcome the challenges of inertia, limited educational materials, and lack of incentives for making changes in engineering education to promote sustainability?

What can we do as individuals to enhance the sustainability content of our engineering courses?

What can we do as a group to promote changing engineering curricula and courses nationwide?