The Reformation of Civil Engineering Education in the United States

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Committee on the Academic Prerequisites for Professional Practice (CAP^3)
Why are we trying to radically change civil engineering education?

What are we doing?

How are we doing it?
Why are we trying to radically change civil engineering education?

What are we doing?

How are we doing it?
“It is evident that the exploding body of science and engineering knowledge can not be accommodated within the context of the traditional four year baccalaureate degree.”

*Educating the Engineer of 2020*

*National Academy of Engineering, 2005*
A Leader No Longer

- Medicine
- Law
- Architecture
- Engineering
- Pharmacy
- Accounting
- Occupational Therapy

Years of Formal Education

- Engineering
- Medicine
- Law
- Pharmacy
- Architecture
- Accounting
- Occupational Therapy

1900 1920 1950 1980 2000 2010
So much to learn —
So little time!
NSPE Professional Policy No. 168

With the continuing rapid expansion of knowledge required to practice . . . , NSPE believes that additional engineering education, beyond the four year ABET/EAC degree, will be required in order to meet the formal academic preparation necessary for the practice of engineering at the professional level (licensure) in the 21st century.

. . . Possible additional requirements could include a master's degree or equivalent.
Why are we trying to radically change civil engineering education?

What are we doing?

How are we doing it?
Historical Perspective

Engineers have been talking about engineering education reform since the late 1800’s

And now -
The American Society of Civil Engineers (ASCE) is leading the reformation of civil engineering education in the United States.
ASCE’s BOK focus is the result of decades of studies such as:

1918: Mann Report
1928: Wickenden Report
1955: Grinter Report
2001: Engineering the Future of CE (ASCE)
2004: The Engineer of 2020 (NAE)
2005: Educating the Engineer of 2020 (NAE)
Recommendations of 1995 ASCE Education Conference


“The ASCE supports the concept of the master’s degree as the First Professional Degree (FPD) for the practice of civil engineering at the professional level”
2001-”The ASCE supports the concept of the Master’s Degree or Equivalent (MOE) as a prerequisite for licensure and the practice of civil engineering at the professional level.”
2004—”The ASCE supports the attainment of the Body of Knowledge (BOK) for entry into the practice of civil engineering at the professional level.”

KNOWLEDGE CENTRIC
Our Profession*

Organization

Ethic of Professional Service

Body of Knowledge

Knowledge, skills, and attitudes necessary to enter into the practice of engineering at the professional level.
BOK – The BIG Picture

1. **Fundamentals** - math, basic science, and engineering science.

2. Technical **breadth**.

3. **Breadth** in the humanities & social sciences.

4. Professional practice **breadth**.

5. Technical **depth** (specialization).
## Civil Engineering Body of Knowledge

<table>
<thead>
<tr>
<th>TECHNICAL</th>
<th>PROFESSIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical core</td>
<td>Inter-disciplinary teams</td>
</tr>
<tr>
<td>Experimentation</td>
<td>Professional &amp; ethical standards</td>
</tr>
<tr>
<td>Design</td>
<td>Communication</td>
</tr>
<tr>
<td>Engineering problems</td>
<td>Impact of engineering</td>
</tr>
<tr>
<td>Engineering tools</td>
<td>Life-long learning</td>
</tr>
<tr>
<td>Specialized area of civil engineering</td>
<td>Contemporary issues</td>
</tr>
<tr>
<td>Project management, construction, and asset mgmt.</td>
<td>Business &amp; public policy</td>
</tr>
<tr>
<td></td>
<td>Leadership</td>
</tr>
</tbody>
</table>
Why are we trying to radically change civil engineering education?

What are we doing?

How are we doing it?
Committee on Academic Prerequisites for Professional Practice (CAP³)
On-going, parallel, and interrelated efforts

- BOK
- Curricula
- Accreditation
- Licensure
- Fulfillment and Validation
- Specialty Certification

- Refining BOK
- Reviewing/changing curricula
- Changing criteria
- Adding education
- Identifying certifiers/validators
- Certifying experts

Vision of Civil Engineering in 2025
Master Plan

Accreditation Criteria

Example Curricula

Accreditation Criteria

Accredited Programs

State Licensing Rules

B + 30 Guidelines

Experience Guidelines

Model Law

Example Language

Policy 465 Implemented In 55 Jurisdictions

Curricula committee
Licensure committee
Accreditation committee
Fulfillment & Validation
Example Paths to BOK Attainment

Path #1
ABET Basic-Level Criteria

Path #2
ABET Advanced-Level Criteria

Validated
BOK-2 Consists of 26 Outcomes

- Encourage accountability and creativity
- Discourage prescription

- Technical: 16
  - Professional: 10
Technical Outcomes

1. Mathematics
2. Physics
3. Chemistry
4. Breadth in basic science
5. Mechanics
6. Materials
7. Breadth in civil engineering
8. Engineering tools
9. Engineering problem recognition and solving
10. Design
11. Experiments
12. Impact of engineering solutions
13. Risk/uncertainty
14. Sustainability
15. Project management
16. Technical specialization
Professional Outcomes

17. Communication
18. History and heritage
19. Globalization
20. Professional and ethical responsibility
21. Public policy

22. Business and public administration
23. Teamwork
24. Leadership
25. Life-long learning
26. Attitudes
How to define desired level of achievement?

Bloom’s Taxonomy
<table>
<thead>
<tr>
<th>Level of achievement</th>
<th>Illustrative verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Evaluation</td>
<td>Critique, decide, judge</td>
</tr>
<tr>
<td>5. Synthesis</td>
<td>Combine, create, plan</td>
</tr>
<tr>
<td>4. Analysis</td>
<td>Analyze, break down, subdivide</td>
</tr>
<tr>
<td>3. Application</td>
<td>Apply, conduct, solve</td>
</tr>
<tr>
<td>2. Comprehension</td>
<td>Describe, discuss, explain</td>
</tr>
<tr>
<td>1. Knowledge</td>
<td>Define, identify, list</td>
</tr>
</tbody>
</table>
Example of a Rubric

<table>
<thead>
<tr>
<th>Level of cognitive achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcome title</td>
</tr>
<tr>
<td>Knowledge</td>
</tr>
</tbody>
</table>

To enter the practice of civil engineering at the professional level, an individual must be able to demonstrate this level of achievement.

**Technical Outcomes**

16 Technical specialization

- **Define** key aspects of advanced technical specialization appropriate to civil engineering (B)
- **Explain** key concepts and problem-solving processes in a traditional or emerging specialized technical area appropriate to civil engineering. (M/30)
- **Apply** specialized tools, technology or technologies to simple problems in a traditional or emerging specialized technical area of civil engineering. (M/30)
- **Analyze** a complex system or process in a traditional or emerging specialized technical area appropriate to civil engineering. (M/30)
- **Design** a complex system or process or create new knowledge or technologies in a traditional or emerging specialized technical area appropriate to civil engineering. (M/30)
- **Evaluate** the design of a complex system or process or evaluate the validity of newly-created knowledge or technologies in a traditional or emerging advanced specialized technical area appropriate to civil engineering. (EPreL)
# Technical Outcomes

<table>
<thead>
<tr>
<th>Technical</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Synthesis</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
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</tr>
<tr>
<td>Physics</td>
<td>B</td>
<td>B</td>
<td>B</td>
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<tr>
<td>Chemistry</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Breadth in basic science</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mechanics</td>
<td>B</td>
<td>B</td>
<td>B M</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth in civil engineering areas</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Engineering tools</td>
<td>B</td>
<td>B</td>
<td>B M</td>
<td></td>
<td></td>
<td>M/30</td>
</tr>
<tr>
<td>Engineering problem solving</td>
<td>B</td>
<td>B</td>
<td>B M</td>
<td></td>
<td></td>
<td>M/30</td>
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<td>Design</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>E</td>
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<tr>
<td>Experiments</td>
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<td>B</td>
<td>B</td>
<td>B</td>
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<tr>
<td>Contemporary Issues &amp; their Relationships to Engineering</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Risk/uncertainty</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Sustainability</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Project management</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Technical specialization</td>
<td>B M/30</td>
<td>M/30</td>
<td>M/30</td>
<td>M/30</td>
<td>M/30</td>
<td>E</td>
</tr>
</tbody>
</table>

Only 2 at the highest level and those are achieved during pre-licensure experience.
## Professional Outcomes

<table>
<thead>
<tr>
<th>Professional</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Analysis</th>
<th>Synthesis</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 Communication</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>18 History and heritage</td>
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<td>B</td>
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<td></td>
<td>E</td>
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<td>19 Globalization</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
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<tr>
<td>20 Prof. &amp; ethical responsibility</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>21 Public policy</td>
<td>B</td>
<td>B</td>
<td></td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Business &amp; public administration</td>
<td>B</td>
<td>B</td>
<td></td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Teamwork</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>24 Leadership</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 Life-long learning</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>E</td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>26 Attitudes</td>
<td>B</td>
<td>B</td>
<td></td>
<td>E</td>
<td></td>
<td></td>
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</tbody>
</table>

**Key:**
- **B** Portion of Body of Knowledge fulfilled through the Bachelor's degree.
- **M/30** Portion of Body of Knowledge fulfilled through the Master's degree or the equivalent.
- **E** Portion of Body of Knowledge fulfilled through pre-licensure experience.

Professional & Ethical responsibility also at highest level.
ACCREDITATION – 10 years needed for implementation

- July 2006: *Criteria (BOK-1) approved by ABET EAC*
- 2006-2007: *Public review period*
- Fall 2008: *First visits* under new Basic-Level Criteria
- 2012: *First graduates* of undergrad programs accredited under new Basic-Level Criteria
- 2016: First graduates of these programs *seek licensure*
- 20??: *Cycle starts again for BOK-2 based Criteria*
The Future Civil Engineer

Body of Specialized Knowledge

Baccalaureate Education

Add’l Education

Experience

Licensure

More Experience, Lifelong Learning, and Specialty Certification

Practice at the Professional Level
Civil engineering is *not going alone*
“We must not walk backwards into the future looking with admiration at where we have been”

---anonymous
Finally--

“It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change.”

Charles Darwin
Information and Knowledgeable Points of Contact

If you have questions or comments, please contact

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Rich Anderson      734-946-4966       roape1@aol.com