Proceedings

Teaching Entrepreneurship to Engineering Students

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Recapturing and Conveying the Excitement of Engineering Through Practice, Innovation and Integration

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Recapturing and Conveying the Excitement of Engineering

Through Practice, Innovation and Integration

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Innovation Comes from Practice

Isn't it a joy to learn and practice often?

Confucius

Toward A More Effective Engineering Education

Teaching

Learning

Implementing

Scholarship Broadly Defined

Knowledge...

⇑ *Creation - Research, Discovery*

⇑ *Transfer - Teaching, Learning*

⇑ *Implementation - Practice, Innovating*

⇑ *Integration - Context, Inspiring*

Boyer Commission Report

The Scholarship of Knowledge Implementation: Innovation

- *Utilizing knowledge effectively to make a difference, embodying wisdom and judgment*
- *Must have contextual knowledge and understanding of contemporary socio-economic, ethical issues*
- *More effective with a cross-disciplinary and integrative approach*
- *Requires development of "higher-order skills", teamwork, communication, problem definition, etc.*
- *Best imparted early, using PBL; also an excellent tool to interest youngsters in engineering*

Next Generation Engineering Skills a la ABET 2000 Criterion 3. Program Outcomes and Assessment

Engineering programs must demonstrate that their graduates have

(a) ability to apply knowledge of mathematics, science, and engineering

(b) ability to design and conduct exp'ts, and to analyze & interpret data

(c) ability to design system, component, or process to meet desired needs

(d) ability to function on multi-disciplinary teams

(e) ability to identify, formulate, and solve engineering problems

(f) understanding of professional and ethical responsibility

(g) ability to communicate effectively

(h) broad education necessary to understand the impact of engineering solutions in a global and societal context

(i) recognition of the need for, and ability to engage in life-long learning

(j) knowledge of contemporary issues

(k) ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The Unity of Knowledge and Action

Knowledge without action is tantamount to not having the knowledge at all.

Wang Yangming
16th Century

Ask Bernstein, Toscanini, and Mehta: It Is How Well You Perform That Counts

"Teaching staff need to fundamentally rethink their roles. They do not merely impart information. They have to facilitate and orchestrate learning in a way somewhat similar to a conductor of an orchestra."

Low Won Fook, President
Singapore Polytechnic Institute
(thru ALNTalk Forum Moderator, July 20, 1999)

"Orchestrate Learning" Means….

- *Impart knowledge and insight*
- *Facilitate understanding & creativity*
- *Cultivate wisdom and character*
- *Inspire confidence and enthusiasm*
- *Maximize performance in practice*

Entrepreneurship: Effectiveness in Knowledge Implementation

- *Important in both small and big business*
- *More than just being creative or inventive; how to get things done or products thrive on the market*
- *Needs synthesis (integrative) as well as analytic skills*
- *Requires understanding of people, the world and marketplace, and how to get things done*
- *Needs "higher order" & "evangelistic" skills*

Intelligence Diversified

- *Analytic*
- *Creative*
- *Integrative*
- *Communicative*

Examples of 21st Century "Industries"

Traditional

- Aerospace
- Agriculture and Food
- Automotive
- Biotechnology
- Chemical & Allied
- Communic./Info. Technology
- Construction/Pub. Works
- Electronics
- Environmental
- Manufacturing
- Petro./Energy
- Pharmaceutical
- Transportation

Broadly Defined

- Architecture and Art
- Banking/Finance
- Economics
- Education, including K-12
- Entertainment/Media
- Legal/Intellectual Property
- Journalism/Publishing
- Management/Consultant
- Marketing
- Medicine and Health Care
- Military and Public Service
- Service
- Etc.

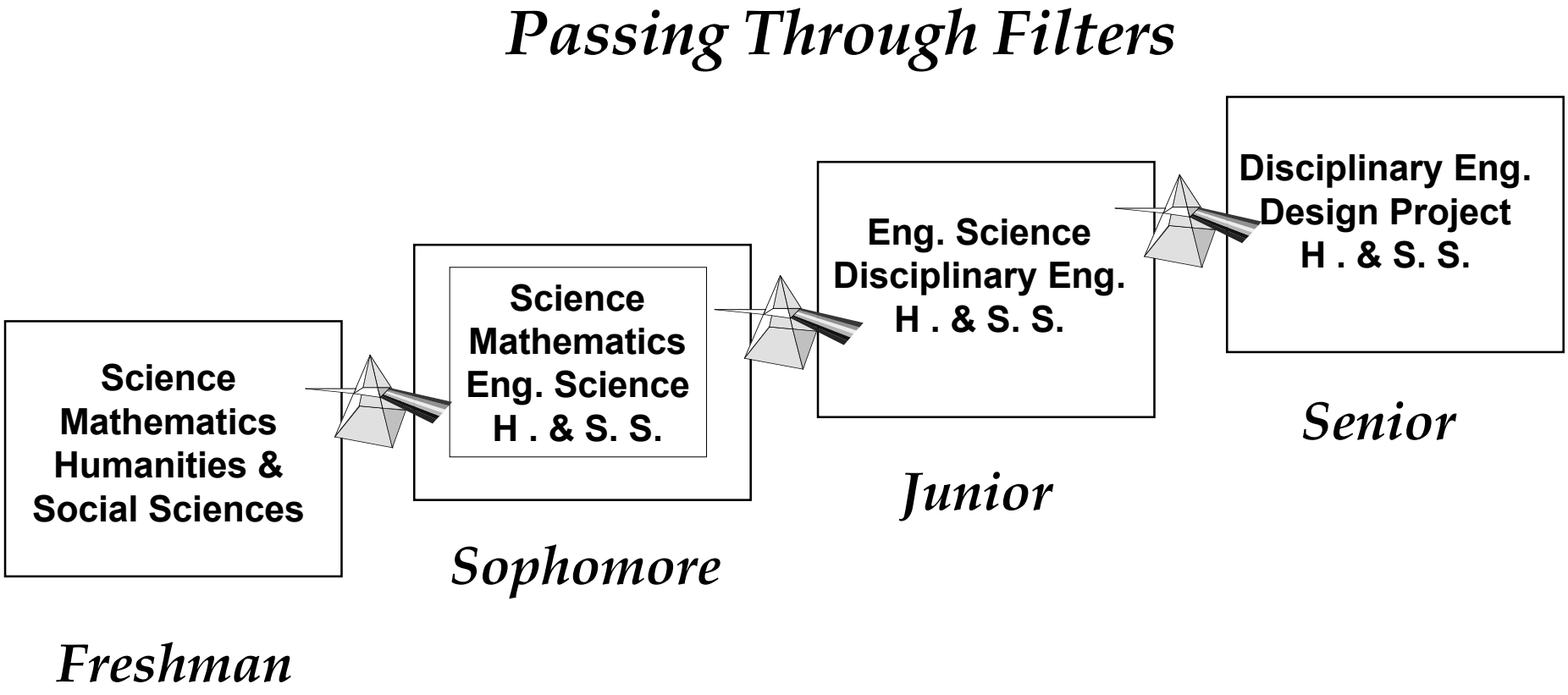
Leadership in the Boardrooms & Executive Suites: Examples of Needed Knowledge

- Advances in Materials
- Artificial Intelligence
- Biotechnologies
- Business Policy
- Concurrent Engineering
- Engineering Economics
- Environmental Managem't
- Global Business Strategies
- Information Systems
- Law and Ethics
- Logistics
- Management of Technology
- Manufacturing
- Marketing Strategies
- Microelectronics
- Organizational Design
- Photonics
- Robotics and Automation
- Strategic Management
- Technology & Public Policy
- Telecommunications
- "The Art of War", Sun Tzu
- Virtual Reality

Components of a Holistic Baccalaureate Education

Analytic (Science) Model	Integrative Model
Vertical (In-depth) Thinking	*Lateral (Functional) Thinking*
Abstract Learning	*Experiential Learning*
Reductionism - Fractionation	*Integration - Connecting the Parts*
Develop Order	*Correlate Chaos*
Understand Certainty	*Handle Ambiguity*
Analysis	*Synthesis*
Research	*Design / Process / Manufacture*
Solve Problems	*Formulate Problems*
Develop Ideas	*Implement Ideas*
Independence	*Teamwork*
Technological - Scientific Base	*Societal Context / Ethics*
Engineering Science	*Functional Core of Engineering*

Traditional Undergraduate Sequenced Curriculum



Baseball Training Schedule Modeled After Traditional Engineering Curriculum

- *Week 1* *Week 2*

Sports Fund'ls + Elec. Sports Lab	**Baseball Rules 2 + Electr. Baseball Lab**
Baseball Rules 1	**Sports Physiology**
Running	**Jumping and Diving**
Calisthenics	**Economics**
Physics	**Biomechanics**

- *Week 3* *Week 4*

Throwing	**Catching**
Batting	**Bunting**
Base-Running	**Sliding/Base-Stealing**
Psychology	**Sportsmanship**
Biz Practices	**Management**
Aerodynamics	**History of Baseball**

- *Week 5* *Week 6*

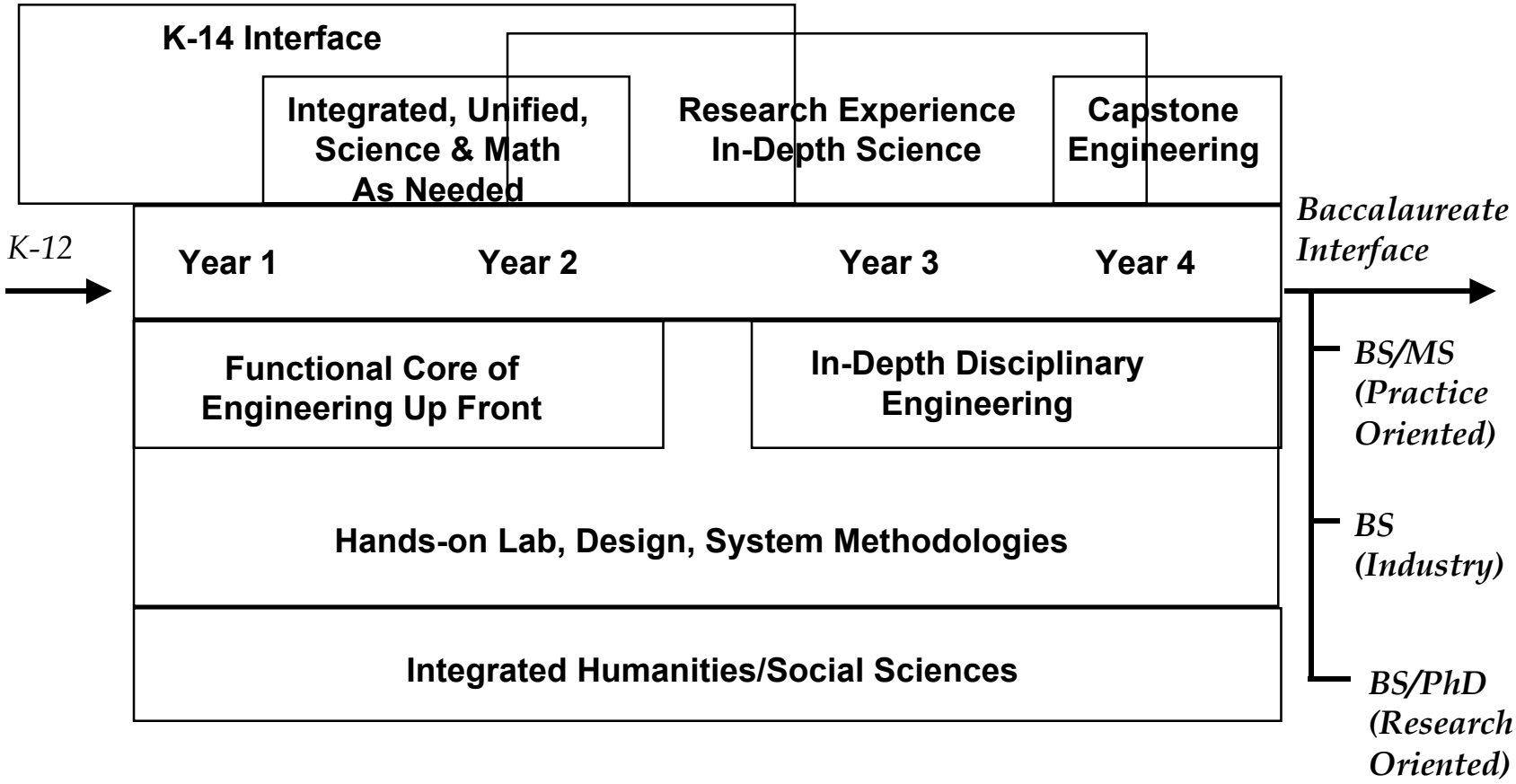
Offens. Stratg's + Elec. Lab. Sim.	**Defens. Strategies + Adv. Elec. Lab. Sim.**
***(E)* Pitching Signaling**	***(E)* Homeplating**
Baseball Biz	***(E)* Tagging**
Teamwork	**Classical Games**
	Coaching

- *Week 7* *Week 8*

***(E)* Pit-Cat Coord.**	**Sports Laws**
Biz/Sports Ethics	**Contracts & Negot'n**
Substance Abuse	***(E)* Verbal Abuse**
***(E)* Inf'ld Stratg's**	***(E)* Baseball Mgm't**
***(E)* Umpiring**	**Baseball Greats**
Games 1	**Games 2**

(E) indicates electives

Holistic Engineering Curriculum



Driving Forces Leading to the Creation of NSF Engineering Research Centers Program*

- *U.S. industry under threat from foreign competitors despite leading scientific excellence*
- *Globalization of industry and markets*
- *Disconnect between academe and industry*
- *Academic engineering had lost its focus on systems, integration, and engineering practice*
- *Graduates took too long to be productive*

** ERC Program initiated in 1985 at recommendation of NAE*

NSF Engineering Research Centers Special or Unique* Features

- *Highly Cross-Disciplinary*
- *Extensive Industrial Participation*
- *Intensive/Active Technology Transfer*
- *Education Coupling and Innovations**
- *Competitiveness Orientation*
- *Engineering Systems Integration***
- *Strategic Planning**

The ERC Rainbow: Are ERC Graduates More Effective in Industry?

Percent industrial supervisors who found ERC Graduates Better to Much Better than their Peers

89% Effectiveness in carrying out job responsibilities

87% Ability to grasp quickly key features of new opportunities

85% Depth of technical understanding

80% Ability to work in teams

71% Ability to integrate knowledge from different disciplines

70% Improved verbal and written communications, networking

Are We Producing Bricklayers or Cathedral Builders?

- *Who will be devising future strategies for the industry and policy for the government?*
- *Who will be making personnel decisions for our corporations and institutions?*
- *Who will be leading the society and country in this technological age?*

We Need Both!

Technology Strategic Planning:
Example

- ***From 18th to mid-20th Century, American enterprises and industries thrived through an intuitive form of technology-based planning***
- ***However, since end of WW2, US business schools have stressed mainly manipulation of economic commodity (money), creating some of the problems***
- ***Meanwhile, Western Europe and Japan continued to refine and hone skills of technology manipulation, enhancing new product and service creation***

M. C. Sekora

Mastering the Art of Competition

Technology Strategic Planning:
Essence

- *A holistic approach enabling corporate planners to "see" their own technologies and those of competitors as if on a chessboard*
- *Enables planners to see how technologies can be both a threat and a resource simultaneously and to maneuver them offensively and defensively*
- *Acquisition - Technology alliances (transfer mechanisms) and counter-alliances (blockage mechanisms)*
- *Utilization - "Frontal attacks", "encirclement", etc.*

Creative Problem-Solving Initiatives: Some Personal Involvement or Knowledge

- *Dartmouth ES-21 Introduction to Engineering plus the Commission on Engineering Education Workshop*
- *Catholic University of America: "Fundamentals of Creative Design" (1966-7?)*
- *AAI-ASPAU Institute of Creative Engineering Methodology (with many non-engineers; 1968-70)*
- *National Taiwan U.: Engineering Methodology (70s)*
- *Problem-Based Learning (1980s and on) and Engineering Education Coalitions (1990-2002)*
- *Global Innovation Camps (Planned)*

Examples of Important Topics To Accompany Problem-Based Learning

- *The Process of Innovation - problem definition, idea generation, functional analysis, brainstorming, etc.*
- *Invention, Patents, and Intellectual Property*
- *Technology Strategic Planning - out-maneuvering competition, making alliances, "The Art of Warfare"*
- *Learner-Centered Communication - listening and visualization, information processing, multi-media technology; writing for different needs; etc.*
- *Leadership - how to inspire people; time and resource management; making deliberate choices ; etc.*
- *Cultural and gender diversity*

Global Innovation Camps

- *One to two weeks duration*
- *Lectures and discussions: invention and the process of innovation, I-U partnering, cultural and gender diversity, leadership, communication, global business strategies, law and ethics, logistics, management of technology, marketing, technology & public policy, etc.*
- *Real-life project*
- *Industrial sponsorships and involvement*
- *Existing interest in several countries*

Everyday Evangelism

- *Spreading a cause; selling a dream**
- *Transferring a vision** into a cause and getting people to share that cause*
- *Yields fundamental, dramatic, and/or long-lasting (cultural) changes*
- *Sustains and grows*
- *Live and work for a cause, not for a job*

*** A la Guy Kawasaki, 1991**

**** An insight not yet perceptible to most people**

Some Individual Agility Skills and Attributes

- *Crossing disciplines and sectors; associative and integrative*
- *Problem formulating and solving; games, riddles, and puzzles*
- *Communication - reading, writing, speaking, listening*
- *Bi-/multi-lingual and cross-cultural (ethnic, upbringing, education, company, etc.)*
- *Collaboration and Teamwork*
- *Ability to see beyond prevailing paradigm*
- *Ability to overcome non-existent assumptions*

Can You Pass the Entrepreneurship Test? (Or, Are You Already One?)*

7 Do you have a passionate desire to make a difference?

6 Do you fearlessly believe in a cause?

5 Do you work for a cause for the intrinsic satisfaction it brings?

4 Do you give up other things to make a commitment?

3 Do you enjoy fighting the mediocre, the mundane, and the status quo?

*2 Do you get accused of being driven, showing chutzpah**, or having more guts than brains?*

1 Does your spouse threaten to leave you?

* **a la Guy Kawasaki, *Selling the Dream*, 1991**

** **Yiddish word for "unmitigated gall," in a positve sense**

Entrepreneurship: A Born-Again Experience

- *New Vision*
- *New Beliefs*
- *New Value*
- *New Attitude*
- *New Methods*
- *New Lifestyle*
- *New Goals*
- *New Strategy*
- *New Spirit*
- *New Thinking*
- *New Purpose*
- *New Future*