Same courses, different outcomes?
Variations in Confidence, Experience, and Preparation in Engineering Design

Center for the Advancement of Engineering Education

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Conceptual Foundation

- Underrepresentation of women in engineering
- Design is a key aspect of engineering academic experience
- Confidence linked to preparation, persistence
- Role of gender & racial/ethnic background
Research Questions

Do…

- **confidence** to do design
- **quantity** of design in engineering coursework
- **preparation** to do design

vary with…

- gender
- racial/ethnic group
- class standing of engineering students?
Sample

• Longitudinal Cohort
  – True-longitudinal subset of 2nd and 4th year engineering students (n=110)

• Respondents
  – Racial/Ethnic Majority group (n=73)
    • White, Asian American/Asian
  – Underrepresented Minority (URM) group (n=37)
    • African American/Black, Latino, Multicultural
  – Women make up about 38% of each group
  – No majority students from UPri, half of URM students from UPri
Instrument

- Three design-focused questions on the Persistence in Engineering (PIE) survey:
  - How confident the student is in her or his ability to do design
  - How often the student engaged in design activities in the current academic year (quantity)
  - How well courses are preparing the student to do design (quality)
- Each question included a list of 8 design activities rated on a Likert scale
- Mann-Whitney U statistical test, p-values adjusted to account for Type I error
## Engineering Design Activities

<table>
<thead>
<tr>
<th>Full wording as presented in questions</th>
<th>Abbreviated Name Used for Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining what the problem really is</td>
<td><strong>Problem definition</strong></td>
</tr>
<tr>
<td>Searching for and collecting information needed to solve the problem</td>
<td><strong>Gathering information</strong></td>
</tr>
<tr>
<td>Thinking up potential solutions to the problem</td>
<td><strong>Generating ideas</strong></td>
</tr>
<tr>
<td>Detailing how to build the solution to the problem</td>
<td><strong>Modeling</strong></td>
</tr>
<tr>
<td>Assessing and passing judgment on a possible or planned solution to the problem</td>
<td><strong>Feasibility analysis</strong></td>
</tr>
<tr>
<td>Comparing and contrasting two solutions to the problem on a particular dimension such as cost</td>
<td><strong>Evaluation</strong></td>
</tr>
<tr>
<td>Selecting one idea or solution to the problem from among those considered</td>
<td><strong>Decision</strong></td>
</tr>
<tr>
<td>Communicating elements of the design in sketches, diagrams, lists, and written or oral reports</td>
<td><strong>Communication</strong></td>
</tr>
</tbody>
</table>
Overview of the Findings

• Students in both their 2nd and 4th years felt confident in their design abilities and that their courses are preparing them well.

• Women
  – are less confident in their design abilities and feel less prepared by their courses than men, though...
  – engaged in design activities in their coursework as often as men

• Gender differences within majority group account for gender differences in overall sample.

• No significant gender differences observed among URM students in the study.
Confidence

• Average confidence level rated “good” to “very good”

• **Majority Group:**
  Men > Women on 5 activities in Y2, 2 activities in Y4

• **URM Group:**
  No significant gender differences
Majority Group: Confidence by Gender

Year 2

Confidence in ability to perform design activities, Year 2

Asterisks indicate significant gender differences ($p \leq 0.014$, Mann–Whitney U; $n = 27$ women + 46 men).
Majority Group: Confidence by Gender

Year 4

Confidence in ability to perform design activities, Year 4

- Problem definition*
- Gathering information
- Generating ideas
- Modeling*
- Feasibility analysis
- Evaluation
- Decision
- Communication

Asterisks indicate significant gender differences ($p \leq 0.014$, Mann–Whitney U; $n = 27$ women + 46 men).
Preparation

• Average preparation level rated “well” to “very well”

• Majority Group:
  Men > Women on 6 activities in Y2,
  no difference in Y4

• URM Group:
  No significant gender differences
Quantity

• Students typically said they engaged in each of the design activities from “2-3 times a week” to “1-2 times a month”

• No significant gender differences
Discussion

• Students are **confident** in their design abilities and believe that their courses are **preparing** them well.

• Women
  – are less **confident** in their design abilities and feel less **prepared** by their courses than men, though…
    – they say they engage in design activities in their coursework as **often** as men

• Gender differences within majority group responsible for gender differences in overall sample.

• No significant gender differences observed among URM students in the study.
Discussion, continued

• What accounts for the difference in confidence and preparation to do design, if women and men engage in design equally often?
  - Different choices of courses and majors?
  - Different standards of confidence, preparation?
  - Different source of preparation for women, e.g. extracurricular activities / employment?
  - Qualitatively different gendered experiences in design classes?
  - Other?
Discussion, continued

• What accounts for the findings of gender differences among majority students but not among URM students?
  – Institutional effects?
    • While still in the minority among engineering students, UPri women comprise 70% of the overall student body.
    • For example, Fleming *et al.* showed that the significant difference in gendered experiences among the APS students was the relative lack of role models for women.
  – Effects of other affiliations/life experiences?
    • For example, Donaldson *et al.* described a difference in confidence between students at different SES levels.
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