College of Engineering

PURDUE'S ENGINEER OF 2020

James McGlothlin: Director: Graduate Program Occupational and Environmental Health Sciences.

Peter Meckl: Co-Chair, Purdue Engineer of 2020 Committee

Michael Harris: Co-Chair, Purdue Engineer of 2020 Committee

Leah Jamieson: John A. Edwardson Dean of Engineering
Presentation Outline

› Introduction – Setting the Stage

› Engineering 2020 – Purdue’s Commitment to the future engineering through today’s students and tomorrow’s leaders.

› Purdue/NIOSH PtD Workshop September 20th, 2011. (*Purdue University, West Lafayette, IN. You are Invited!*)

› Selected Case Studies

› Consortium of Virtual Design of Healthcare Environments.

› Designing Safe Temporary Structures: An Emerging Issue.

Engineer of 2020 Initiative

› Purdue’s Future Engineer: Designing Curricula for the 21st Century

› Phase I:
  - Identify the attributes that will characterize Purdue Engineering graduates of the future

› Phase II: Implementation in the Schools
  - Develop the key attributes of an engineering curriculum that will prepare our students for 21st century careers: a blueprint for curriculum reform

https://engineering.purdue.edu/Engr/Academics/Engineer2020/
### Purdues’s Engineer of 2020 Target Attributes

**Vision:** Purdue Engineers will be prepared for leadership roles in responding to the global technological, economic, and societal challenges of the 21st century.

**Strategy:** We will provide educational experiences that develop students’ knowledge areas, abilities and qualities to enable them to identify needs and construct effective solutions in an economically, socially, and culturally relevant manner.

<table>
<thead>
<tr>
<th>Abilities</th>
<th>Knowledge Areas</th>
<th>Qualities</th>
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</thead>
<tbody>
<tr>
<td>• leadership</td>
<td>• science &amp; math</td>
<td>• innovative</td>
</tr>
<tr>
<td>• teamwork</td>
<td>• engineering fundamentals</td>
<td>• strong work ethic</td>
</tr>
<tr>
<td>• communication</td>
<td>• analytical skills</td>
<td>• ethically responsible in a global, social, intellectual, and technological context</td>
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<tr>
<td>• decision-making</td>
<td>• open-ended design &amp; problem solving skills</td>
<td>• adaptable in a changing environment</td>
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<tr>
<td>• recognize &amp; manage change</td>
<td>• multidisciplinarity within and beyond engineering</td>
<td>• entrepreneurial and intrapreneurial</td>
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<tr>
<td>• work effectively in diverse &amp; multicultural environments</td>
<td>• integration of analytical, problem solving, and design skills</td>
<td>• curious and persistent continuous learners</td>
</tr>
<tr>
<td>• work effectively in the global engineering profession</td>
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<tr>
<td>• synthesize engineering, business, and societal perspectives</td>
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**The Three Pillars of the Purdue Engineering Undergraduate Education**

Red – beyond ABET
Engineer of 2020 Initiative
Phase II - Implementation

› Annual Seed Grant Program

› Annual Engineer of 2020 Workshop for engineering faculty

› Benchmarking (internal and external)

› Sharing of Best Practices Across Schools
Selected Seed Grant Awards

› Project Centered Multidisciplinary Spiral Curriculum as a Model for Developing Purdue's Engineer of 2020
› Incorporating Sustainability Concepts into the Engineering Curriculum
› Assessment of Global Learning Opportunities of Purdue University's College of Engineering
› Development and Assessment of 'Ethics in Engineering Practice': A New Technical Support Elective
› Building and Enhancing Innovation through Design
› The Engineer as an Entrepreneur: Using Case-Driven, Problem-Based Learning to Develop Adaptive Expertise
Purdue Engineer of 2020 Workshops

- 2007 Workshop focused on **Innovation, Multidisciplinarity** and Continuous Learning.

- 2008 Workshop focused on **Ethics, Global** issues and Leadership

- 2009: **Environmental** and Societal Impacts of Engineering Practice

- 2010: Embedding Elements of **Entrepreneurship** into Engineering Courses

- 2011: **Prevention through Design (PtD):** Designing a Safer Tomorrow through Engineering Today (co-sponsored with the National Institute for Occupational Safety and Health: NIOSH)
Educating the Engineer of 2020 Workshop

Prevention through Design: Designing a Safer Tomorrow through Engineering Today

Tuesday, September 20, 2011
Stewart Center, Purdue University
Agenda

Educating the Engineer of 2020 Workshop

Prevention through Design: Designing a Safer Tomorrow through Engineering Today

8:00 am
Continental Breakfast

8:30 – 8:45 am
Welcome: Peter Meckl, Professor of Mechanical Engineering, and Co-Chair, Engineer of 2020 Committee

Opening Remarks: Leah Jamieson, John A. Edwardson Dean of Engineering

Opening Remarks: James D. McGlothlin, Associate Professor of Health Sciences, Director: Graduate Program in Occupational & Environmental Health Sciences

8:45 – 9:45 am
Paul Schulte and Donna Heidel, NIOSH
Overview of Prevention through Design National Initiative
PtD in Engineering Education
PtD in Engineering Textbooks

9:45 – 10:00 am
Break

10:00 – 10:45 am
Keynote Presentation: Deborah Grubbe, President & Owner, Operations & Safety Solutions, LLC

10:45 – 11:30 am
Keynote Presentation: Dennis Warner, President & CEO, Aero Engine Controls, LLC

11:30 am – 1:00 pm
Lunch & Poster Session: 2010 & 2011 Engineer of 2020 Seed Grant Awardees
PtD Student Competition Posters
PMU Faculty Lounges
Agenda

Educating the Engineer of 2020 Workshop

1:15 – 2:15 pm
Describing PtD Curriculum Activities:

**Invited Speaker:** Wayne S. Maynard, Technical Director, Ergonomics & Tribology, Liberty Mutual Research Institute for Safety

**Invited Speaker:** Deborah Young-Corbett, Assistant Professor, Department of Civil and Environmental Engineering, Virginia Tech

2:15 – 3:15 pm
Panel of Faculty describing PtD Activities:
Moderator: Michael Harris, Professor chemical Engineering, Associate Dean, College of Engineering, & Co-Chair, Engineer of 2020 Committee, (featuring ABET/PtD engineering education modules)
Discussion

3:15 – 3:30 am
Break

3:30 – 4:30 pm
Panel of Faculty & Students describing PtD projects:
Moderator: Craig L. Miller, Professor of Computer Graphics Technology, College of Technology
Discussion

4:30 pm
Closing Remarks – Next Steps in PtD and Universities
Paul Schulte, NIOSH
Leah H. Jamieson, John A. Edwardson Dean of Engineering

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PtD Student Competition

A chance for teams of students to design innovative solutions to safety and health concerns in the workplace.

Application areas include manufacturing, chemical processes, health care, and environmental concerns.

Awards will be given to teams based on judges' ranking of their projects. Winners will be featured during the workshop.

All student team projects will be able to describe their ideas during a poster show over lunch.
Purdue Engineer of 2020: Must know facts and how to use them, but also relationships and interdisciplinary connectivity to the world.

Thanks to Professor Karthik Ramani and design@purdue for this slide and the next 3 slides. Type me444 Purdue on YouTube for more design ideas.
Value of design decisions

Cost incurred

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**India Market Share**

- **Maruti Suzuki**: 53%
- **Hyundai**: 21.0%
- **Tata**: 12.0%
- **Mahindra**: 5.8%
- **GM**: 4.0%
- **Honda**: 3.5%
- **Toyota**: 3.4%
- **Ford**: 2.0%

Data: J.D. Power & Associates

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**On the Road**

India's domestic passenger vehicle sales

- 1.5 million
- 1.2 million
- 1.0 million
- 0.8 million
- 0.6 million
- 0.4 million
- 0.2 million

**Note:** Fiscal year ends March 31

Source: Society of Indian Automobile Manufacturers
cost?
PtD Examples – on going research and lessons learned.

› **Prevention** of injuries and fatalities among Wind Turbine workers **through Design**.

› **Prevention** of injuries among laboratory workers with lower limb disabilities (including amputations) **through Design**.

› **Prevention** of radiation exposure and musculoskeletal disorder among nuclear pharmacists **through Design**.

› **Prevention** of injuries related to the use of surgical tools (to perform laparoscopic surgery) **through Design**.

› **Prevention** of knee and back injuries in EMT workers **through Design**.

› **Prevention** of Temporary Structure Collapse through Design.

**Purdue Engineering**
So, if someone suffers an injury or heart attack up here (~300 ft. or 30 stories high), how do we safely and quickly get the worker safely down and alive?
Prevention of injuries among laboratory workers with disabilities through Design.
The sink is not accessible:
• Underneath cabinet
• The depth of the sink

The position of the switch is too high.
Add another light switch on the side of the sink.

Estimating the position of the faucet

Adjustable workstation

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Prevention of radiation exposure through Design.

Fifty percentile female standing at L-Block (lead shield) in Nuclear Pharmacy Simulation.

Ninety-fifth percentile male standing at L-Block (lead shield) in Nuclear Pharmacy Simulation.

Anthropometric measurements
Prevention of radiation exposure through Design.

<table>
<thead>
<tr>
<th>% of Time that Peak Exposures Occur</th>
<th>Optimal Work Practices</th>
<th>Non-Optimal Work Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
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</table>

On average:
Protocol length: Optimal work practices ≈ 2x length of non-optimal work practices
Peak exposures percentage: Optimal work practices ≈ 1/3 of non-optimal practices
Cumulative dose: Optimal work practices ≈ 1/10 of non-optimal work practices


<table>
<thead>
<tr>
<th>Normalized Cumulative Dose in 1 Hour (µSv/µCi)</th>
<th>Optimal Work Practices</th>
<th>Non-Optimal Work Practices</th>
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</table>
Design Adjustable L-block so window height at middle ranges between 143-173.2 cm

Adjust the width to fit smaller worker

Height of Workbench L-Block: 96.9 cm (38.1”)
Height: window middle to floor: 151.05 cm (59.5”)
Eye height of 50-50 mixed male-female population*:
• Mean: 158.1 cm (62.2”)
• Std. Dev: 9.2 cm (3.6”)

Workstation range to fit 90% population with eye height at middle of window:
143 -173.2 cm (56.3”-78.2”)

Prevention of injuries related to the use of surgical tools (to perform laparoscopic surgery) through Design.
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In many instances surgical hand tools are designed for male hands not female hands, yet in many OB/GYN facilities the majority of these surgeons are female.
Prevention of injuries related to the use of surgical tools (to perform laparoscopic surgery) through Design.
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Prevention of injuries related to the use of surgical tools (to perform laparoscopic surgery) through Design.
Prevention of knee and back injuries in EMT workers through Design

• According to the Bureau of Labor Statistics, in 2009 the incident rate for EMTs and Paramedics was $233.5/10,000$ workers
  – This is greater than $7 \times$ the national average of $33.0/10,000$ workers.
Physical Risk Factors among EMTs.

- Patient Handling
- Heavy lifts
- Twisting/bending
- Moving people versus inanimate objects
- Awkward Postures
- Kneeling
- Bending
- Inactivity during down time
- Getting out of shape from poor eating and lifestyle habits
Psychological Risk Factors among EMT’s.

- Post-traumatic stress
- Fatigue
- Burnout
- Coping with death (including children)
- Anxiety/ Depression
- High sympathetic stimulation
Psychological Risk Factors among EMT’s.

› According to the Bureau of Labor Statistics, in 2010 the mean annual wage of EMTs and paramedics was $33,300.

› Many EMS personnel seek additional employment to support their families. Working more than one job may lead to increased risk to develop a MSD due to fatigue.

› Many runs are “non-emergencies” leading to disillusionment and sustained job satisfaction. While other runs are major multiple injury/fatality leading to on the spot life and death decisions leading to mental stress, fatigue and post-traumatic disorders.
Physical and Psychological Stressors among EMTs.
PtD Engineering Temporary Structures: Indiana State Fair Stage Collapse (08/13/2011)

STORM TIMELINE

- 8:39 pm Severe Thunderstorm Warning Issued
- 8:45 pm 60-70 mph wind gust at the fair
- Wind damage occurs before rain begins

What is a Gust Front?
- Cool downdraft ahead of thunderstorms
- Creates strong & damaging wind

Indiana State Fair Winds 60-70 mph
PtD of Temporary Structures: Indiana State Fair Stage Collapse (08/13/2011)

Consortium of Virtual Design of Healthcare Environments

http://www.cvdhe.org

› Engineering Class on Ethics: From Purdue E2020 website.

› Case Example #1: Hyatt Regency Hotel in Kansas City, Missouri Collapse of suspended walkway.

› Case Example #2: Crain Collapse in New York City.
Engineering Ethics

1981 Kansas City Hyatt Regency Skywalk Collapse

MSE 497
Credit to Prof. Rod Trice
Purdue University

Credit to Professor Rod Trice for the next 5 slides.
On July 17, 1981, the Hyatt Regency Hotel in Kansas City, Missouri, held a videotaped tea-dance party in their atrium lobby. With many party-goers standing and dancing on the suspended walkways, connections supporting the ceiling rods that held up the second and fourth-floor walkways across the atrium failed, and both walkways collapsed onto the crowded first-floor atrium below. The fourth-floor walkway collapsed onto the second-floor walkway, while the offset third-floor walkway remained intact. As the United States' most devastating structural failure, in terms of loss of life and injuries, the Kansas City Hyatt Regency walkways collapse left 114 dead and in excess of 200 injured. In addition, millions of dollars in costs resulted from the collapse, and thousands of lives were adversely affected.

http://ethics.tamu.edu/ethics/hyatt/hyatt1.htm
The Original Design of the Walkway

- W4 box beams carry only the mass of the 4th floor (structure and people). This weight is transferred through the 4th floor nuts to the rod, which is attached to the roof.

- W2 box beams carry only the mass of the 2nd floor (structure and people). This weight is transferred through the 2nd floor nuts to the rod, which is attached to the roof.

2D Image shows side view of the skywalks
W4 box beams now held the W4 (structure and people) and the W2 (structure and people). The weight of W4 and W2 was transferred to the upper rod through the bottom nuts on the 4th floor.

The approx. 2x load on the 4th floor walkway cracked the under weld in beams near each of the bottom nuts. The nuts, with 2x load on them, deformed through the cracked box beam, releasing the 4th floor skywalk. This collapsed to the 2nd floor, which collapsed to the first floor.

2D Image shows side view of the skywalks
Case Study Example

Failure of the As-Constructed Design

Note: the steel rods never yielded.
Case Study Example

Photographs of the Destruction

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November, 1984: Duncan, Gillum, and G.C.E. International, Inc. found guilty of gross negligence, misconduct and unprofessional conduct in the practice of engineering. Subsequently, Duncan and Gillum lost their licenses to practice engineering in the State of Missouri, and G.C.E. had its certificate of authority as an engineering firm revoked.
Other examples of poor design and possible ethical issues in engineering

- Ford Pinto Recall – Exploding Gas Tanks
- Dan Applegate and the DC-10
- Wm. LeMessurier and the Citicorp Building
- Chernobyl
- Three Mile Island
- Ford Explorer Rollover
- Ceiling Collapse and Boston’s Big Dig
Engineering and Ethics: Incident in 2008.

http://bcove.me/jtn53rd0
Questions?

Neil Armstrong Engineering Building

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