HUMAN-CENTERED SUSTAINABLE PRODUCT DESIGN: DESIGNING FOR DIVERSITY IN ENGINEERING EDUCATION
How can we design engineering courses that attract and retain women & ethnic minorities?
How does Human-Centered Sustainability Service Learning content affect Project preferences A-K ABET criteria confidence of Women Ethnic minority students
E10: ENGINEERING DESIGN AND ANALYSIS

- General Introduction (3 wks)
- First Module (6 wks)
  - Mechanical Engineering
  - Civil Engineering
  - Industrial Engineering
  - Nuclear Engineering*
- Second Module (6 wks)
  - Mechanical Engineering
  - Civil Engineering
  - Industrial Engineering
  - Nuclear Engineering*
Mechanical Engineering Module
“Human-Centered Sustainable Product Design”

- User Research
- Brainstorming
- Concept Selection
- Prototyping
- User Testing
- Presentation
EXAMPLE PROTOTYPES

- PV Solar
- Solar Thermal
- L.A.S.E.R
- Smart Lighting
- Seguro Pesticide Protection Clothing
- Acara Firefly
- Black Cloud
- Sensorship
- Sustainable Culturally-Sensitive Housing
- Pomo Nation
- iBea
- San Francisco Dutch Windmill
Does the ME module affect students’ confidence in A-K ABET Criteria skills? Is this different for women and ethnic minority students? Do women and ethnic minority engineering students prefer different types of design problems?
RESULTS
<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th></th>
<th>2009</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Class</td>
<td>Module 1</td>
<td>Module 2</td>
<td>Full Class</td>
</tr>
<tr>
<td>Total Students</td>
<td>174</td>
<td>65</td>
<td>58</td>
<td>142</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
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<tr>
<td>Women</td>
<td>45</td>
<td>17</td>
<td>12</td>
<td>34</td>
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<tr>
<td>Men</td>
<td>129</td>
<td>48</td>
<td>46</td>
<td>108</td>
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<td>Ethnicity</td>
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</tr>
<tr>
<td>African-American</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Chicano</td>
<td>18</td>
<td>6</td>
<td>6</td>
<td>14</td>
</tr>
</tbody>
</table>
Project Preferences

• Women preferred…
  – projects serving underrepresented communities (Seguro, Pinoleville Pomo Nation)
  – education-related projects (Black Cloud, Mobile Learning)

• Men preferred…
  – “traditional” engineering projects (Bicycle Transportation, Wind Energy, Smart Lighting)
Average Confidence, Before ME Module 1 (2009)

- Strong Analytical Skills
- Creativity
- Develop Design
- Engineering Problems
- Communication
- Team Skills
- Leadership
- Ethical
- Dynamic/Agile/Resilient
- Use Techniques and Tools of Engineering Practice
- Recognize Global Impact

Women

Men
Δ Confidence, after ME Module 1 (2009)

- Strong Analytical Skills
- Creativity
- Develop Design
- Engineering Problems
- Communication
- Team Skills
- Leadership
- Ethical
- Dynamic/Agile/
- Use Techniques and Tools of Engineering Practice
- Recognize Global Impact

- Analysis
- Problem Solving
- Teams

- Statistically Significant, by Gender
- Statistically Significant, combining Men & Women

- Women
- Men
QUALITATIVE RESULTS
“I chose the material testing because I know people who would actually be affected by these suits. It would be a great opportunity to aid them in any way.”

“I liked the Pomo Nation project the best because I thought it would be really interesting to design an entirely green building; there are so many options it would be fun to come up with the best options that would best fit the needs of the nation.”

SUBJECT MATTERS
“I enjoyed learning and practicing the design process. I absolutely loved being able to be creative and feeling that I could make a difference in the world around me.”

“The class was very useful in getting students' creative natures to come out. It showed how design is a very important part of engineering. I like the whole design project.”

CREATIVE IMPACT
“I hated this module [...] It communicated what Human Centered Design is, but that is not what all of Mechanical Engineering is. I would actually be turned away from Mechanical Engineering if this module was my first introduction to it and I hadn't competed in over 20 robotics seasons and had years of experience in outside of High School that taught me what Mechanical Engineering can be.”

(FEW) EXCEPTIONS
Summary & Questions

Before/After Skill Improvement

Male
- Ability to Solve Engineering Problems
- Team Skills
- Recognize Global Impact

Female
- Ability to Solve Engineering Problems
- Strong Analytical Skills
- Develop Designs to meet Objectives
- Recognize Global Impact

Discussion Questions

- How do we frame the design problems that engineering students tackle?
- How could this extend to K-12 education to recruit better engineering diversity?
- How are we defining “engineering”? How is this reflected in engineering curricula?
- Which of the A-K criteria are most important for sustainable design?
Upload/ Download Sustainable Design Lecture Slides, Exercises, Tools, etc.

www.planetcares.org
BACKUP SLIDES
Combined Initial Skill Confidence

- Possess strong analytical skills
- Exhibit creativity and practical ingenuity
- Ability to develop designs that meet needs, constraints and objectives
- Ability to identify, formulate, and solve engineering problems
- Good communication skills with multiple stakeholders
- Good team skills with people from diverse backgrounds and disciplines
- Leadership and management skills
- High ethical standards and a strong sense of professionalism
- Dynamic/agile/resilient/flexible
- Ability to learn and use the techniques and tools used in engineering practice

Women
Men

Possess strong analytical skills
Exhibit creativity and practical ingenuity
Ability to develop designs that meet needs, constraints and objectives
Ability to identify, formulate, and solve engineering problems
Good communication skills with multiple stakeholders
Good team skills with people from diverse backgrounds and disciplines
Leadership and management skills
High ethical standards and a strong sense of professionalism
Dynamic/agile/resilient/flexible
Ability to learn and use the techniques and tools used in engineering practice
<table>
<thead>
<tr>
<th>A-K ABET General Criteria</th>
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</thead>
<tbody>
<tr>
<td>Analytical Skills</td>
</tr>
<tr>
<td>Creativity and Practical Ingenuity</td>
</tr>
<tr>
<td>Develop Designs that meet needs, constraints and objectives</td>
</tr>
<tr>
<td>Ability to identify, formulate, and solve engineering problems</td>
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<tr>
<td>Ability to learn and use the techniques and tools used in engineering practice</td>
</tr>
<tr>
<td>Ability to recognize the global, economic, environmental, and societal impact of engineering design and analysis</td>
</tr>
</tbody>
</table>
2008 Module 2 Preferences

Smart lighting
Bicycle
Transportation
Portable Electronic Devices
Dorm Room Furnire
Hesse Hall
SEGURO
Composting at Cal
Pinoleville Pomo Nation
Women
Men
2009 Module 1 Preferences

- Smart Lighting
- Black Cloud
- PPN Solar Thermal
- PPN Renewable
- Mobile Learning
- Greening Your Dorm
- Seguro
2009 Module 2 Preferences

- Smart Lighting
- Greening your Dorm
- Wind Energy in Golden Gate Park
- PPN Sustainable Building Design
- Black Cloud
- Seguro
- Mobile Learning

The bar chart compares preferences between women (blue) and men (light blue) for the above topics.
Project Preferences

• 2008 ME Module 2
  – Seguro Materials Testing ($M<W$)
  – Bicycle Transportation ($M>W$)

• 2009 ME Module 1
  – Mobile Learning ($M<W$)

• 2009 ME Module 2
  – Mobile Learning ($M<W$)
  – Seguro Materials Testing ($M<W$)
## Project Choices

<table>
<thead>
<tr>
<th>2008 Module 2</th>
<th>2009 Module 1</th>
<th>2009 Module 2</th>
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<tbody>
<tr>
<td>Smart Lighting</td>
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<td>Smart Lighting</td>
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<tr>
<td>for Pesticide Protection</td>
<td>for Pesticide Protection</td>
<td>for Pesticide Protection</td>
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<tr>
<td>Pinoleville Pomo Nation (PPN) Sustainable Building</td>
<td>PPN Solar Thermal Energy</td>
<td>PPN Solar Thermal Energy</td>
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<tr>
<td>Dorm Room Furniture</td>
<td>PPN Renewable Electricity</td>
<td>Pinoleville Pomo Nation (PPN) Sustainable Building</td>
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<td>Bicycle Transportation</td>
<td>Greening Your Dorm</td>
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<tr>
<td>Humanizing Hesse Hall Composting at Cal</td>
<td>Black Cloud – Art and Technology for Sustainability</td>
<td>Black Cloud – Art and Technology for Sustainability</td>
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<tr>
<td></td>
<td>Mobile Learning</td>
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<tr>
<td></td>
<td></td>
<td>Wind Energy in Golden Gate Park</td>
</tr>
</tbody>
</table>
Qualitative Comments

• Not just a benefit to the minority…
  – “Today, we had our innovation workshop at the PPN reservation in Ukiah. Man-where to begin! Overall, I'd have to say the experience was a positive one. I mean yes, it was a bit of a hassle getting there and it was certainly a very long day, but I feel that the knowledge gained about the PPN people and their needs . . . It was a productive/informative day, and I look forward to beginning the design process with my team mates.” (Asian Male Student, PPN)