
Cynthia Atman, Sheri Sheppard, Lorraine Fleming, Ronald Miller, Karl Smith, Reed Stevens, Ruth Streveler
Center for the Advancement of Engineering Education
ASEE 2009, Austin, TX 2009 June 16

Based upon work supported by National Science Foundation Grant No. ESI-0227558. Opinions, findings and conclusions or recommendations expressed in this material are the authors’ and do not necessarily reflect the views of the NSF.

Acknowledgements
► Current and former advisory board members
► Special thanks to Denice D. Denton
(image courtesy M. Klawe)

Plan for session
► Introduction to CAEE
► Academic Pathways Study (APS)
  - Overview
  - Three selected findings
► Small-group discussion of implications
► Large-group discussion with panel

Center for the Advancement of Engineering Education
► Addressing three aspects of engineering education
  - Students: Academic Pathways Study (APS)
  - Faculty: Studies of Engineering Educator Decisions (SEED), Jennifer Turns
  - Building rigorous research capability: Institute for Scholarship on Engineering Education (ISEE), Robin Adams
Academic Pathways Study
Sheppard (lead), Atman, Fleming, Miller, Smith, Stevens, Streveler

- Large-scale, multi-method study of undergraduate engineering students
- 3 cohorts of engineering student participants
- Multiple groups of early-career engineers
- Additional analysis of national survey data

Research on the engineering learning experience from the student perspective

Plan for session

- Introduction to CAEE
- Academic Pathways Study (APS)
  - Overview
  - Three selected findings
- Small-group discussion of implications
- Large-group discussion with panel

Research methods & samples

- A. NSSE national sample
  - N = 11,819 matched pairs (first-year and senior) from 247 institutions
- B. Longitudinal cohort
  - Surveys, structured interviews, ethnographic interviews and observations, engineering design tasks, academic transcripts; 2003–2007
  - N = 160 from four campuses
  - Oversampled for underrepresented groups
- C. Broad national sample
  - APPLEx2 survey, Spring 2008
  - N = 4,266, cross-sectional sample from 21 engineering colleges
  - Oversampled for underrepresented groups

Three findings for discussion

- A. Getting in
  (NSSE sample, N = 11,819)
- B. Getting through
  (APS longitudinal sample, N = 160)
- C. Getting out
  (APS broad national sample, N = 4,266)

Discussion preview

- Consider the implications of each finding on how...
  - educators
  - student advisors and support services staff
  - department heads and deans
  - industry
  - others who influence engineering education
  ...go about their work.
A. Getting in:
APS-NSSE partnership
- How does persistence in the engineering major compare to persistence in other major groups?
- What are the migration patterns into and out of engineering and non-engineering majors?
- In what ways are engineering majors like and not like students in other major groups?

(See Donaldson & Sheppard, 2007; Lichtenstein et al., 2009; and Ohland et al., 2008.)

Migration terminology
- Persisters: Students whose senior-year major category is the same as first-year (% of first-years)
- In-Migrants: Students who enter a major category (% of seniors)
- Net Migration: Difference between in- and out-migrants (% of first-years)

Persistence and in-migration by major category

Engineering vs. other majors:
Enriching educational experiences

<table>
<thead>
<tr>
<th>HIGH</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culminating senior experience</td>
<td>Study abroad</td>
</tr>
<tr>
<td>95%</td>
<td>22%</td>
</tr>
<tr>
<td>Practicum/co-op/internship/field experience</td>
<td>Indep. study/self-designed major</td>
</tr>
<tr>
<td>86%</td>
<td>23%</td>
</tr>
<tr>
<td>Foreign language coursework</td>
<td>(% seniors)</td>
</tr>
<tr>
<td>34%</td>
<td></td>
</tr>
</tbody>
</table>

Study abroad 22%
Indep. study/self-designed major 23%
Foreign language coursework 34%
Engineering vs. other majors: Enriching educational experiences

<table>
<thead>
<tr>
<th>Field</th>
<th>CULMINATING EXPERIENCE</th>
<th>FOREIGN LANGUAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engr</td>
<td>80%</td>
<td>40%</td>
</tr>
<tr>
<td>STM</td>
<td>60%</td>
<td>20%</td>
</tr>
<tr>
<td>CS</td>
<td>40%</td>
<td>0%</td>
</tr>
<tr>
<td>Bus</td>
<td>20%</td>
<td>0%</td>
</tr>
<tr>
<td>SS</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>A&amp;H</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Oth</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Engineering vs. other majors: Engagement and outcomes scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Engagement</th>
<th>FY higher order thinking practices</th>
<th>FY gains, practical competence</th>
<th>Sr gains, practical competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>71</td>
<td>73</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>LOW</td>
<td>62</td>
<td>49</td>
<td>55</td>
<td></td>
</tr>
</tbody>
</table>

Culminating experience

Foreign language

B. Getting through: Conceptualizing design

How do students conceptualize engineering design?

APS Longitudinal cohort
- Survey question
- Years 1 and 4

(See Atman, Kilgore, & McKenna, 2008, and Chachra et al., 2008.)

Important design activities

"Of the twenty-three design activities below, please put a check mark next to the SIX MOST IMPORTANT:

- Abstracting
- Brainstorming
- Building
- Communicating
- Decomposing
- Evaluating
- Generating alternatives
- Goal setting
- Identifying constraints
- Imagining
- Iterating
- Making decisions
- Making trade-offs
- Modeling
- Planning
- Prototyping
- Seeking information
- Sketching
- Synthesizing
- Testing
- Understanding the problem
- Using creativity
- Visualizing

Imported design activities

Understanding the problem
Communicating
Brainstorming
Making decisions
Using creativity
Visualizing
Goal setting
Seeking information
Building
Identifying constraints
Evaluating
Generating alternatives
Modeling
Prototyping
Abstraction
Making trade-offs
Decomposing
Synthesizing
Iterating
Important design activities, changes

**Important design activities, by gender**

<table>
<thead>
<tr>
<th>Seeking Information**</th>
<th>Building**</th>
<th>Prototyping**</th>
<th>Goal Setting**</th>
<th>Testing*</th>
<th>Building**</th>
</tr>
</thead>
<tbody>
<tr>
<td>women (55)</td>
<td>men (91)</td>
<td>women (59)</td>
<td>men (64)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% participants including item among six "most important"

*p < 0.05, **p < 0.01

**C. Getting out: Post-graduation plans**

What do students plan to do after completing their engineering degrees?

- Engineering jobs
- Non-engineering jobs
- Engineering graduate study
- ...

(See Lichtenstein et al., 2009, and Sheppard et al., 2009.)

Students’ post-graduation plans: Engineering jobs

Factors that predict engineering work plans

<table>
<thead>
<tr>
<th>Student-level independent variables</th>
<th>Engr. job</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Financial motivation</td>
<td>+</td>
</tr>
<tr>
<td>2. Exposure to engineering profession</td>
<td>+</td>
</tr>
<tr>
<td>3. Academic involvement: Engineering</td>
<td>+</td>
</tr>
<tr>
<td>4. Intrinsic psychological motivation</td>
<td>+</td>
</tr>
<tr>
<td>5. Confidence in professional and interpersonal skills</td>
<td>-</td>
</tr>
<tr>
<td>6. Extracurricular participation: Non-engineering activities</td>
<td>Ø</td>
</tr>
<tr>
<td>7. GPA (self-reported)</td>
<td>-</td>
</tr>
</tbody>
</table>

*positive predictor

*negative predictor
Post-graduation work plans

Factors that predict work plans

Factors that predict engineering plans

Plan for session

Summary: A. Getting in

Summary: B. Getting through
**Summary:**

**C. Getting out**

- Most graduates consider engineering careers,
- ...but many also consider engineering graduate study,
- ...as well as non-engineering careers.
- Predictors of plans to continue in engineering include low confidence in professional and interpersonal skills.

**Plan for session**

- Introduction to CAEE
- Academic Pathways Study (APS)
  - Overview
  - Three selected findings
  - Small-group discussion of implications
  - Large-group discussion with panel

**What does this mean for you?**

- Select a role:
  - Educator
  - Student advisor or support services
  - Department head or dean
  - Industry
  - Other: _____________________

- Consider the implications of each finding on how someone in that role goes about their work.

  *Think, pair (or group), and share.*

**Please take notes!**

- For full-group discussion with APS team panel
- Handing in for transcription and sharing via the CAEE web site

**Roles and implications**

**Notes from discussion (1 of 5)**

- Educators
  - Guiding students into sciences as appropriate, but hard to guide them into engineering
  - Providing courses for science majors to get introduced to engineering
  - First-year summer bridge to ease entry into engineering
  - Considering multiple entry paths, different levels of preparation when teaching upper-level courses
  - Accommodating broader interests and ways of thinking by offering more curricular flexibility
Roles and implications
Notes from discussion (2 of 5)

 Educators (cont.)
- Remember that many engineering grads go on to non-engineering careers.
- Help students see that engineering involves problem-solving that is relevant, interesting.
- Help students appreciate impact of science, engineering (e.g., historical framing).
- NAE Grand Challenges-based first-year intro course (UW-M)
- Following through after innovative first-year curricula

Roles and implications
Notes from discussion (3 of 5)

 Student advisors and support services staff
- Reach out to undeclared students w/info about engineering majors, opportunities (e.g., problem-solving to help people).
- Find out what undeclared students are interested in
- Clarify credit transfer, policies, requirements, expectations for prospective majors.
- Ensure advisors, others “on front line” are appropriately informed and prepared to present engineering as option.

Roles and implications
Notes from discussion (4 of 5)

 Department head or dean
- (A) Focus recruiting on community colleges, on campus.
- Foster collaborations between engineering and non-engineering faculty, engaging students in interdisciplinary problem-solving and diversifying repertoire of relevant teaching methods.
- Putting more engineering experiences early, allowing for later entry
- Addition of engineering minor programs? (See CS.)
- Make intro engineering count as general science credit, and make it an engaging, popular, exciting course.
- Consider need to change conventional curricula, possibly by examining what alternative entry paths offer.

Roles and implications
Notes from discussion (5 of 5)

 Industry
- Coop/internship experiences that appropriately emphasize interpersonal, professional skills
- Rethink what engineers and scientists are and what their respective industries are.

 Researchers?
- Find out whose perceptions of engineering are influencing students and their valuation of interpersonal, professional skills.

Wrapping up

Insights on engineering learning from the student perspective

 Strength of the multi-method, multi-institution approach
- Variety of findings across many aspects of the student experience
- Instruments that can be used on your campus

Implications?
References

A. Getting in

B. Getting through

C. Getting out

http://www.engr.washington.edu/caee/

This material is based on work supported by the National Science Foundation under Grant No. ESI-0222058, which funds the Center for the Advancement of Engineering Education (CAEE). Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. CAEE is a collaboration of five partner universities: Colorado School of Mines, Howard University, Stanford University, University of Minnesota, and University of Washington.