What is Global Education for? *or* ..

Partnering with the Engineering Curriculum

Gary Downey

Alumni Distinguished Professor

Department of Science and Technology in Society

Department of Engineering Education

Virginia Tech

Quiz: #1

During the summer of 1940, German U-boats were successfully sinking British freighters. Doubting its survival, the U.K. sent a purchasing commission to U.S. shipyards. A deal was quickly reached, but then all progress came to a stop. To the commissioners' dismay, their ship plans proved meaningless to American engineers, workers, and managers. The entire set of drawings had to be redrafted and hundreds of additional drawings were needed before work could begin on building the ships that would help save the war for Britain. Explain.

Quiz: #2

An American engineer working in the avionics group at Honeywell reported a confusing experience with a French colleague. At a 50-minute engineering group meeting one day to decide the type of circuit they needed for a particular avionics system, the French engineer suddenly ran to the whiteboard and began deriving equations. This happened again on other occasions, even under severe time pressure. What was happening here?

Quiz: #3

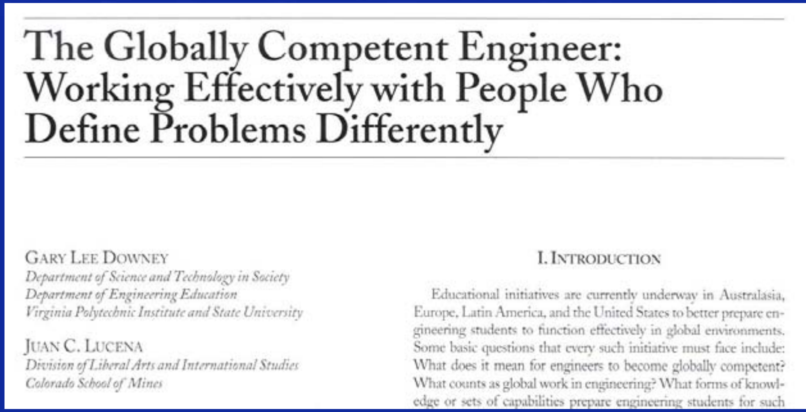
- ABET EC 2000 criteria (11)
  - 1st = ability to apply math and science
  - 6th = understanding professional responsibility/ethics
  - 8th = global, societal, environmental, economic
- Japanese 1999 accreditation criteria (8)

Japan Accreditation Board for Engineering Education

  - 3rd = ability to apply math and science
  - 2nd = understanding of "social responsibilities"
  - 1st = ability to "consider . . . issues from a global and multilateral viewpoint."
- Explain

Engineers and Countries

- Mathematics is the same everywhere but . . .
  - Bringing people adds human dimensions to problem solving
  - Issues of work and career
- What has it meant to be an engineer in different countries?
  - 19 lectures (www.globalhub.org; Dan Hirleman, Director)
  - France, Germany, Japan, Soviet Union/Russia, UK, USA



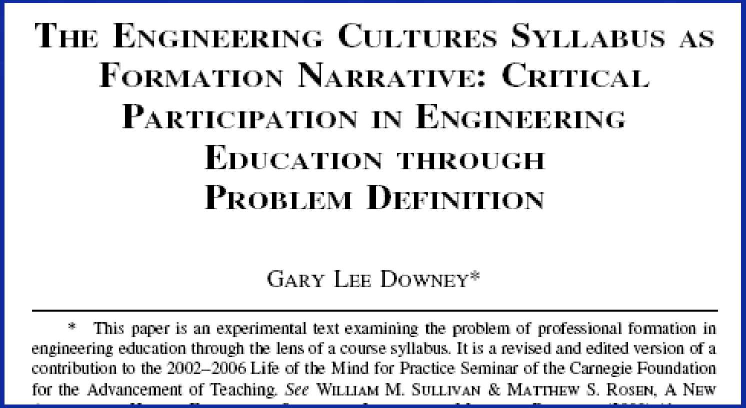
The Globally Competent Engineer: Working Effectively with People Who Define Problems Differently

GARY LEE DOWNEY
Department of Science and Technology in Society
Department of Engineering Education
Virginia Polytechnic Institute and State University

JUAN C. LUCENA
Division of Liberal Arts and International Studies
Colorado School of Mines

I. INTRODUCTION

Educational initiatives are currently underway in Australasia, Europe, Latin America, and the United States to better prepare engineering students to function effectively in global environments. Some basic questions that every such initiative must face include: What does it mean for engineers to become globally competent? What counts as global work in engineering? What forms of knowledge or sets of capabilities prepare engineering students for such



THE ENGINEERING CULTURES SYLLABUS AS FORMATION NARRATIVE: CRITICAL PARTICIPATION IN ENGINEERING EDUCATION THROUGH PROBLEM DEFINITION

GARY LEE DOWNEY*

* This paper is an experimental text examining the problem of professional formation in engineering education through the lens of a course syllabus. It is a revised and edited version of a contribution to the 2002–2006 Life of the Mind for Practice Seminar of the Carnegie Foundation for the Advancement of Teaching. See WILLIAM M. SULLIVAN & MATTHEW S. ROSEN, A NEW

Testing international knowledge?

Pre/Post essay assessment

As an American engineer, you have been invited by Airbus Industries in Toulouse, France to help design an "environmentally sustainable and socially responsible" manufacturing plant. The design team includes engineers from France, Germany, and United Kingdom because Airbus is jointly owned by companies from those countries. How prepared are you to enter this work situation? What knowledge and capabilities do you have and what do you lack?

Knowledge: dominant practices of engineering formation

- **0 (*Inadequate*)**: . . . characterizes engineering work as entirely technical, showing no awareness of national differences among engineers in France, Britain, and/or Germany
- **1 (*Needs improvement*)**. . . shows awareness of differences in language and customs . . . but does not recognize national differences related to engineering work.
- **2 (*Adequate*)**: . . . describes national patterns of engineering knowledge and engineers' identities . . . but does not explain how these patterns are important in engineering work
- **3 (*Excellent*)**: . . . describes national patterns of engineering knowledge and engineers' identities . . . and explains how these patterns are important in engineering work.

Dominant practices

Courses			Pre-Essay		Post-Essay	
Section	Type	#	**% 0-1**	% 2-3	% 0-1	**% 2-3**
VT 1	In-class	31	**97**	3	7	**93**
VT 2	In-class	35	**86**	14	13	**87**
VT 3	In-class	32	**84**	16	7	**93**
VT 4	Online	25	**84**	16	16	**84**
VT 5	Online	25	**96**	4	16	**84**
CSM 1	In-class	29	**87**	13	0	**100**

Dominant practices

- 87% A/SA: “have a better understanding of how my perspective as an engineer is different from those of engineers from other countries”
- 96% A/SA: “better prepared to work with engineers from different countries”
- 93% A/SA: “better at working with people who define problems differently than I do.”

Dominant practices

- International knowledge
  - "Encountering an American (engineering) self" (Dolby 2004)
  - Dominant practices vary by country
  - What is given in U.S. engineering education

NSF/CASEE workshop (Sept 2008): Agents of Change

Conger, Amy (U Michigan)

Downey, Gary (Virginia Tech)

Elliott, Gayle (U Cincinnati)

Gerhardt, Lester (Rensselaer)

Grandin, John (URI)

Hirleman, Dan (Purdue U)

Lucena, Juan (CSM)

McKnight, Phil (Georgia Tech)

Mihelcic, James (U South Fla)

Mook, Joseph (SUNY-Buff)

Nugent, Michael (U.S. DOD)

Parkinson, Alan (BYU)

Phillips, Linda (MTU)

Pinnell, Margaret (U Dayton)

Ramaswami, Anu (U Colo-Den)

Vaz, Rick (WPI)

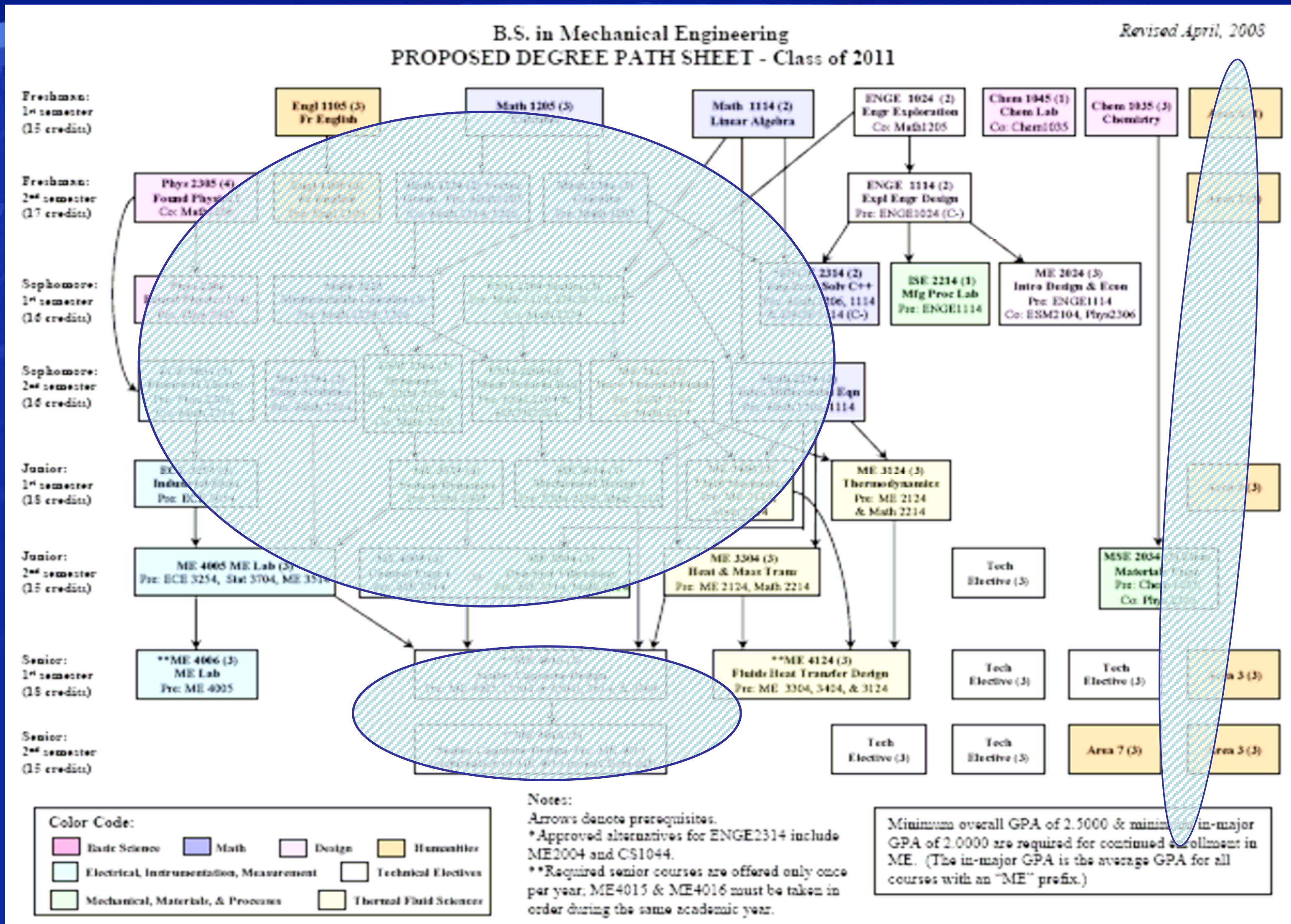
Widdig, Bernd (BC)

Jesiek, Brent (Purdue U)

Some observations

- Engineering faculty (by and large) do not care about international education
- Engineering students care about international education as much as faculty do
- Engineering curriculum = key site of engagement

Dominant practice: core vs. periphery



Some observations

- Small networks built by charismatic people
- Work in the margins of the curriculum
  - Study abroad/exchange
  - Internships/co-ops
  - Projects, service learning, research
  - Double major/dual degree
  - Certificates/minors
  - Elective courses

Some observations

- Transformative experiences
  - Desire to share knowledge
- More objectives than economic competitiveness
  - International citizenship
  - Being an American (engineer) in the world
  - Being "of" there

Some observations

- Emphasizing culture can reinforce marginality
  - Falls outside of engineering
  - Sensitivity rather than knowledge
- Many engineering faculty have international knowledge
  - U.S. born
  - Non-U.S. born

Some observations

- A focus on U.S. student competencies can hide the perspectives of partners in other countries
  - Reciprocate with knowledge resources?

Implications:

How to partner with the engineering curriculum?

(1) Focus on knowledge outcomes

- What do they know when they come back that they didn't know when they left?
- Develop instruments
  - "How prepared are you to enter this work situation? What knowledge and capabilities do you have and what do you lack?"
    - 0 = entirely technical, no awareness
    - 1 = languages and customs, no awareness
    - 2 = describes national patterns, does not explain
    - 3 = describes national patterns, explains

(2) Attract engineering science faculty

- Only if international engineering education is “within” engineering
- Annual evaluations?
- Include non-engineers on their faculty

(3) Alternatives to the "degree path" view?

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Student Name: [redacted]
Student ID:
Date of Birth:

STUDENT'S RECORD

Basis Admit: WOODBRIDGE SENIOR HIGH SCHOOL

Undergraduate

MAJOR: Chemistry

Transfer Credit:
Northern Virginia Cmty College
Attendance Period: SU 98/SS 99
Credits accepted from the Above Institution: 24.00

Subject Title	Dept.	No.	Hrs.	Gr.	Qual. Cr.
Fall Semester 1996					
GENERAL CHEMISTRY	CHEM	1035	3	C	6.0
GENERAL CHEMISTRY LAB	CHEM	1045	1	B+	3.3
FRESHMAN ENGLISH	ENGL	1105	3	B-	8.1
ELEM LIN ALG	MATH	1114	2	C	4.0
CALCULUS	MATH	1205	3	C	6.0
LANGUAGE AND LOGIC	PHIL	1504	3	B+	9.9
			15		37.3
[redacted] TERM GPA: 2.48					
Cum GPA: 2.48					
Spring Semester 1997					
CHEMICAL COMPUTATION	CHEM	1064	1	D	1.0
ANALYTICAL CHEMISTRY	CHEM	2114	4	C	8.0
FRESHMAN ENGLISH	ENGL	1106	3	C+	6.9
CALCULUS	MATH	1206	3	B	9.0
VECTOR GEOMETRY	MATH	1224	2	D	2.0
			13		26.9
[redacted] TERM GPA: 2.06					
Cum GPA: 2.29					
Fall Semester 1997					
TWENTIETH-CENTURY ART	ART	3784	3	B	9.0
PRINCIPLES ORG CHEM	CHEM	2565	3	D	3.0
INTRO DIFF EQUATIONS	MATH	2214	3	C	6.0
FOUND PHYSICS I	PHYS	2305	4	C	8.0
ABNORMAL PSYCHOLOGY	PSYC	3014	3	B-	8.1
			16		34.1
[redacted] TERM GPA: 2.13					
Cum GPA: 2.23					
Spring Semester 1998					
###-Resigned Effective 01-FEB-1998					
Fall Semester 1999					
GLASSWORKING	CHEM	2064	2	B	6.0
PRINCIPLES ORG CHEM	CHEM	2565	3	F	0.0
FOUND PHYSICS II	PHYS	2306	4	D	4.0
INTRO STATISTICS	STAT	2004	3	B	9.0
			12		19.0
[redacted] TERM GPA: 1.58					
Cum GPA: 2.09					
Spring Semester 2000					
GENETICS	BIOL	2004	3	D-	2.1
GENERAL MICROBIOLOGY	BIOL	2604	3	D+	3.9
ORG SYN TECH LAB	CHEM	2555	2	B	6.0
PRINCIPLES ORG CHEM	CHEM	2566	3	C	6.0
RESOURCES GEOLOGY	GEOL	1024	3	C	6.0
			14		24.0
[redacted] TERM GPA: 1.71					
Cum GPA: 2.01					

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A transcript view: collection of resources

Thermodynamics

Humanities

SWE

Heat Transfer

Service learning

Statics

ASME work

Senior design

Calculus

Dynamics

Freshman engineering

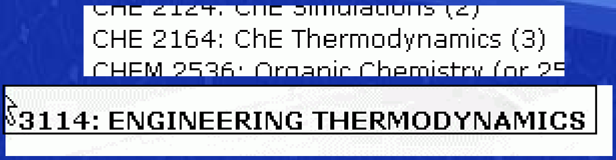
Summer job

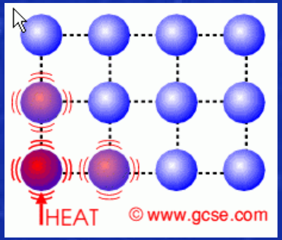
Social sciences

Fluid Mechanics

Transcript view of teaching the core: Thermo

- Why am I devoting my career to this field?
- Differences between thermo and heat transfer?
- Differences between thermo in ChemE and ME?
- Classify problem sets in addition to solving them, e.g. explain conduction and convection; in practical applications, what can be done with them and what cannot?





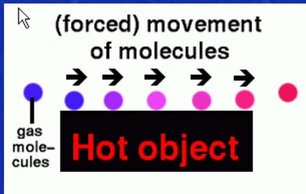
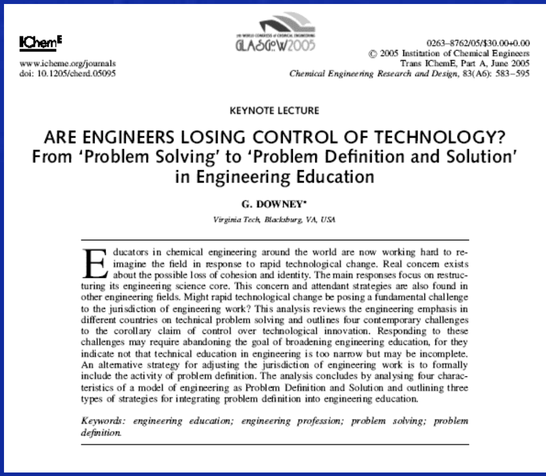


Fig. 2 - FORCED CONVECTION



IChemE
www.icheme.org/journals
doi: 10.1205/cherd.05095
0263–8762/05/$30.00+0.00

Trans IChemE, Part A, June 2005
Chemical Engineering Research and Design, 83(A6): 583–595

KEYNOTE LECTURE

ARE ENGINEERS LOSING CONTROL OF TECHNOLOGY?
From ‘Problem Solving’ to ‘Problem Definition and Solution’ in Engineering Education

G. DOWNEY*
Virginia Tech, Blacksburg, VA, USA

Educators in chemical engineering around the world are now working hard to re-imagine the field in response to rapid technological change. Real concern exists about the possible loss of cohesion and identity. The main responses focus on restructuring its engineering science core. This concern and attendant strategies are also found in other engineering fields. Might rapid technological change be posing a fundamental challenge to the jurisdiction of engineering work? This analysis reviews the engineering emphasis in different countries on technical problem solving and outlines four contemporary challenges to the corollary claim of control over technological innovation. Responding to these challenges may require abandoning the goal of broadening engineering education, for they indicate not that technical education in engineering is too narrow but may be incomplete. An alternative strategy for adjusting the jurisdiction of engineering work is to formally include the activity of problem definition. The analysis concludes by analysing four characteristics of a model of engineering as Problem Definition and Solution and outlining three types of strategies for integrating problem definition into engineering education.

Keywords: engineering education; engineering profession; problem solving; problem definition.

Thermo

- Extend to include international knowledge
  - Dig into your own past
  - Seek international experiences
    - How is thermo taught in different countries?
    - Research projects with international companies & organizations
      - 300 French-owned companies in Atlanta
  - Ask international faculty/student colleagues for help

(4) Seek curricular depth

- Make small programs sustainable
- Offer technical electives, capstone design, certificates, minors, double majors, degree tracks (global track)
- Metric of success: closer to the core, the better
  - Reach the 95%

Conclusion

- The biggest issue is not about Purdue retaining its competitive advantage; It is about keeping engineering from declining into technical support

Purdue's Engineer of 2020 Target Attributes

CORE

Knowledge Areas

- science & math
- engineering fundamentals
- analytical skills
- open-ended design & problem solving skills
- multidisciplinarity within and beyond engineering
- integration of analytical, problem solving, & design skills

Abilities

- leadership
- teamwork
- communication
- decision-making
- recognize & manage change
- work effectively in diverse & multicultural environments
- work effectively in the global engineering profession
- synthesize engineering, business, and societal perspectives

PERIPHERY

Quiz 1

The knowledge outcomes of engineering education include:

a) a core of technical competencies in engineering problem solving (+design) and a diverse set of peripheral experiences that are both irrelevant to engineering and produce no clear or significant competencies;

b) a core of technical competencies in engineering problem solving (+design) and a diverse set of peripheral competencies that add breadth to engineers as people but are irrelevant to engineering practice;

Quiz 1

c) a core of technical competencies in engineering problem solving and an integrated set of peripheral competencies in the form of professional skills;

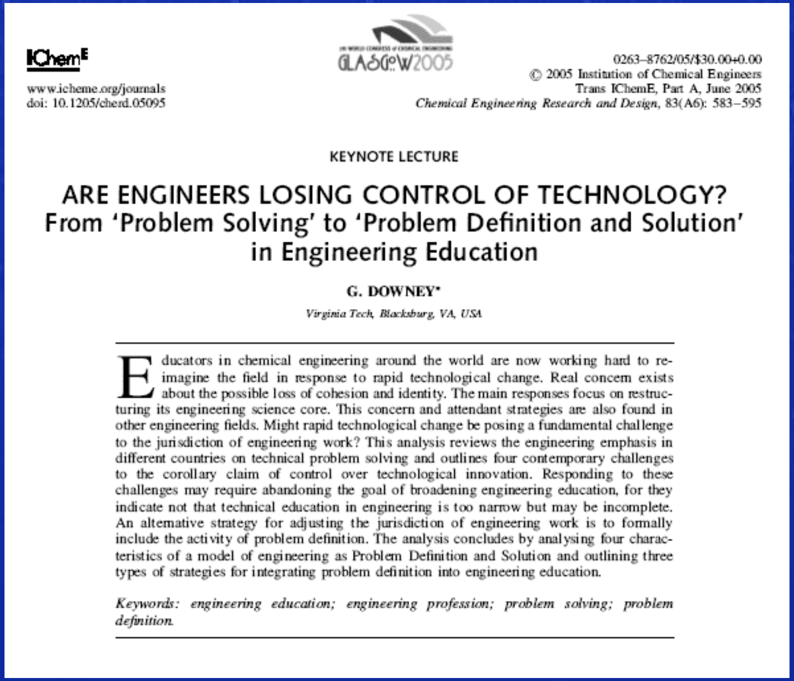
d) two sets of professional core competencies, including a set of competencies in engineering problem solving and a set of competencies in collaborative problem definition, both of which have technical and non-technical dimensions

Teach differently

- Different pedagogy
- Add tracks

Two themes

- Engineering at risk of decline from *technology's creators* to *technical support*
- Global education: one part in rethinking the core of engineering curricula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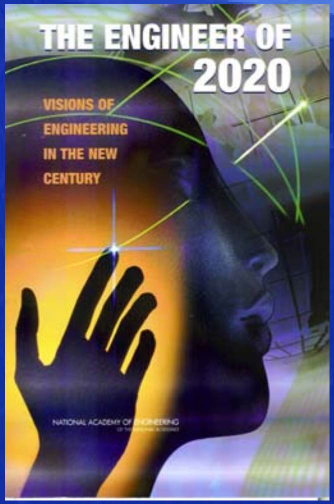
Keywords: engineering education; engineering profession; problem solving; problem definition.

Risk of decline?

- Engineering has long claimed jurisdiction over technological developments
  - Technical problem solving to design solutions
  - *2020* report: “technology is the outcome of engineering”
  - Core = engineering sciences + design
- But we now live in a built world
  - Technology is pervasive



Risk of decline?

- Many fields claiming technology
  - Especially the sciences
- Mass production of technical support engineers
  - Egypt, Philippines, India, China
  - Explosion of certifications
    - Become "engineer" with a single test (e.g. Novell engineer)
- Emphasis on teamwork shares authority

Risk of decline?

To continue to focus narrowly on technical problem solving puts engineering at risk of declining from *technology's creators* to *technical support*

Problem Definition and Solution, cont'd

1. Engineers expected to be involved early, before clear design problem emerges
   a. Able to map positions, interests, vision of stakeholders
      1) Know how environmental regulation works
      2) Know what key worker issues are
      3) Know executive visions of the cheque-printing business
   b. Stand out by also possessing technical knowledge

Problem Definition and Solution, cont'd

2. Prepared to collaborate with people who define problems differently than they do
   a. Go beyond gathering ideas from management, workers, environmental consultants, health/safety administrators
   b. Map how others define the problem and the implications of solutions
      1) Are workers worried about their jobs? Skeptical of management?
      2) Who fears loss of the cheque-printing business? Who welcomes it?
      3) Relationship between company and regulatory agency?

Problem Definition and Solution, cont'd

3. Assess implications of alternative solutions for stakeholders
   a. C_7H_8 is still toxic: what about workers?
      1) Would they see this as a management imposition?
      2) Agree that it's preferable to shutting down the process?
      3) How to mitigate these effects on workers?
   b. Any solutions beyond chemical engineering?
      a. Breathing apparatus for the workers?
      b. A clean room to collect emissions?

Problem Definition and Solution, cont’d

4. Achieve leadership through technical mediation
   a. Trade-offs both among alternative needs/specs and among alternative groups and technical perspectives!
   b. Not a touchy-feely search for consensus but decision making that takes account of different perspectives
   c. Still engineering work
      1) Depends upon technical insight
      2) Retains larger societal mission

Visible leadership will not come only through technical genius and technological heroism . . . It must also come from hard work of including collaborative problem definition as core competency and responsibility

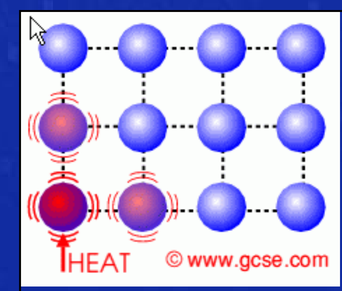
Better addressing problem definition in engineering education

Key criterion: How does this learning activity prepare engineering students to work with people who define problems differently than they do?

1. Adapt pedagogies in engineering sciences to explain what they do not teach
   - a. Introductions to abstract mathematical worlds that only partly overlap with one another
   - b. How do thermo and heat transfer differ from one another? Differences between thermo in ChemE and MechE?
   - c. Classify problem sets in addition to solving them, e.g. explain conduction and convection; in practical applications, what can be done with them and what cannot?
   - d. Separate course on problem definition with case examples of disagreement and conflict among engineers and non-engineers

CHE 2164: ChE Thermodynamics (3)

3114: ENGINEERING THERMODYNAMICS



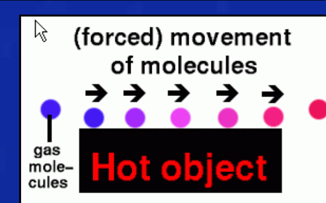
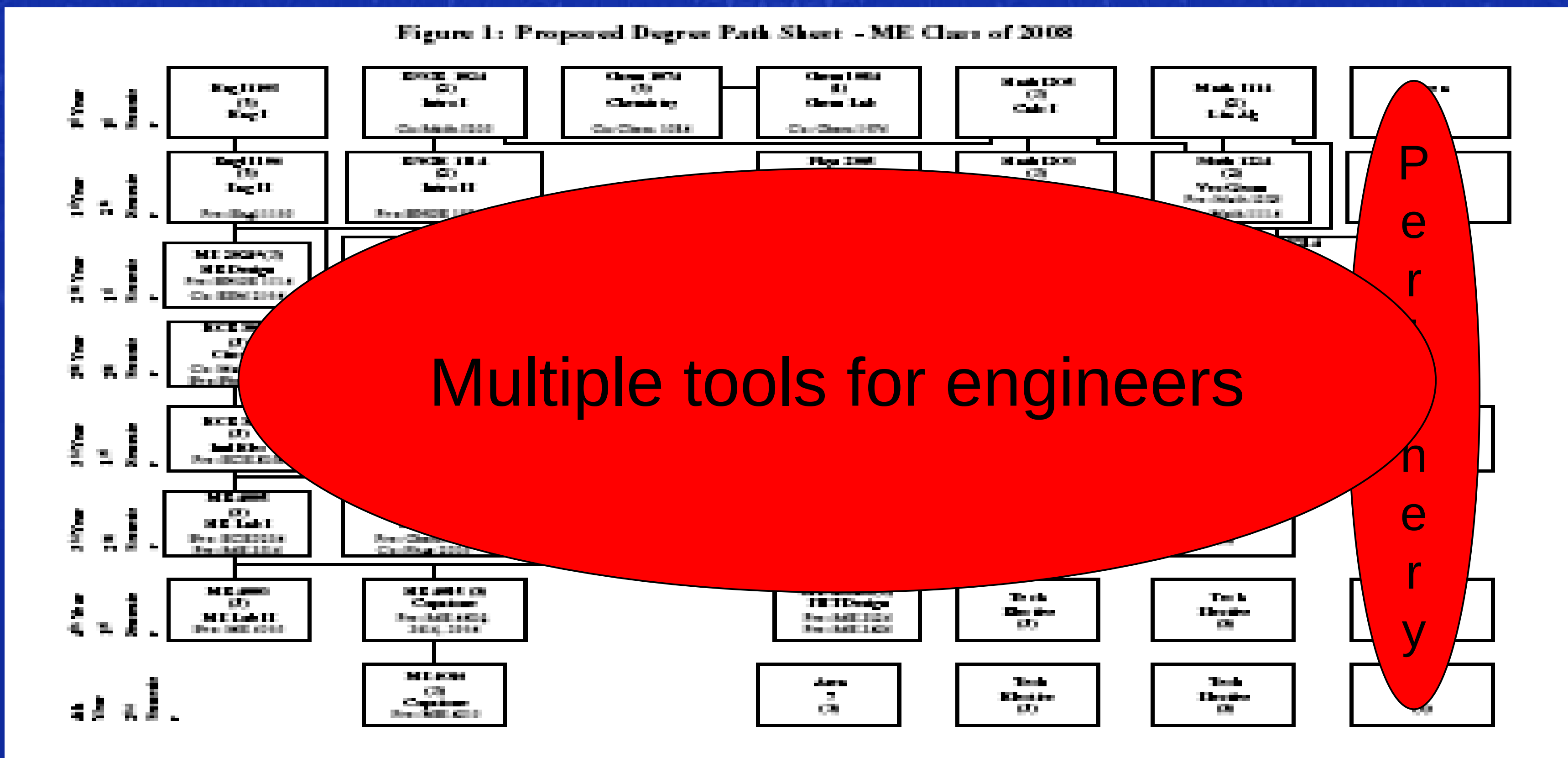


Fig. 2 - FORCED CONVECTION

Integrating Problem Definition, cont'd

2. Mold 'peripheral' courses to advance practical reasoning of engineers in problem definition



Integrating Problem Definition, cont'd

a. Social sciences, humanities, business management courses can be highly inflexible
b. Promote practice of 'integrated liberal arts education,' e.g. "Engineering Cultures"
c. As important in China, India, as in Europe & US
d. Key criterion: do they help students learn to work with people who define problems differently than they do?

Integrating Problem Definition, cont'd

3. Curricula for more than one type of technical professional
   a. 25% of careers fit the undergraduate image--must they start out the same?
   b. Make current curriculum a "track" alongside other tracks
      - Engineering science track => research/graduate school
        - Split up engineering science tracks?
      - Engineering design track => design work
      - Engineering and management track => problem definition in private industry, including understanding of other approaches
      - Engineering and policy track/engineering and society track => government or non-profit sectors
   c. Potential benefits
      a. Faculty have to compete for students
      b. Every track is followed by continuing education
      c. Engineers who become managers are still engineers

Conclusion

- Integrating problem definition into engineering education claims "technical mediation" as fully half of engineering work, alongside problem solving
- Help engineering respond to new vulnerability
- Enable engineering education to better prepare students for what has always counted as quality work by the best engineers

- Engineering faculty do not care about global education

- Engineering students care about global education as much as engineering faculty do

What is global knowledge?

- Transformational experience?
  - Expressed in emotional terms
  - Understand myself differently
  - See myself through eyes of others
  - I have a point of view, one among many

Encountering an American Self: Study Abroad and National Identity

NADINE DOLBY

Introduction

American undergraduates are often enticed to study abroad by the promise that they will have the experience of a lifetime and the experience of the world. For example, one American university attracts participants by claiming

Other findings

- Product of small networks established by passionate people
- Vulnerable to disappearance

Recommendations

- Institutionalize the small-scale programs
  - Study abroad, international design,
  - GEARE, Service learning,