NAE Practices for Engineering Education and Research (PEER) Program Guidance Group

Major Shifts in Engineering Education

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He pronouns

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Shifts in Engineering Education

- What were/are they?
- What did we learn/are we learning about advancing engineering education?
- What are the implications for the future of engineering education?

Prior Shifts

Engineering science

Outcomes and accreditation

Engineering design

Social-behavioral sciences

ICC technologies

Five Major Shifts in 100 Years of Engineering Education

By Jeffrey E. Froyd, *Fellow IEEE*, Phillip C. Wankat, and Karl A. Smith

http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&tp=&arnumber=6185632

Engineering Science and Analytical Emphasis

Theory
(Study grounded in theory/conceptual framework)

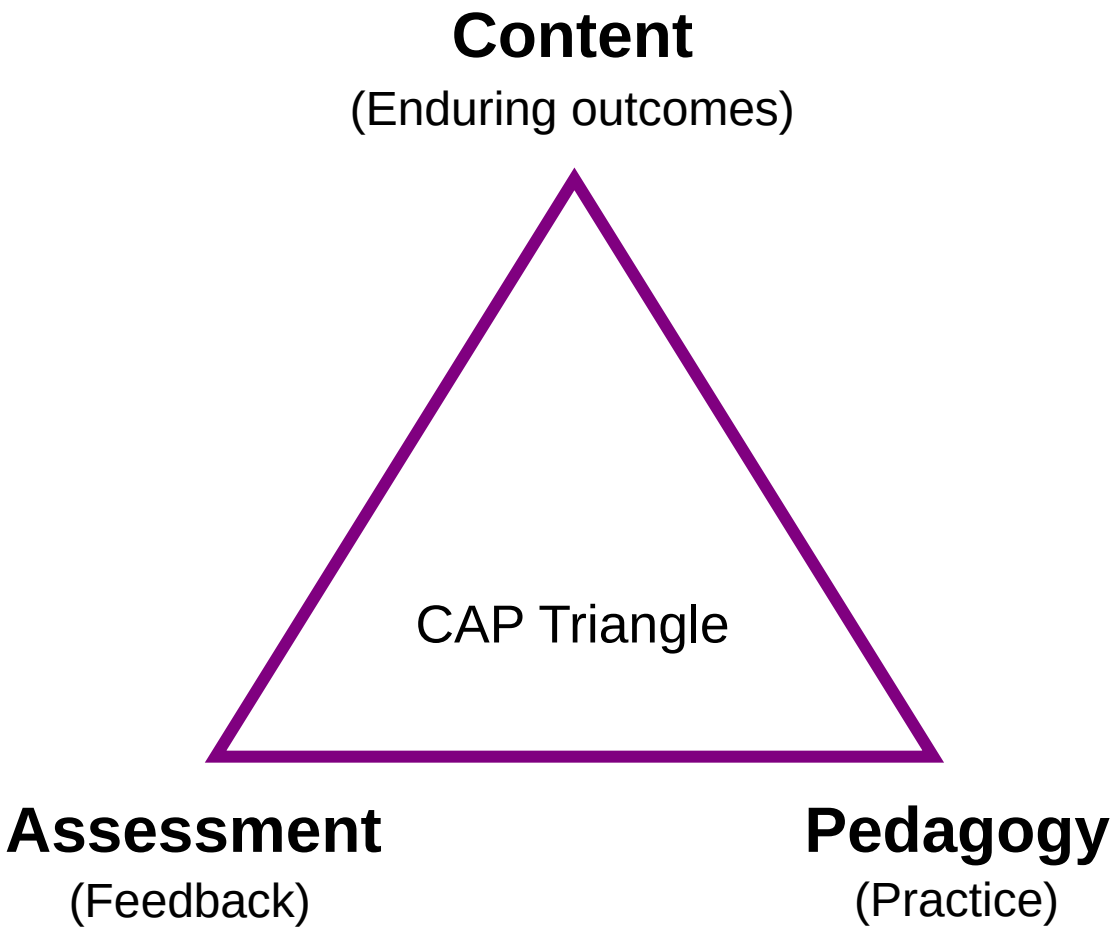
Research
(Appropriate design and methodology)

Practice
(Implications for practice)

IMPLICATION:

Theory and research matter.

Outcomes-based Education and Accreditation

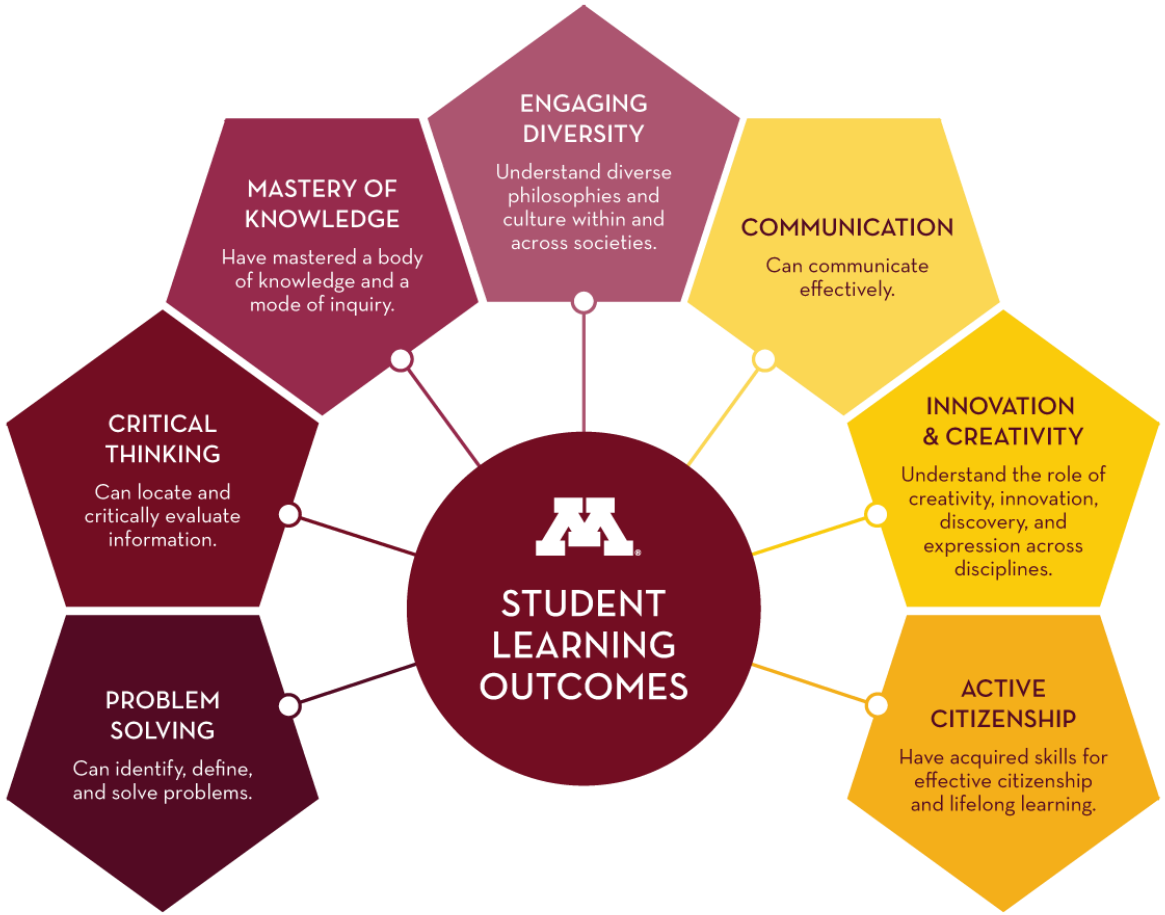


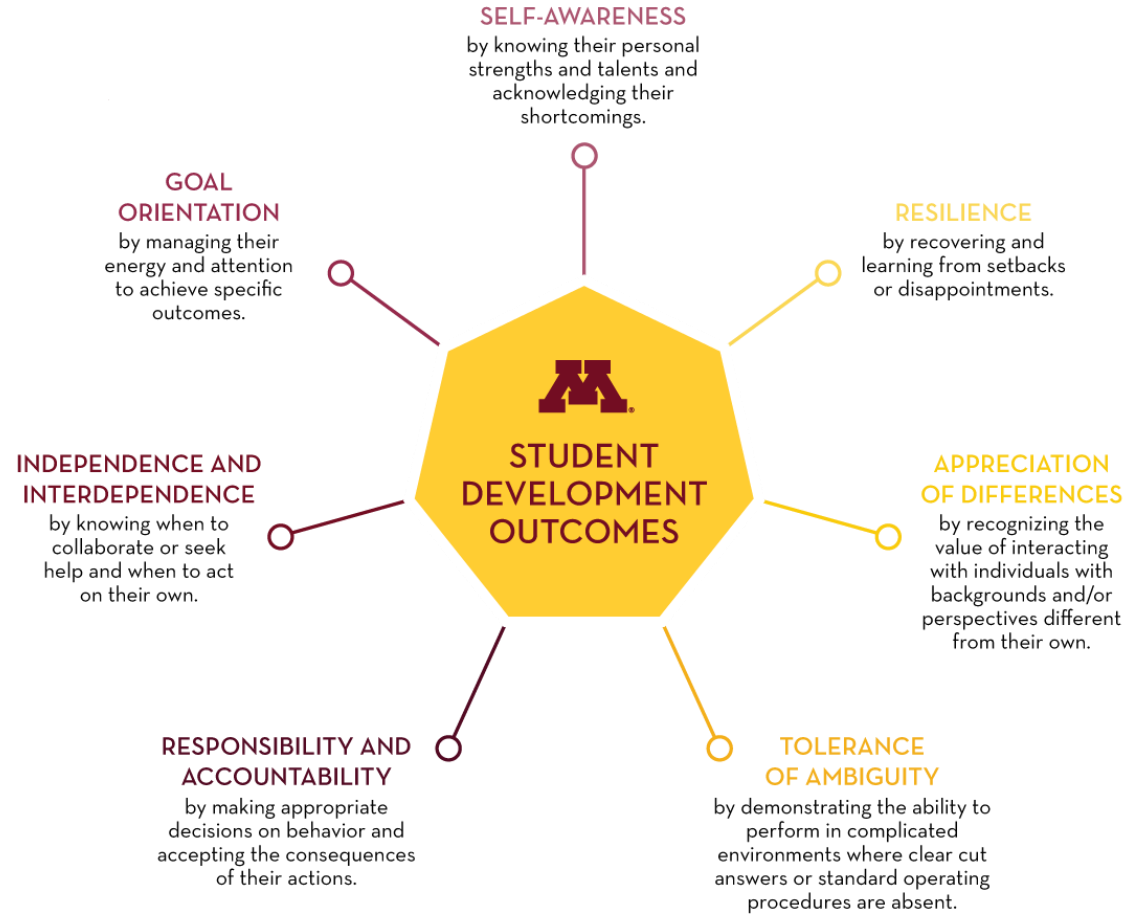
IMPLICATION:

Identifying and articulating enduring outcomes is a critical part of effective course design.

See: Streveler & Smith (2020)

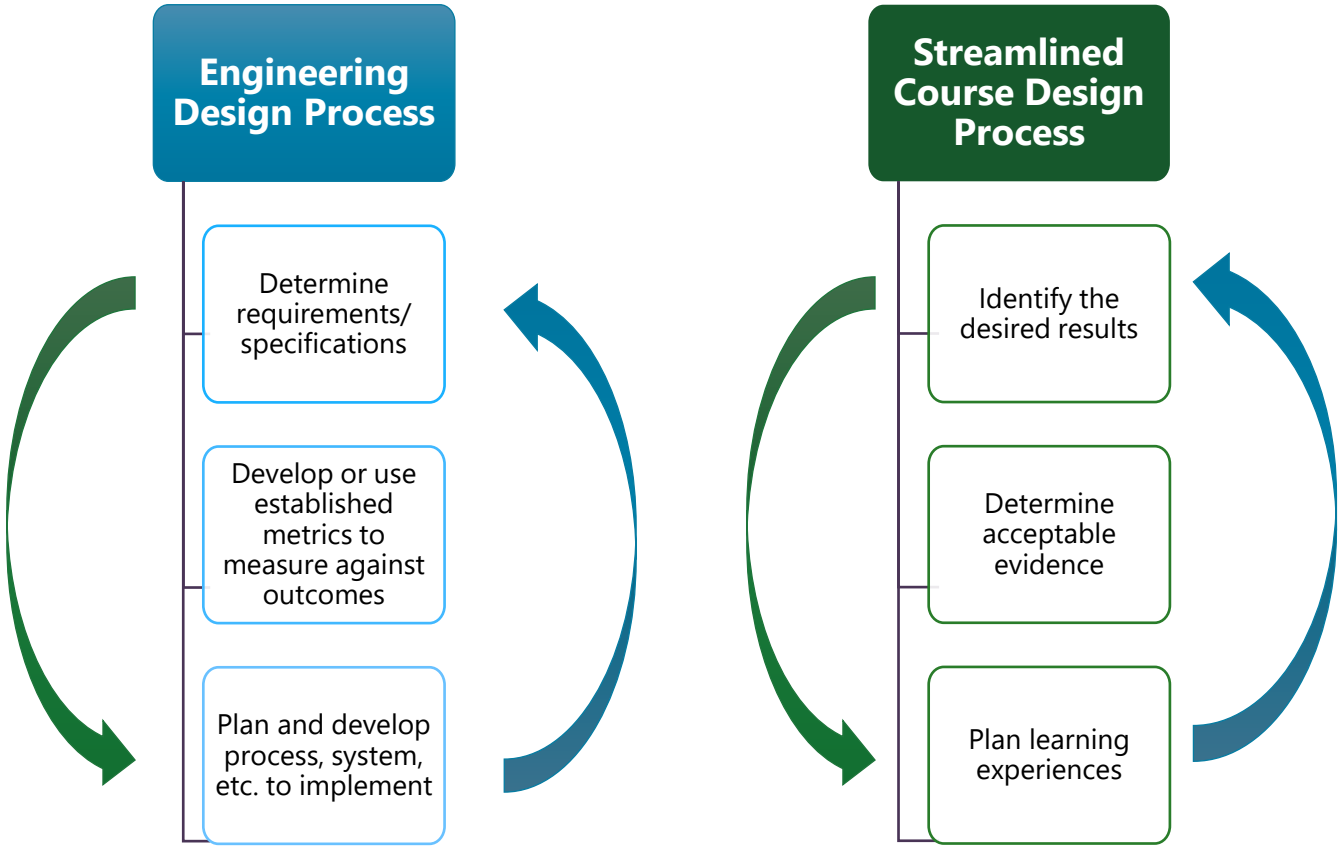
Learning and Development Outcomes UMN





https://slo.umn.edu

Emphasis on Engineering Design



IMPLICATION:

Embracing the engineering design process for course design makes sense.

https://advances.asee.org/opinion-course-design-in-the-time-of-coronavirus-put-on-your-designers-cap/

James Duderstadt

Nuclear Engineering Professor
Former Dean, Provost and President
University of Michigan

“ It could well be that faculty members of the twenty-first century college or university will find it necessary to set aside their roles as teachers and instead become **designers of learning experiences, processes, and environments.”**

Education, Learning and Social-Behavioral Sciences

- How People Learn
- Interactive Learning
- Personal and Academic Support
- Psychological Safety

IMPLICATIONS:

Applying what we know about learning is essential:

Cognitive Domain

Affective Domain

Education, Learning and Social-Behavioral Sciences

How People Learn

Interactive Learning

IMPLICATIONS:

Applying what we know about learning is essential:

Cognitive Domain

Learning Requires…

Deliberate

- Cognitive load (bandwidth)
- Reflection
- Processing

Distributed

- Repetition over time
- Multiple input modes

Practice

- Attentive
- Constructive
- Interactive

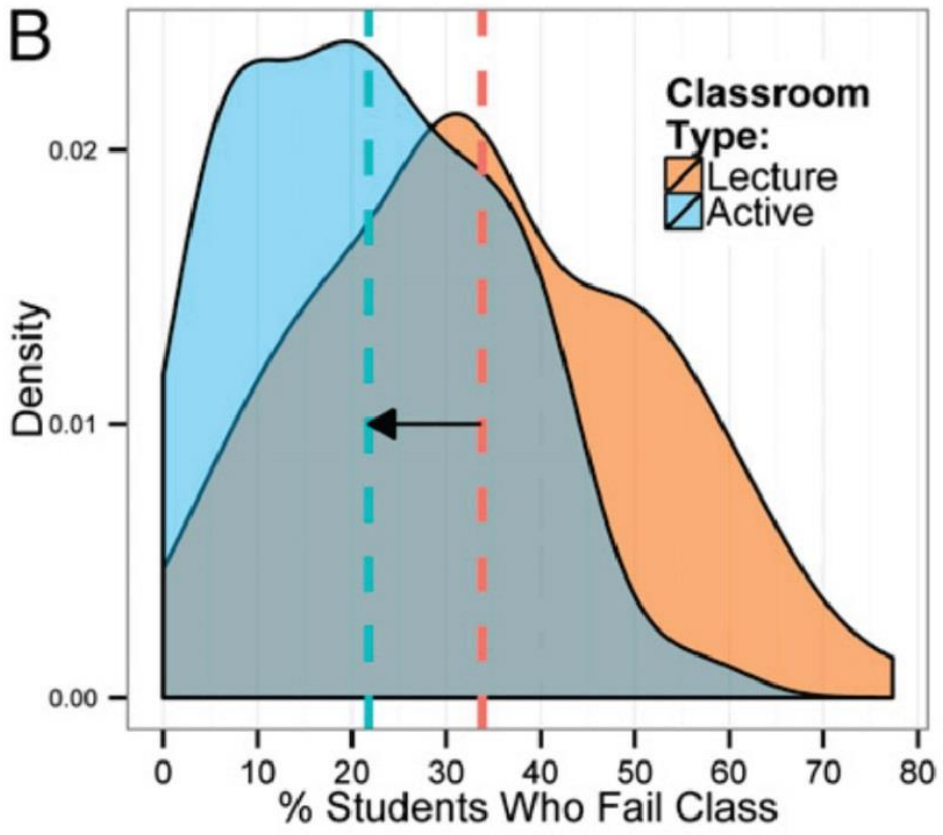
I-C-A-P Framework

Interactive	> Constructive	> Attentive ~~(Active)~~	> Passive
Substantive dialogue on the same topic, not ignoring a partner's contribution	Producing outcomes that go beyond presented information	Doing something physically Paying attention	
Guided-construction	Self-construction	Engaging activities	
Joint creation processes	Creation processes	Attending processes	

See: Chi (2009)

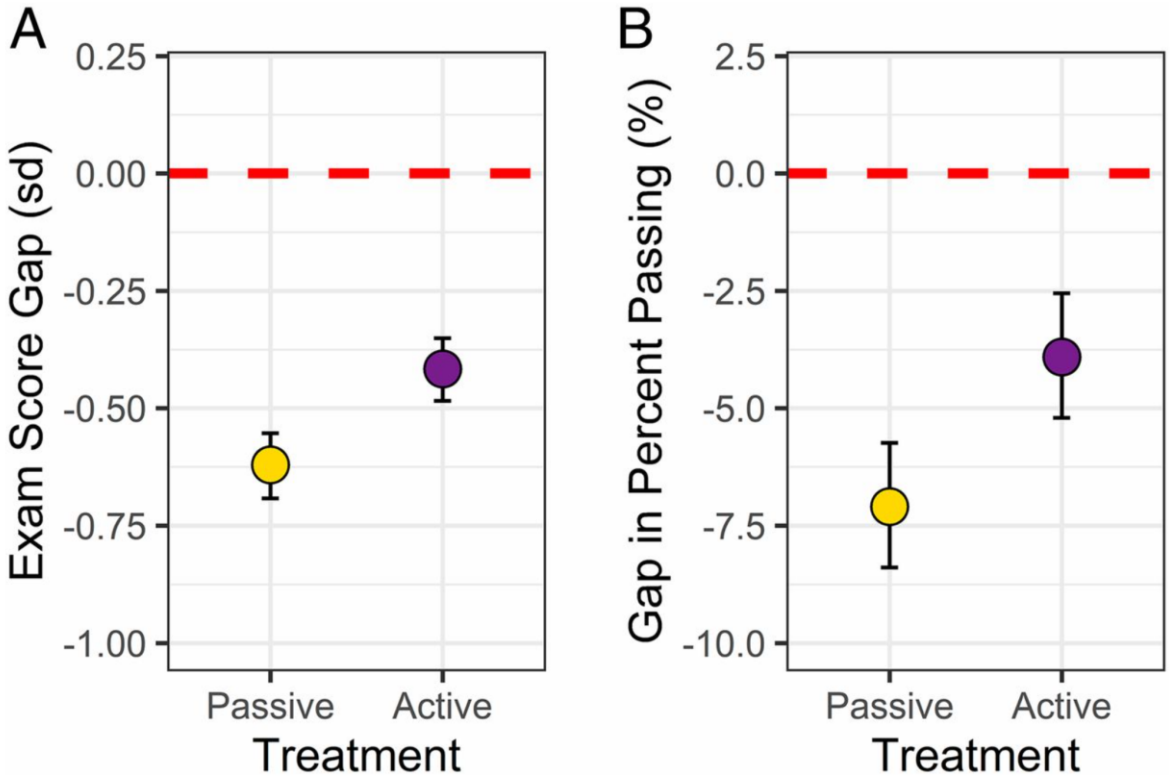
Interactive Learning

Reduces Failure Rates



See: Freeman, et.al. (2014)

Narrows Achievement Gap



See: Theobald, et.al. (2020)

Education, Learning and Social-Behavioral Sciences

IMPLICATIONS:

Applying what we know about learning is essential:

Personal and Academic Support

Psychological Safety

Affective Domain

Student Support is Essential

Academic Support

Classmates and faculty:

Help students succeed academically.

Personal Support

Classmates and faculty:

Care about and are personally committed to the **well-being** of each student.

The greater the social support,

the greater the academic challenges may be.

See: Johnson, Johnson and Smith (2006)

https://advances.asee.org/aee-covid-19-home-page/

Creative Tension Between Challenge and Security

PSYCHOLOGICAL SAFETY	ACCOUNTABILITY FOR MEETING DEMANDING GOALS: LOW	ACCOUNTABILITY FOR MEETING DEMANDING GOALS: HIGH
HIGH	**Comfort Zone** People really enjoy working with one another but don't fell particularly challenged. Nor do they work very hard.	**Learning Zone** The focus is on collaboration and learning in the service of high-performance outcomes.
LOW	**Apathy Zone** People tend to be apathetic and spend their time jockeying for position.	**Anxiety Zone** People fear to offer tentative ideas, try new things, or ask colleagues for help

See: Edmonson (2008)

See also: Pelz and Andrews (1966); Pelz (1976)

Integration of Information, Communication, and Computational (ICC) Technologies

DELIVERY: Television, Audio & Video Tape & Internet

Personal Response Systems (clickers)

Computational Technologies

Simulations

Individualized Feedback

Intelligent Tutors

Grading

Games and Competitions

IMPLICATIONS:

Technology provides affordances to mediate learning—but education is a human activity.

Elements of a paradigm shift in engineering education

	Older paradigm	Newer paradigm
Knowledge	Transferred from faculty to students	Jointly constructed by students and faculty
Students	Passive vessels to be filled by faculty's knowledge	Active constructors, discoverers, and transformers of knowledge
Faculty purpose	Classify and sort students	Develop students' competencies and talents
Context	Competitive /individualistic	Cooperative
Climate	Conformity	Diversity
Assumption about teaching	Any expert can teach	Teaching is complex and requires considerable training

Johnson, Johnson & Smith (1991, 2006); Smith & Waller (1997); Smith & Felder (2023)

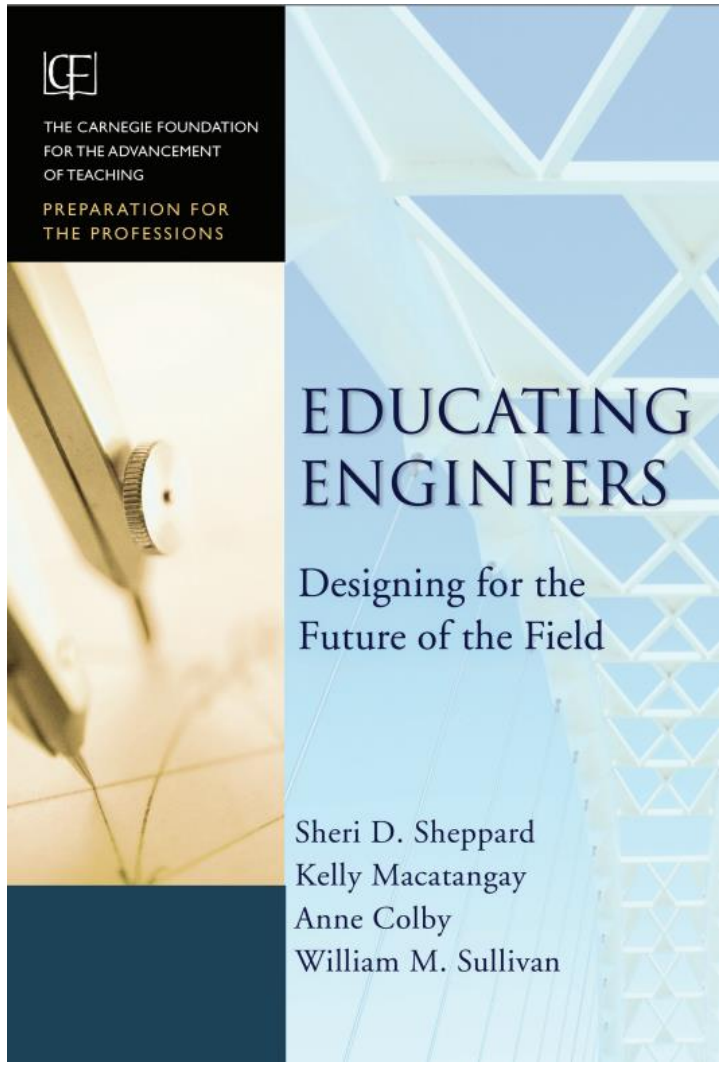
Prior Shifts

- Were prompted by outside forces
- Were met with resistance
- Were eventually embraced (to varying degrees)
- Did not change core values/practices

Engineering Education Reports

Mann Report (1918)	Wickenden Report (1930)
Hammond Report (1940)	Grinter Report (1955)
"Goals" Report (1968)	Green Report (1994)
Innovation with Impact (2002)	Educating the Engineer of 2020 (2005)

https://www.asee.org/member-resources/reports



Sullivan (2005) – The Three Apprenticeships of Professional Education

1. Head – intellectual/cognitive development
2. Hand – tacit body of skills shared by competent practitioners
3. Heart – ways of thinking and habits of mind, including the values and attitudes shared by the professional community

Ubiquitous Remote Teaching and Learning

Emergency Remote Teaching

Effective Distance Education

IMPLICATIONS:

Engineering teaching and learning can be accomplished remotely—but there are challenges:

- Video conference fatigue
- Lack of human/social interaction

Emphasis on Justice, Equity, Diversity, and Inclusion

Be Identity-conscious

Be Relational

Be Transparent

Be Accessible

Be Proactive

Be Flexible

"Do the best you can until you know better. Then when you know better, do better."

—Maya Angelou

IMPLICATION:

Working towards creating and maintaining equitable and inclusive learning environments is imperative.

https://www.celt.iastate.edu/wp-content/uploads/2020/06/Equity-and-Inclusion-in-the-Online-Learning-Environment.pdf

Shifts in Engineering Education: Implications

Engineering Science

Theory and research matter.

Outcomes Accreditation

Identifying and articulating enduring outcomes is a critical part of effective course design.

Engineering Design

Embracing the engineering design process for course design makes sense.

Social Sciences

Applying what we know about learning is essential:

Cognitive Domain

Affective Domain

ICC Technologies

Technology provides affordances to mediate learning—but education is a human activity.

Remote Learning

Engineering teaching and learning can be accomplished remotely—but there are challenges.

Justice, Equity, D&I

Working towards creating and maintaining equitable and inclusive learning environments is imperative.

PRIOR SHIFTS

EMERGING SHIFTS

Prior Shifts

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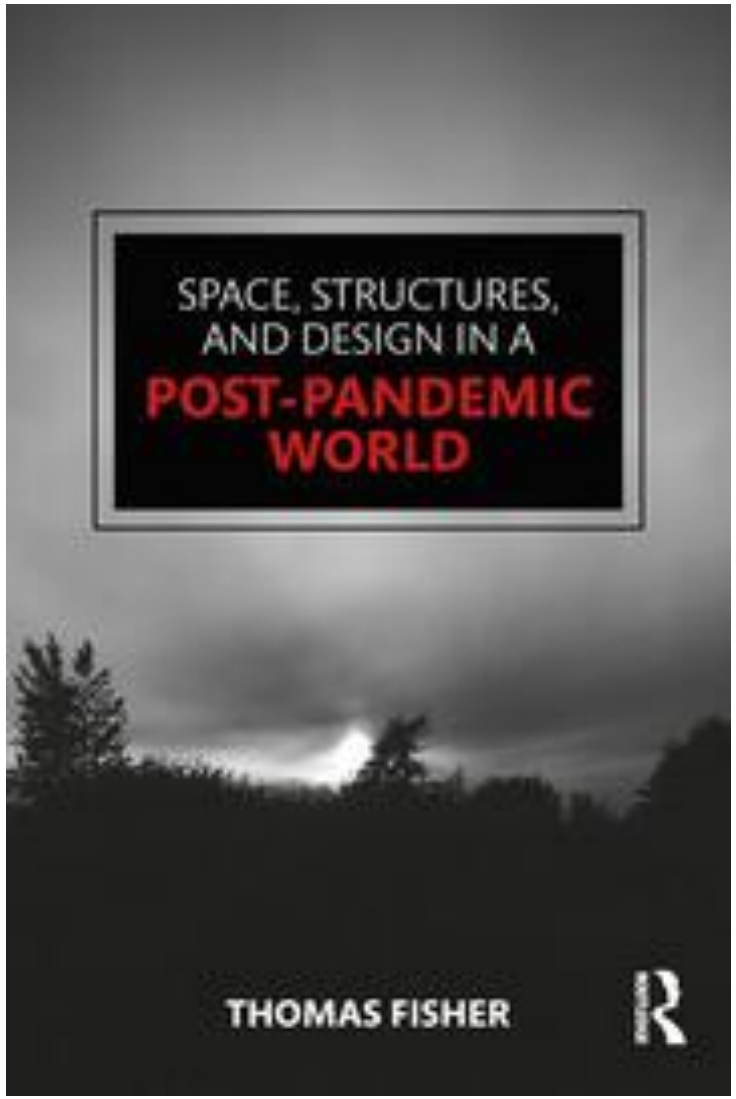
- **Did not change core values/practices**

Post-Pandemic

What do we want to keep?

Pandemics

1. Accelerate us into the future and magnify trends
2. Reveal inequities and dysfunctions in existing systems
3. Bring renewed attention to public & personal health
4. Create opportunities for those who grasp the change



The impact on education

Cholera, 1852-4

- Land-Grant Universities
- Morrill Act 1857-1862

Flu, 1918-20

- Junior Colleges
- AAJC, 1920

COVID, 2020-22

- Alternative Universities?

Thank you!

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