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Engineering Education Systems that are Fit for the Future

Turning Ideas into Action: Making Systems Thinking Practical for Engineering Educators

A "Masterclass" in Engineering Education: Systems within Systems

Kevin D. Hall, Ph.D., P.E.
Hicks Endowed Professor of Infrastructure Engineering
University of Arkansas, USA
25 September, 2018

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Our "Chat" Today…

- A Case for Change
- Systems Thinking in Life-long Engineering Education
- An Examination of the "Subsystem" of University Education
  - Efforts by the American Society of Civil Engineers (ASCE)
    - "Raise the Bar" (RTB); The Body of Knowledge (BOK); Accreditation (ABET); Curriculum; Classroom Instruction (ExCEEd Teaching Workshop)
- Concluding Remarks

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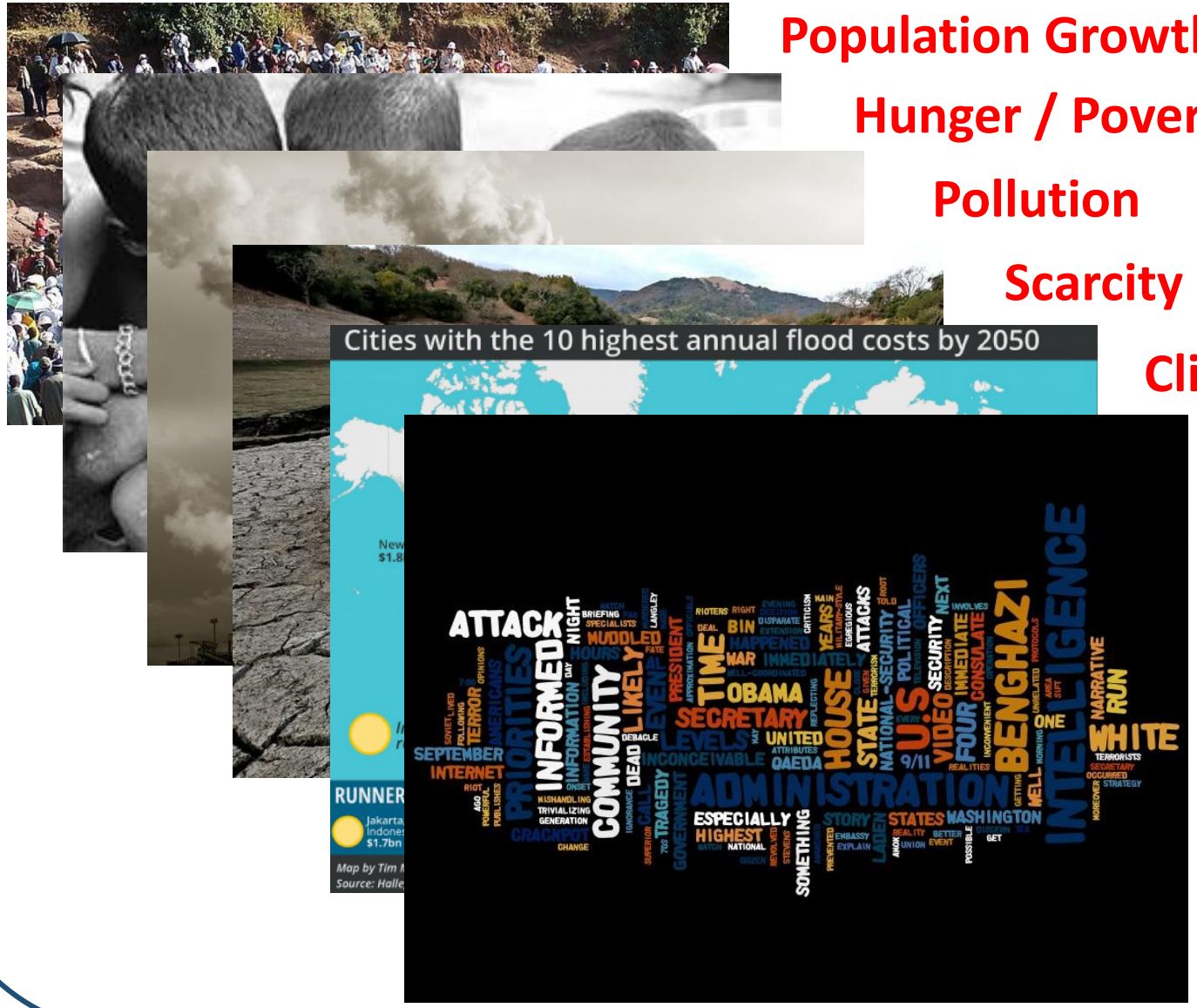
A “Few” Major Challenges



Population Growth

Hunger / Poverty

Pollution

Scarcity of Resources

Climate Change

Security

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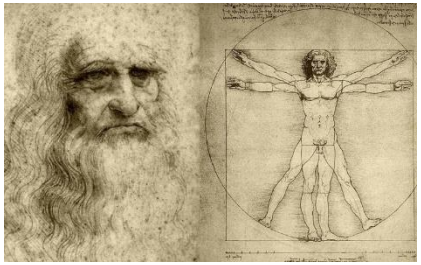
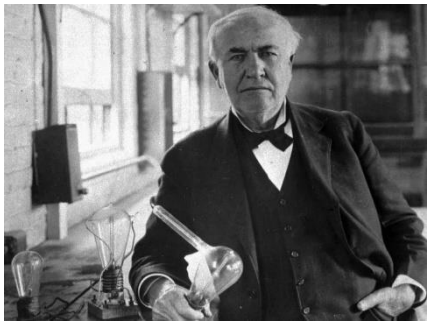
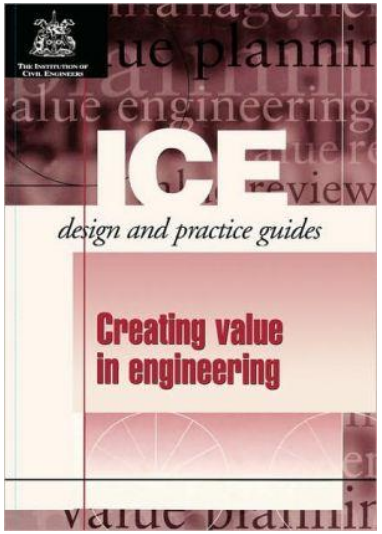
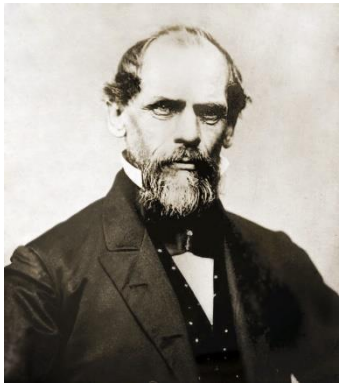
The 21st Century Engineer (?)

- Polymath Guru
- Value Creator
- Inventor
- Practitioner / Teacher / Researcher (P-T-R)
- *Global* P-T-R
- Project Leader
- Societal Leader









BREADTH and DEPTH

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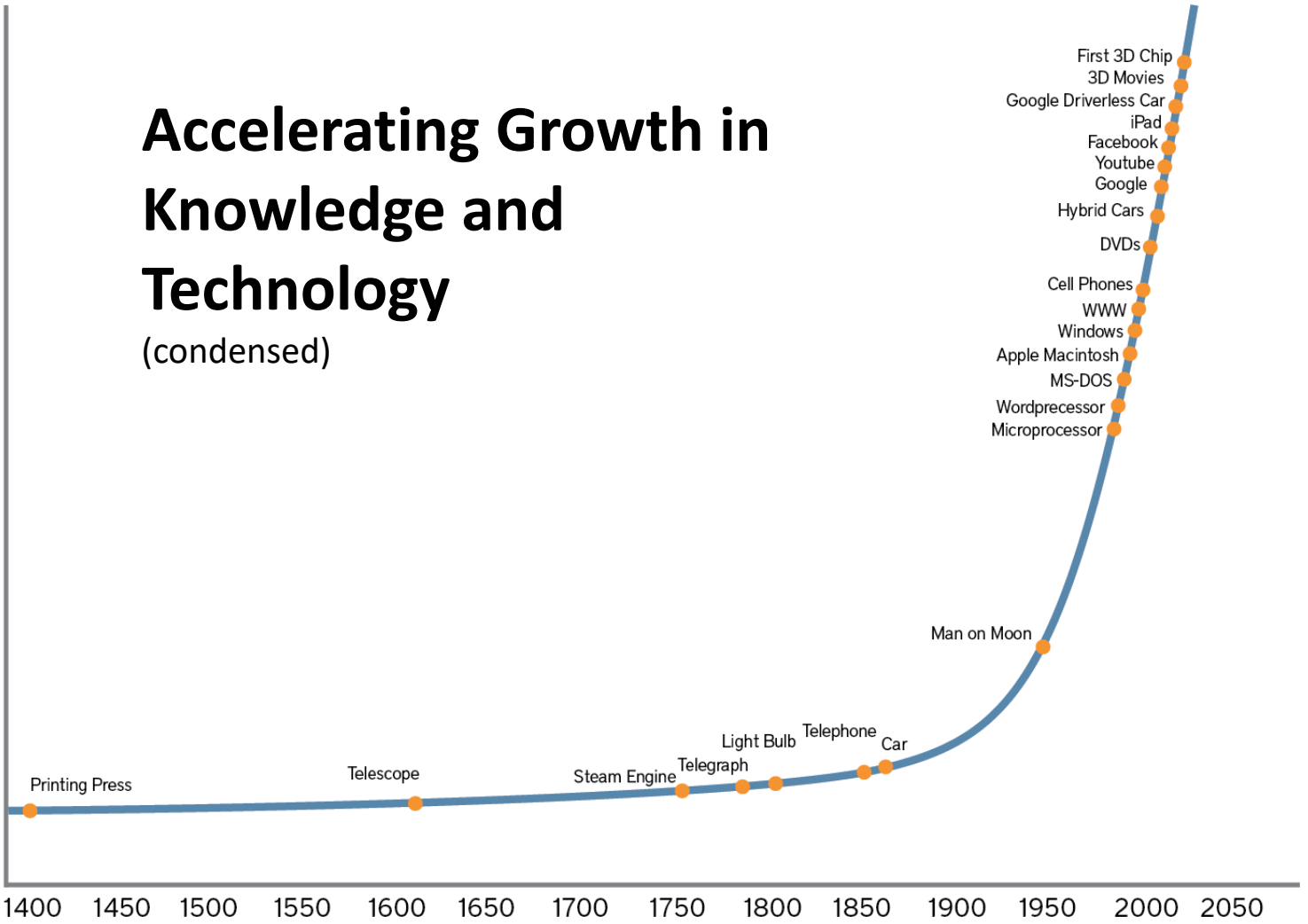
Accelerating Growth in Knowledge and Technology

(condensed)



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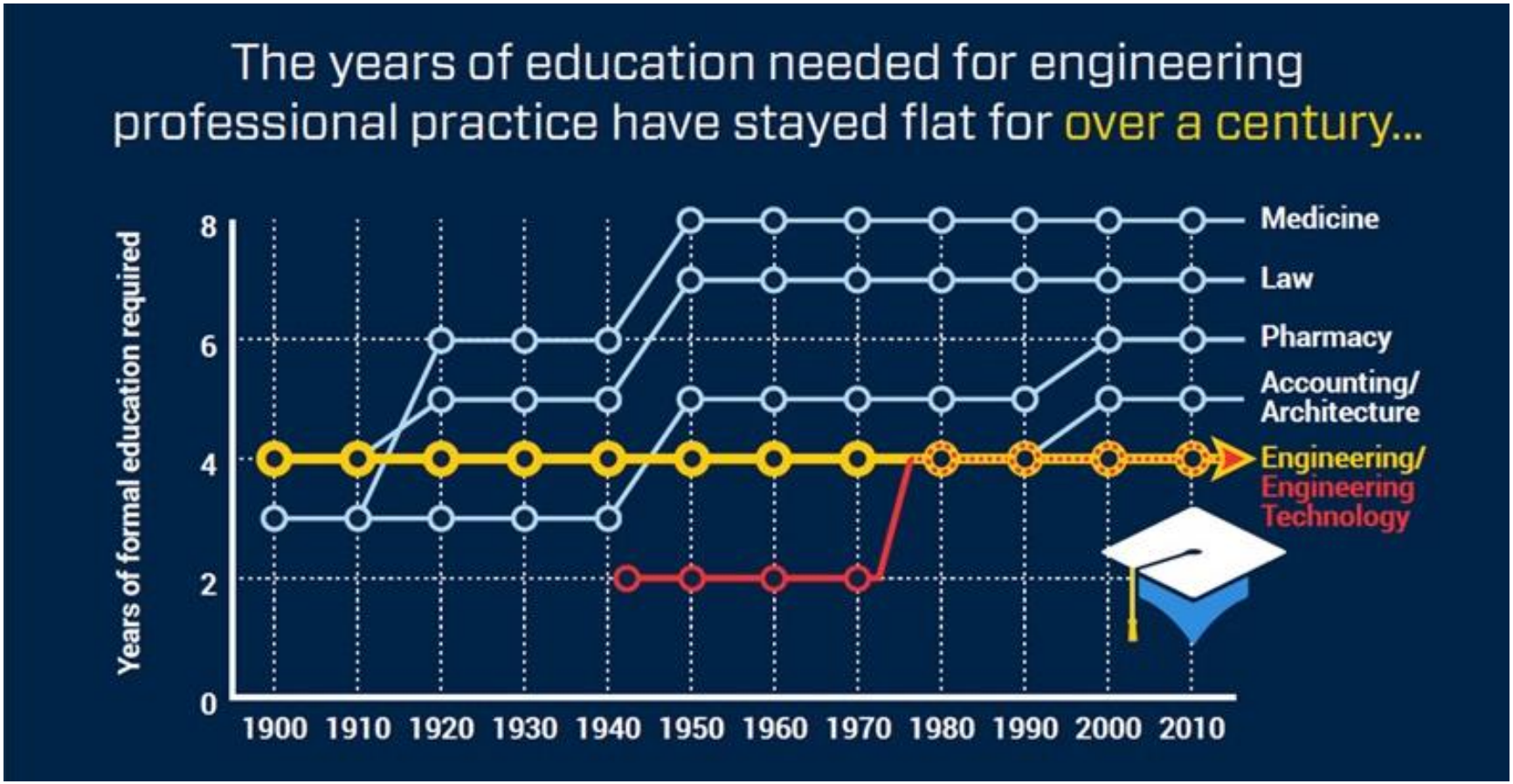
Engineering Education: *Keeping Pace??*



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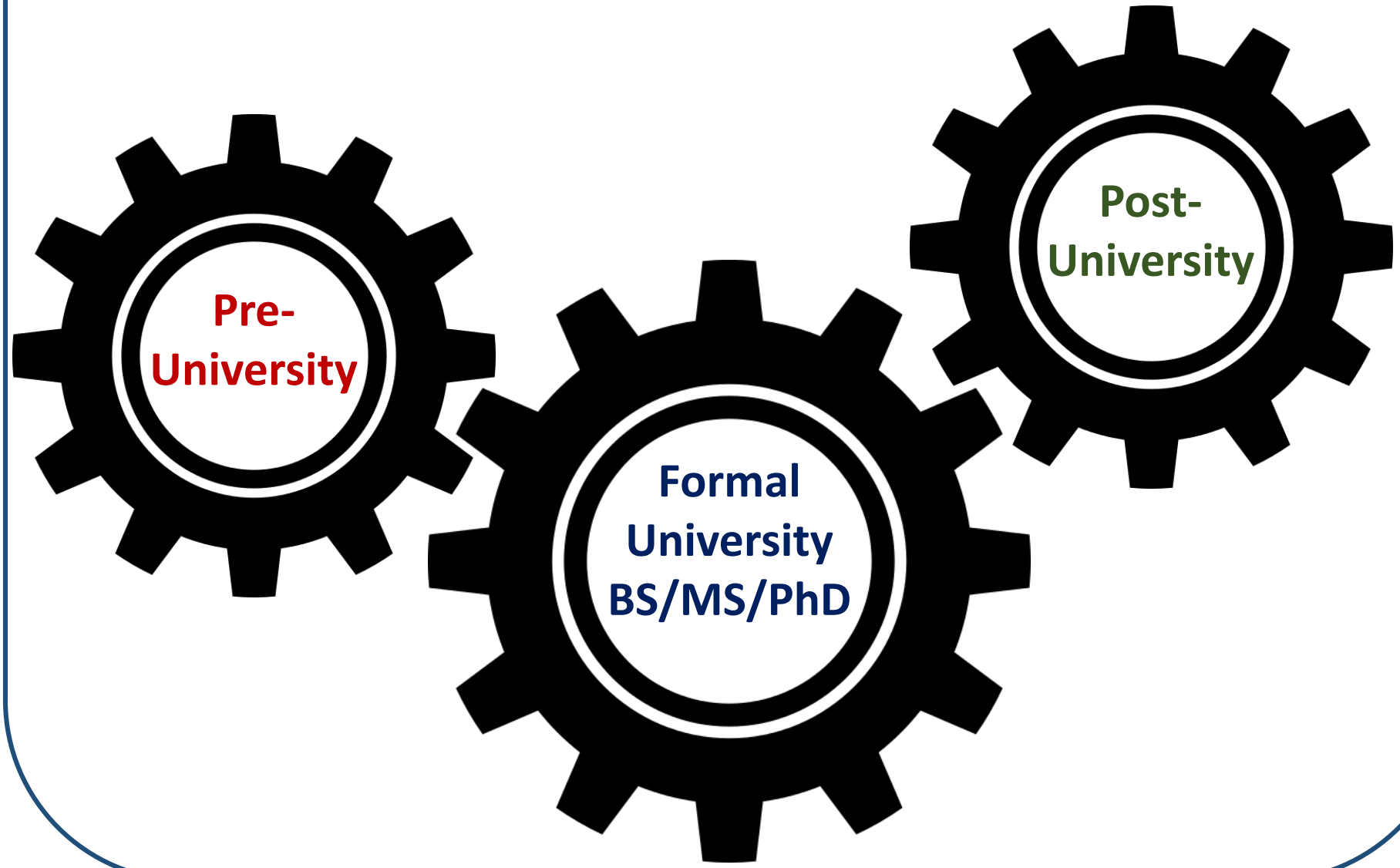
Engineering Education: A *System* of Life-long Learning



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Curriculum

Accreditation

Body of Knowledge

Pedagogy and Classroom Instruction

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ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

Raise the Bar:
Preparing the Future Professional CE

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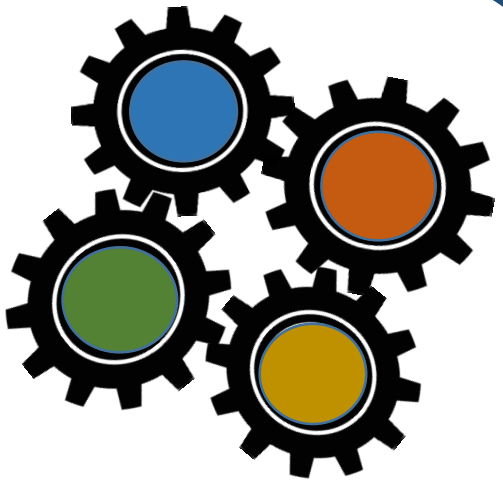
ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS



Committee on Education

Accreditation

Body of Knowledge

- Committee on Accreditation
  - Committee on Accreditation Operations
- Committee on Faculty Development
- Department Heads Coordinating Council
- CE Body of Knowledge Task Committee

Pedagogy and Classroom Instruction

Curriculum

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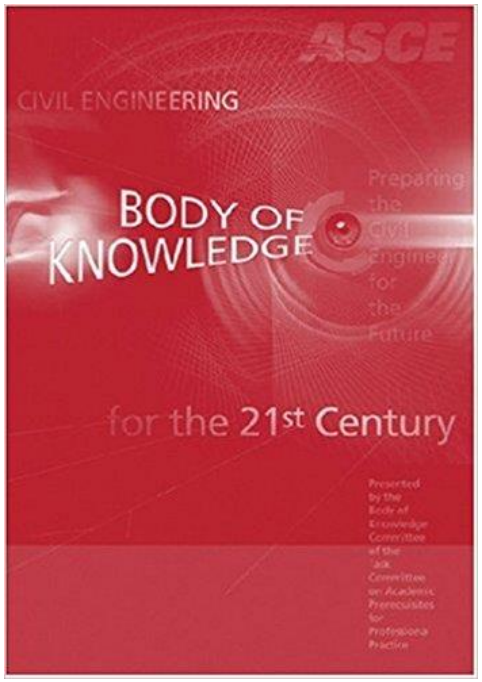
The CE Body of Knowledge (CE-BOK)

The CE-BOK is the <u>foundation</u> of the ASCE strategy to

“Raise The Bar”



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Q: What is a Body of Knowledge?

A: "A BOK is the complete set of concepts, terms and activities that make up a professional domain, as defined by the relevant learned society or professional association"

Q: What is the CE BOK?

A: … as defined by the civil engineering profession (ASCE)

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What is the purpose of the CE BOK?

Define the knowledge, skills, and attitudes needed to enter into the practice of civil engineering at the professional level

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Scholarly Basis for BOK

- Over 50 separate publications, including
  - Engineering Body of Knowledge (NSPE)
  - Environmental Engineering Body of Knowledge (AAEES)
  - Body of Knowledge for Chemical Engineers (AIChE)
  - Vision 2030: Creating the Future of Mechanical Engineering Education (ASME)
  - Draft Civil Engineering Technologist Body of Knowledge (ASCE)
  - Graduate Attributes and Professional Competencies (IEA)
  - Engineering Competency Model (USDOL)
  - Peer-reviewed papers form ASEE, ASCE, etc.

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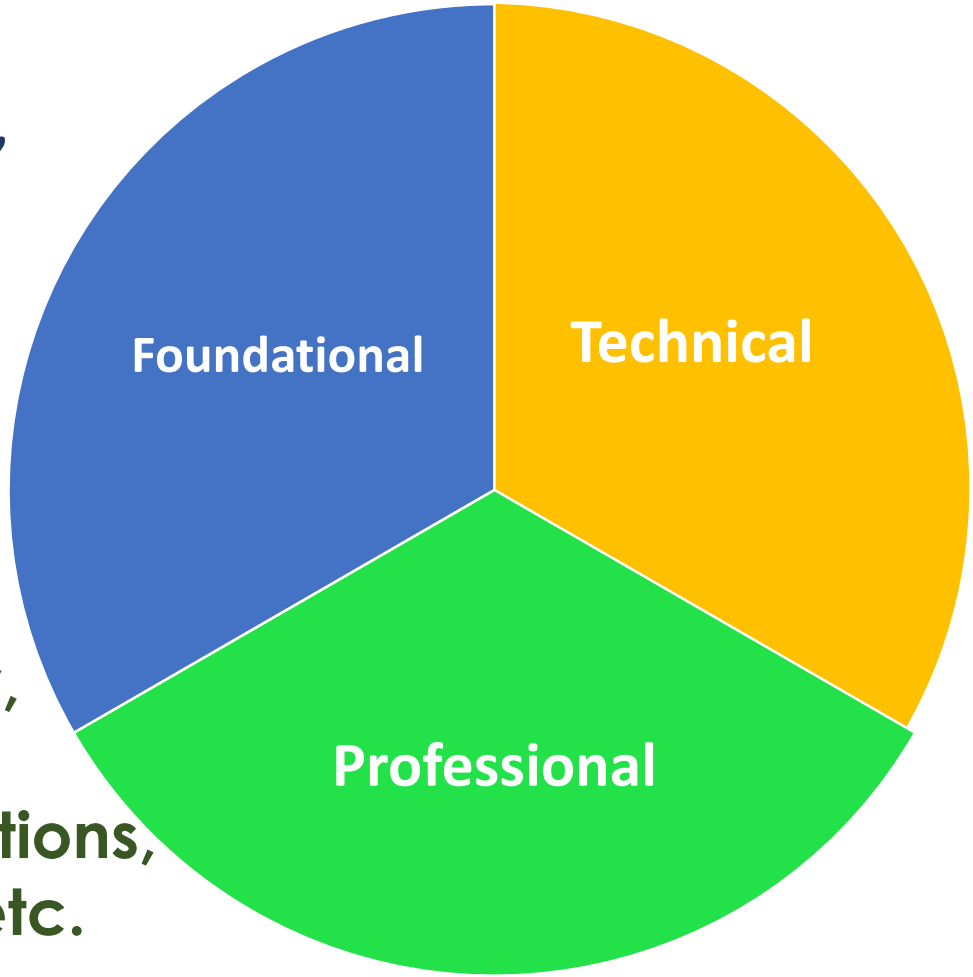
CE-BOK Outcomes: The "WHAT"

Math, Science, Humanities



Mechanics, Design, Problem Solving & Recognition, CE Breadth & Depth, etc.

Business, Public Policy, Leadership, Communications, Teamwork, etc.

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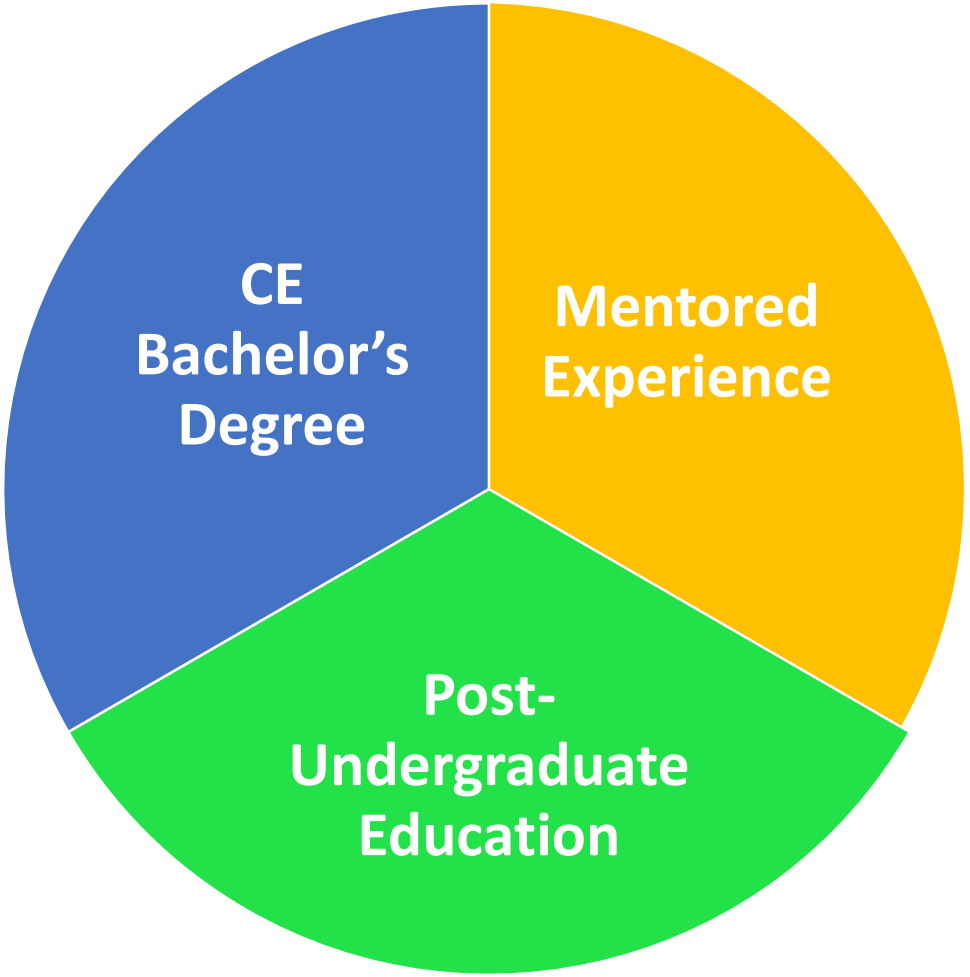
CE-BOK Fulfillment: The "HOW"



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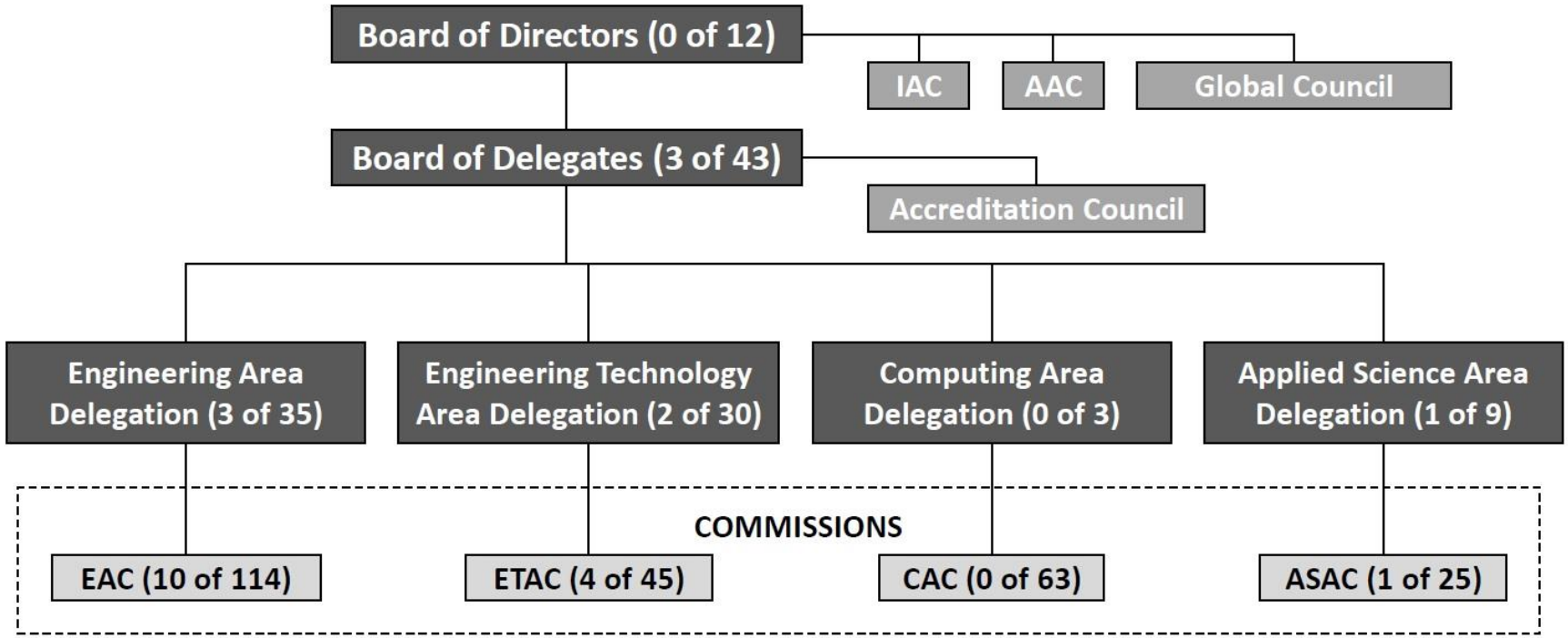
ABET Governance Structure

(with ASCE representation)



Program Criteria for Civil Engineering and Similarly Named Programs

- Lead Society: American Society of Civil Engineers

- 1. Curriculum: The curriculum must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science; apply probability and statistics to address uncertainty; analyze and solve problems in at least four technical areas appropriate to civil engineering; conduct experiments in at least two technical areas of civil engineering, and analyze and interpret the resulting data; design a system, component, or process in at least two civil engineering contexts; include principles of sustainability in design; explain basic concepts in project management, business, public policy, and leadership; analyze issues in professional ethics; and explain the importance of professional licensure.
- 2. Faculty: The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate that it is not critically dependent on one individual.

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CE-BOK and ABET

Event	BOK 2nd Edition	BOK 3rd Edition	BOK 4th Edition
BOK Task Committee organized	Already accomplished	**October 2016**	October 2024
BOK finalized		**September 2018**	September 2026
BOK published		March 2019	March 2027
CE Program Criteria Task Committee organized	October 2012	October 2020	October 2028
Draft CE Program Criteria published	March 2014	March 2022	March 2030
CE Program Criteria approved by ABET EAC (1st reading)	July 2014	July 2022	July 2030
CE Program Criteria approved by ABET Board of Directors/Eng. Area Delegation (1st reading)	October 2014	October 2022	October 2030
Public Review of CE Program Criteria initiated	November 2014	November 2022	November 2030
CE Program Criteria approved by ABET EAC (2nd reading)	July 2015	July 2023	July 2031
CE Program Criteria approved by ABET Board of Directors/Eng. Area Delegation (2nd reading)	October 2015	October 2023	October 2031
First Review Under New CE Program Criteria	September 2016	September 2024	September 2032

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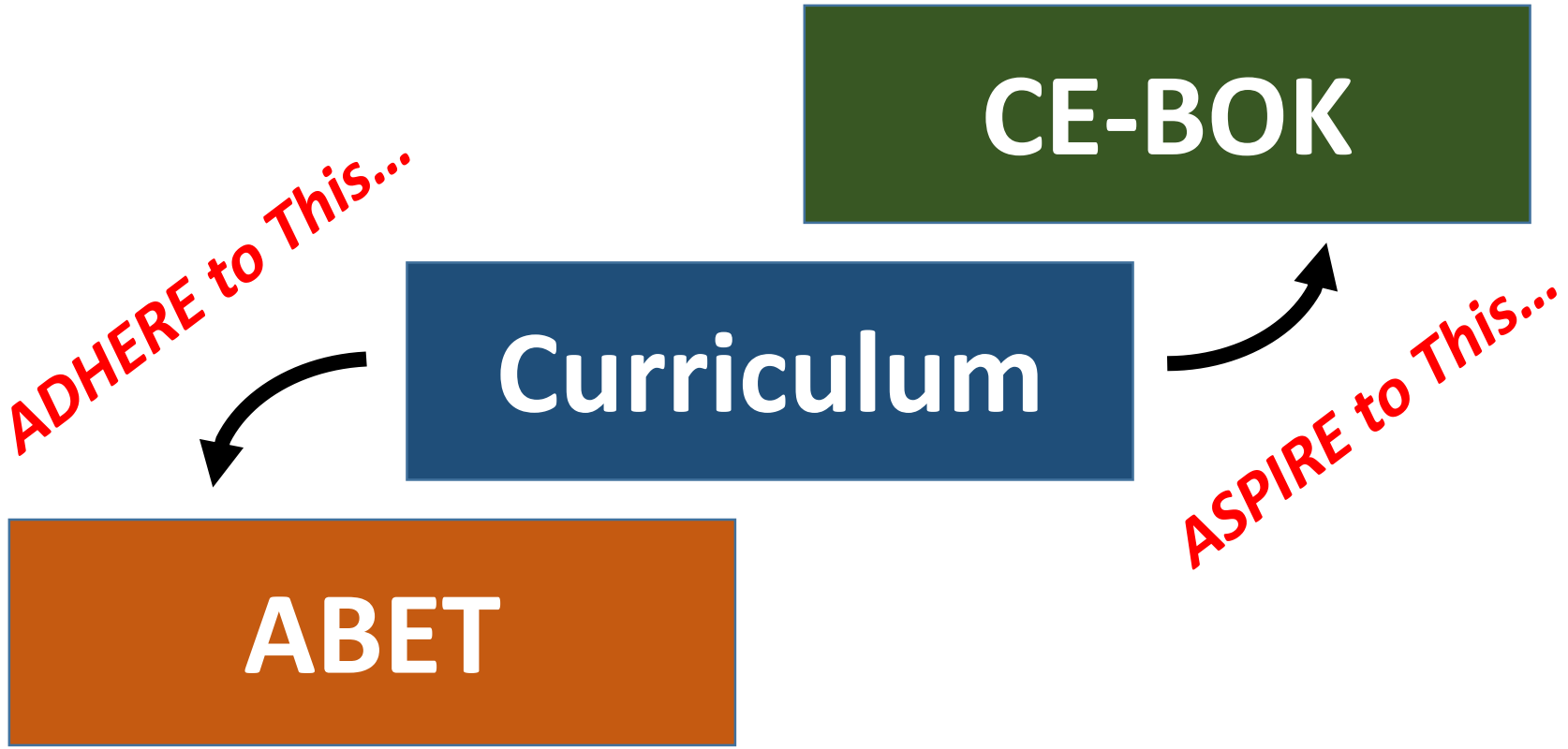
CE-BOK and ABET and Curriculum



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Excellence in Civil Engineering Education

ExCEEd Faculty Teaching Workshops (40)

- **U. S. Military Academy (1999-2013, 2015-2018) -- 19**
- **Univ. of Arkansas (2000-2006, 2008) -- 8**
- **Northern Arizona Univ. (2002-2003, 2007, 2009) -- 4**
- **Univ. of Colorado at Boulder (2010) -- 1**
- **Univ. of Texas at Tyler (2011) --1**
- **Florida Gulf Coast Univ (2012 – 2018) --7**

Course Organization

- Seminars
  - All 24 participants together.
  - Presentations, discussion, and small group work.

Seminar Topics

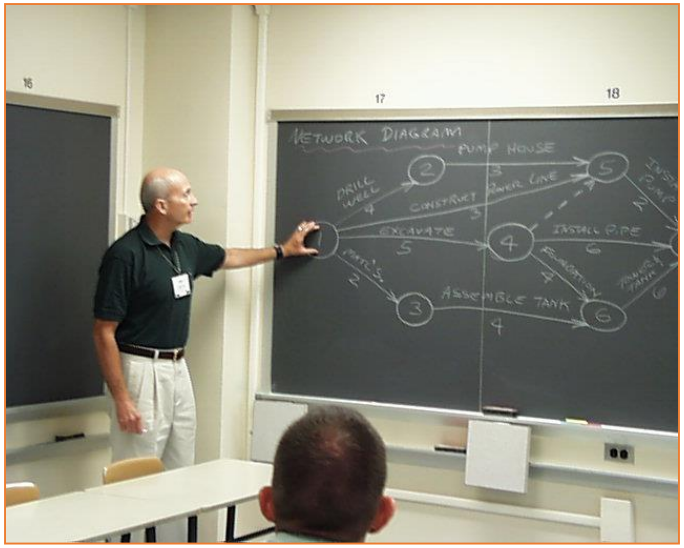
- I: Learning to Teach
- II: Principles of Effective Learning and Teaching
- III: Teaching Assessment
- IV: An Introduction to Learning Styles
- V: Learning Objectives
- VI: Planning the Class
- VII: Classroom Assessment Techniques
- VIII: Communication Skills: Writing and Speaking
- IX: Communication Skills: Questioning
- X: Non-verbal Communication
- XI: Systematic Design of Instruction
- XII: Making ExCEEd Work at Your Institution
- XIII Interpersonal Rapport

Course Organization (cont'd)

- Demonstration Classes
  - All 24 participants together.
  - ExCEEd faculty model effective teaching techniques.
  - Participants role-play as students.

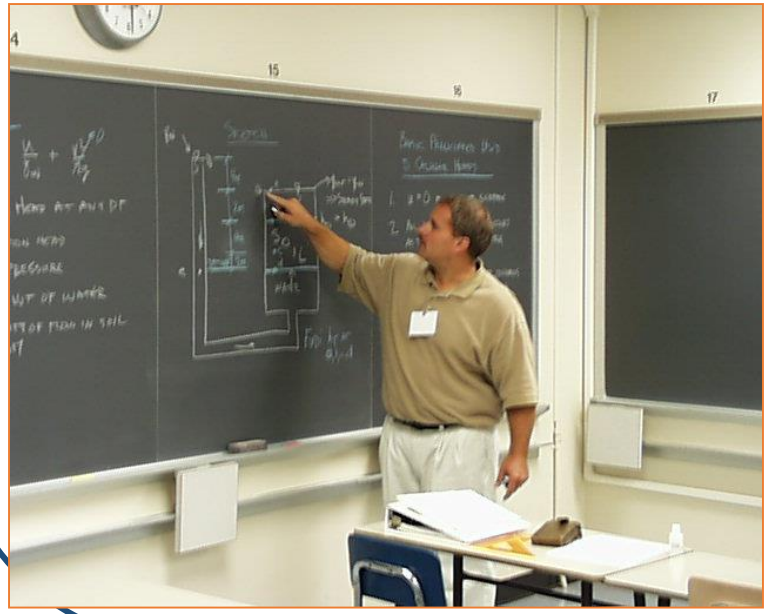
Course Organization (cont'd)

- Labs
  - 6 groups
    - 4 participants
    - 1 mentor
    - 1 assistant mentor



Role-Playing

- For All Classes:
  - View the class from the perspective of an undergraduate engineering student.
  - Answer questions accordingly.
  - Ask questions accordingly.



Teaching Assessments

- First Class: Mentor
- Second Class: Peers
- Third Class: Self

Other ETW Activities

- Introductory Banquet or Picnic
- Breaks
- Skits
- Hudson River Cruise or Final Banquet
- Host-University Tour
- ASCE Gift of the Day

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ExCEEd

COURSE SCHEDULE

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8:00		Admin & Gift	Admin & Gift	Admin & Gift	Admin & Gift	Admin & Gift
		Demo Class I	Lab III Practice Class 1	Lab IV Practice Class 2	Lab V Practice Class 3	Interpersonal Rapport
10:00		Principles of Teaching & Learning				ASCE Programs
		Learning Objectives				ETW Assessment
12:00		Lunch	Lunch	Lunch	Lunch	Graduation
		Planning A Class	Teaching Assessment	Lab IV (continued)	Design of Instruction	
2:00		Chalkboard	Demo Class II	Demo Class III	Non-verbal Communi-cation	
	Intro To ETW	Lab II Objectives	Communi-cation Skills	Instructional Technology		
4:00	Learning To Teach					
		Working Dinner & Class Prep			Hudson River Cruise	
6:00	Lab I Team-Building					

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ExCEEd

ExCEEd Graduation

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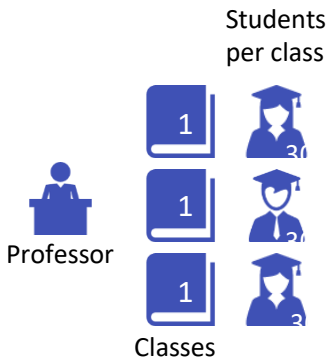
ExCEEd

ExCEEd's REACH
PRIOR TO 2018



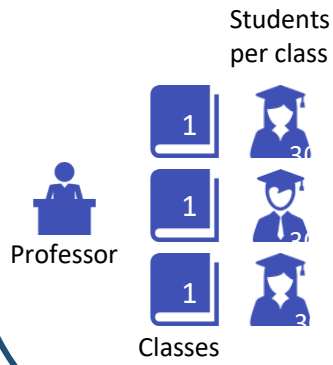
***90** Students per semester*

180 Students per year

X **48** ExCEEd Graduates per summer

= **8,640** Students Affected per Academic Year

ExCEEd's REACH
2018 WORKSHOPS



***90** Students per semester*

180 Students per year

X **72** ExCEEd Graduates per summer

= **12,960** Students Affected per Academic Year

963

ExCEEd Graduates!!

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Concluding Remarks…

- Change is necessary (perhaps overdue??).
- Life-long engineering education is best considered a *system*.
- Each element of the overall engineering eduation system is, itself, a system.
- The totality of our engineering education system must be complementary – all subsystems working towards a common goal.
- In addition to efforts in K-12 and Workforce Development, ASCE is actively 'engineering' formal, university-based education.

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Engineering Education Systems that are Fit for the Future

Turning Ideas into Action: Making Systems Thinking Practical for Engineering Educators

THANK YOU!!!

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