Opportunities and Challenges for PtD Education

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Outline

• The Challenges for PtD Education
  • ABET General and Program Criteria
  • Competing emerging topics
• The Opportunities for PtD Education
  • Ethics
  • Social Sustainability
  • Integrated Design and Construction
  • Life Cycle Perspectives
  • Public Policy
Adding Prevention through Design to Civil Engineering Educational Programs

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Introduction
Prevention through design (PtD) (also called design for constructability) influence how much it costs to build, how quickly it can be built, and how easily the quality attributes desired by the client can be achieved (Gambatese et al. 2005; Weinstein et al. 2005; Fonseca et al. 2014; Zhong et al. 2016). [The term “constructability” is mentioned four times in the current civil engineering body of knowledge (ASCE 2008) but is not defined.] Prevention through design adds a fourth criteria to constructability: the safety of the construction worker and maintenance worker. A design’s safety constructability reflects the extent that the design can be constructed by a competent set of construction professionals and maintained without unnecessarily high inherent levels of risk (Tymvios and Gambatese 2015).

Proponents of the PtD concept point to the research performed in the United States (Behm 2005; Weinstein et al. 2005; Gambatese et al. 2008; Rajendran and Gambatese 2013) and around the globe (Bennett 2004; Haslam et al. 2005; Driscoll et al. 2008; Lingard et al. 2014) that shows a connection between design and the inherent

Challenges from ABET

✓ And yet the fundamental ABET accreditation, heavily influenced by the ASCE Committee on Curriculum and Accreditation supports an engineering curriculum that is nearly devoid of safety education and training.
ABET General Criteria

• Criterion 3. Student Outcomes

  “Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.”

• “2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.”
Construction Eng. Program Criteria

- Lead Society: American Society of Civil Engineers
- “These program criteria apply to engineering programs that include “construction” or similar modifiers in their titles.
- The program must prepare graduates to apply knowledge of mathematics through differential and integral calculus, probability and statistics, general chemistry, and calculus-based physics; to analyze and design construction processes and systems in a construction engineering specialty field, applying knowledge of methods, materials, equipment, planning, scheduling, safety, and cost analysis; to explain basic legal and ethical concepts and the importance of professional engineering licensure in the construction industry; to explain basic concepts of management topics such as economics, business, accounting, communications, leadership, decision and optimization methods, engineering economics, engineering management, and cost control.”
Civil Eng. Program Criteria

- Lead Society: American Society of Civil Engineers
- “These program criteria apply to engineering programs that include “civil” or similar modifiers in their titles.
- 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.”
Competing Emerging Topics

✓ “There are large pressures to embrace the increasing body of knowledge while decreasing the credits to earn a bachelor's degree.”
ABET Civil Eng. Program Criteria

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- 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.”
- And what about virtual design and construction (BIM)?
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Adding PtD to Programs

✓ “Fully support integration of Safety throughout our engineering curriculum. It has a place in every class ….”

• 1-2 hour introduction to PtD lecture*
• 10-hour OSHA course
• Add PtD emphasis to existing courses
• Add PtD modules to existing design courses*
• Add PtD requirement to senior design courses
• Offer PtD courses

* free on www
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The Ethics of PtD

✓ ASCE Code of Ethics Canon 1:

“Engineers shall hold paramount the safety, health and welfare of the public ….”

“a. Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering judgments, decisions and practices incorporated into structures, machines, products, processes and devices.”
Annual Construction Accidents in US

- Nearly 200,000 serious injuries
- 1,000+ deaths
The Ethics of PtD

• Do not our duties include minimizing all risks (especially to people) that we have control over?

• Do not we have the same duties for construction and maintenance workers as for the “public”? 

The Ethics of PtD

- ASCE Code of Ethics Canon 8:
  “Engineers shall, in all matters related to their profession, treat all persons fairly and encourage equitable participation without regard to gender or gender identity, race, national origin, ethnicity, religion, age, sexual orientation, disability, political affiliation, or family, marital, or economic status.”
Sustainability and the Triple Bottom Line
Social Sustainability

• Definition of Sustainable Development in Brundtland Commission Report (1987)

• Focus on people as much as on the environment
  – Meet the needs of people who can’t speak for themselves
Sustainable Development

Design and construction that doesn’t unfairly affect people who are not at the table

Further reading:
Social Sustainability Issues

• How will we convince all stakeholders that our project will not unfairly affect people who are not at the table during the concept development, design and construction planning?
  – Building occupants
  – Nearby residents
  – Local politicians and regulators
  – Our employees
  – Construction workers
  – Maintenance workers
Social Sustainability Issues

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  • **Integrated Design and Construction**
    • Life Cycle Perspectives
    • Public Policy
Need for Integrated Design and Construction

✓ “Contractors have superior understanding of construction means and methods, constructability, cranes, sequences of construction and shoring methods....”
✓ “Support Integration and Collaboration!”
✓ “Constructability reviews must be integrated into the overall design process during early design stages. “
✓ “Facilitate communication and collaboration between the designer and the contractor early and often.”
✓ “Be an advocate for alternate contract delivery methods that embrace early contractor involvement and prevent isolation of the contractor and designer.”
Integrated Design and Construction

• Project success requires that design reflects input from all stakeholders, including:
  – Users/occupants
  – Owner facility management personnel
  – Contractors

• Constructability feedback must start early in the design process
Benefits of Integrated Design and Construction

- **Obvious:** Cost, Schedule, Quality
- **Accepted:** Sustainability
- **Emerging:** Prefabrication
- **Emerging:** Safety
PtD Process

Get the right people talking about the right things at the right time!
PtD Design Review

• Hazard identification
  – What construction safety hazards does the design create?

• Risk assessment
  – What is the level of safety and health risk associated with each hazard?

• Design option identification and selection
  – What can be done to eliminate or reduce the risk?
  – Remember the hierarchy of controls……
LEED PtD Pilot Credit

- Identify and document the items found for the following two stages:
  - Operations and Maintenance
  - Construction
- For each stage, complete three stages of analysis:
  - Baseline
  - Discovery
  - Implementation
PtD Process

**Concept**
- Owner
- AE
- GC/CM

- Establish PtD process
- Identify PtD checklists, other tools
- Select primary materials
- Identify opportunities for prefabrication/modular.

**30% Design**
- Owner, AE, GC/CM
- Key trade contractors
- Key equip. manufacturer

- Finalize design aspects to facilitate prefabrication
- Review design checklists
- Perform preliminary hazard analysis
- Apply multi-attribute decision tools
- Select secondary materials

**60% Design**
- Owner, AE, GC/CM
- Key trade contractors

- Use design checklists
- Draft erection plans
- Communicate critical hazards on plans and specs
- Identify needed anchorage points, work platforms

**90% Design**
- Owner, AE, GC/CM
- All trade contractors

- Review safety constructability of all plans, specs
- Identify safety expectations in all contract docs
- Identify safety parameters for subcontracts

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ABET General Criteria

• Criterion 3. Student Outcomes

• “Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.”

• “3. an ability to communicate effectively with a range of audiences

• 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

• 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives”
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Design for Maintenance Safety

• Provide safe access for recurring maintenance/preventive maintenance
  – Lamps, Air Filters, Belts, Valves
  – At height, confined space, awkward ergonomics
• Provide safe minimum approach distance in electrical construction
  – Performing maintenance on switches and circuit breakers
  – Accessing terminal boxes and control panels
• Provide safe clearance for replacing units
  – Blower Units, Boilers, Compressors, Pumps
  – Isolation, Material handling, Path out and in
Public Policy Issues

• Why is PtD required in European Union, Singapore and South Africa, and strongly encouraged in Australia and New Zealand, but not in the United States?

• Does the explanation include differing perceptions about the importance of occupational safety, the appropriate role of the government, or the balance of power of business versus labor in different nations?

• Does the lack of PtD regulations in US reflect pragmatic understanding that even well-intentioned laws can be abused in an excessively litigious society?

• These questions are best discussed with a liberal arts colleague in the room!
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Free PtD Educational Materials

- Concrete
- Steel
- MEP
- Architectural
Welcome to Prevention through Design!

News:

The first in a series of NIOSH-funded Prevention through Design (PtD) workshops will be hosted on March 11, 2020, 8 am – 3:30 pm in Tempe, Arizona. The theme of the first workshop is “CURRENT AND FUTURE STATE-OF-THE-ART ON RESEARCH, PRACTICE, & EDUCATION.” With a roster of
Wrap Up

• Adding PtD to civil & construction engineering curriculum will be challenging but required and emerging curricular topics provides promising opportunities
  • Ethics
  • Social Sustainability
  • Integrated Design and Construction
  • Life Cycle Perspectives
  • Public Policy

• Our students, our citizens and our project site/facility professionals deserve our best effort
Thank you for listening!
Please share your thoughts.

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https://ptd.engineering.asu.edu/
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