Enabling Engineering Student Success
Using Research to Inform Engineering Education Decisions

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Center for the Advancement of Engineering Education

► Academic Pathways Study
► Studies of Engineering Educator Decisions
► Engineering Teaching Portfolio Program
► Institute for Scholarship on Engineering Education

► 7-year grant
► 100+ researchers at 16 institutions

CAEE Leadership team: Robin Adams, Cynthia Atman, Sheri Sheppard, Lorraine Fleming, Larry Leifer, Ronald Miller, Barbara Olds, Karl Smith, Reed Stevens, Ruth Streveler, Jennifer Turns
CAEE Final Report

Available at www.engr.uw.edu/caee

Talk overview

1. FACULTY
   - Studies of Engineering Educator Decisions (SEED)

2. STUDENTS
   - Academic Pathways Study (APS)

3. INFORMING TEACHING DECISIONS
Talk overview

1. FACULTY
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3. INFORMING TEACHING DECISIONS

Teaching decisions

Decision as a commitment to action

Outline
- What and why
- Our Study
- Findings
Teaching decisions

Why teaching decisions?
Studies of Engineering Educator Decisions (SEED)

Approach

- Critical decision method interview: A planning and an interactive decision; also demographics, teaching history, process for making decisions
- 31 participants, all ranks, 9 of 10 departments, volunteer
- One-hour interviews

General findings

- All but one educator responded by talking about decisions.
- References to time were pervasive.
- Few information sources were mentioned.
- Faculty talked about engaging in some teaching practices that are theoretically linked to motivation.
How do the educators take learners into account in their teaching decisions?

► Why: Being “learner-centered” is a best practice, yet has divergent meanings
  • From *How People Learn*: Effective learning environments are learner-centered...
  • From research on teaching conceptions: More effective teachers have “learner-centered” rather than “instructor-centered” conceptions.

► Can we explore learner-centeredness with our data?

Differentiating based on learner characteristics

► Knowledge (18 of 31)
► Behavior (29 of 31)
► Educational classifications (22 of 31)
► Social classifications (14 of 31)

Faculty in this sample were taking learners into account. How can we help with a next step...
Challenges in learner-centered decision-making

- Learner information is only one type of information.
- Limited time to get to know students
- ...
- What can faculty know about students?

What can we know about students?
## Talk overview

### 1. FACULTY

1. **Studies of Engineering Educator Decisions (SEED)**

### 2. STUDENTS

#### Academic Pathways Study (APS)

- **APS lead:** Sheri Sheppard
- **APS team:** Cynthia Atman, Lorraine Fleming, Ronald Miller, Karl Smith, Reed Stevens, Ruth Streveler

### 3. INFORMING TEACHING DECISIONS
APS research methods & samples

- National Survey of Student Engagement
- \(N = 11,819\); matched pairs (first-year and senior) from 247 institutions

Longitudinal cohort (2003–2007)
- Surveys, structured interviews, ethnographic interviews and observations, engineering design tasks
- \(N \approx 160\,*\) from four campuses

Broad national sample (Spring 2008)
- APPLES2 survey
- \(N = 4,266\,*\) cross-sectional sample from 21 engineering colleges

- Interviews
- \(N = 101\), early-career engineers at a range of private and public organizations

*Oversampled for underrepresented groups

SELECTED APS FINDINGS

Successful engineering students

► Learning skills and language of engineering, e.g., teamwork, communication
► Becoming more confident with design
► Developing identity as engineers
► Better understanding what engineers do, e.g., through co-ops, internships
► Good persistence rates, but little in-migration
SELECTED APS FINDINGS

Challenges

► Heavy workload, competitive culture
► Disconnect between early math/science courses and “real engineering”
► Difficult transition from individual work on “textbook” problems to teaming on open-ended problems
► Gendered experiences, confidence

Which three are the most important?

Contemporary issues            Life-long learning
Societal context               Data analysis
Global context                Math
Conducting experiments        Creativity
Professionalism              Design
Management skills            Ethics
Science                      Engineering analysis
Business knowledge          Teamwork
Leadership                   Communication
Engineering tools            Problem solving
2. STUDENTS

Importance (seniors)

- Societal context
- Global context
- Contemporary issues

2. STUDENTS

Preparedness (seniors, self-report)

- Global context
- Contemporary issues
- Societal context
The well-rounded engineer

► Understanding engineering as discipline and profession
► Life-long learning
  “...the engineer of 2020 will learn continuously throughout his or her career, not just about engineering but also about history, politics, business, and so forth.”
► Consideration of broader context
  “Successful engineers in 2020 will, as they always have, recognize the broader contexts that are intertwined in technology and its application in society.”
2. STUDENTS

Motivation to study engineering

Seniors

\[ N = 1,130 \]

Mean score

<table>
<thead>
<tr>
<th>Motivational construct</th>
<th>Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrinsic psychological</td>
<td>80</td>
</tr>
<tr>
<td>Intrinsic behavioral</td>
<td>90</td>
</tr>
<tr>
<td>Social good</td>
<td>60</td>
</tr>
<tr>
<td>Financial</td>
<td>40</td>
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<tr>
<td>Mentor influence</td>
<td>20</td>
</tr>
<tr>
<td>Parental influence</td>
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</tbody>
</table>

2. STUDENTS

Pathways through engineering curriculum

1 2 3 4

Pathways through real life
2. STUDENTS

What counts as engineering?

1. "idealized world"
   - well-defined problems
   - individual
   - single solution

2. "real world"
   - open-ended problems
   - teams
   - multiple solutions

ENGINEERING COMPARED WITH OTHER MAJORS
Engagement and outcomes scales

**HIGH**
- First-year higher order thinking practices
- First-year gains, practical competence
- Senior gains, practical competence

**LOW**
- First-year gains, general education
- Senior gains, personal & social development
- Senior integrative learning practices
- Senior reflective learning practices
2. STUDENTS

Important design activities, changes

**down in Year 4**
- Visualizing***
- Planning*
- Communicating*
- Using creativity
- Building
  ...

**up in Year 4**
- Identifying constraints***
- Iterating**
- Modeling
- Evaluating
- Prototyping
  ...

*p < 0.05, **p < 0.01, ***p < 0.001; N = 89

2. STUDENTS

Alternating design tasks

1. Midwest floods
2. Street crossing
3. Midwest floods
4. Street crossing

29
Midwest floods design task

10-minute, paper-and-pencil design task

“Over the summer the Midwest experienced massive flooding of the Mississippi River. What factors would you take into account in designing a retaining wall system for the Mississippi?”

Year 3 floods task responses
2. STUDENTS

Floods coding scheme

- **Broad context** factors: social, natural, riverbank, surroundings, etc.
  - “aesthetic appeal – is it going to draw local complaint?”
  - “the surrounding habitat – make sure little or no damage is done to the environment”
  - “would wall impact use of the river by industry?”

- **Close context** factors: technical, wall, logistical, water, etc.
  - “cost of materials”
  - “check the budget available for the operation”
  - “how to contain the river water that has flooded out”
2. STUDENTS

More factors in Year 3

- Year 1: 6 factors
- Year 3: 15 factors

$N = 69$ (longitudinal sample)
$p < 0.001$ (total factors)

More close context in Year 3

- Year 1: 8 close, 4 broad
- Year 3: 10 close, 12 broad

$N = 69$ (longitudinal sample)
$p < 0.001$ (total factors and close context factors)
Gender differences

► Important design activities
  - Women were less likely to select *Building*, more likely to select *Seeking information* and *Goal setting*.

► Midwest floods
  - Women cited more factors than men.
  - Specifically, women cited more *broad context* factors than men.
Early career engineers

- Perception of not doing a lot of “real engineering”
  “I don’t feel like I’ve had to actually do engineering”
- Problems highly uncertain, ambiguous, complex
  “In the real world, it’s a lot more difficult to model things...There’s a lot more variables involved...”
- More practical, hands-on work
  “There’s no mathematical formula you could use, like you would in school...”

The well-rounded engineer

- Understanding engineering as discipline and profession
- Life-long learning
  “...the engineer of 2020 will learn continuously throughout his or her career, not just about engineering but also about history, politics, business, and so forth.”
- Consideration of broader context
  “Successful engineers in 2020 will, as they always have, recognize the broader contexts that are intertwined in technology and its application in society.”
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Local Inquiry Questions

► **Awareness of engineering careers:**
Are there courses/programs that show students the wide range of engineering careers?

► How well do you understand similarity and variability in your students’ motivation, background, interests, learning challenges, confidence, and future plans?

► How many areas beyond math, science, and analysis would students list as important components of engineering?

See Appendix D
3. INFORMING TEACHING DECISIONS

Local Inquiry Questions

► Do your students consider global, environmental, societal, economic, and cultural context in engineering design?
► When and where do your students develop the skills required to be self-directed learners?
► Do you help your students reflect on their industry (e.g., internship) and research experiences and integrate them into their understanding of the engineering profession?

See Appendix D

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See the final report for references:

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