Findings from the Academic Pathways Study of Engineering Undergraduates 2003–2008

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Center for the Advancement of Engineering Education

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- **Leadership team:** Robin Adams, Cynthia Atman, Sheri Sheppard, Lorraine Fleming, Larry Leifer, Ronald Miller, Barbara Olds, Karl Smith, Reed Stevens, Ruth Streveler, Jennifer Turns
- **Assistant Director:** Dennis Lund
- **APS team members at ASEE:** Samantha Bozek, Debbie Chachra, Deborah Kilgore, Micah Lande, Holly Matusovich, Sarah Parikh, Dawn Williams, Sherry Woods, Ken Yasuhara
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  (image courtesy M. Klawe)

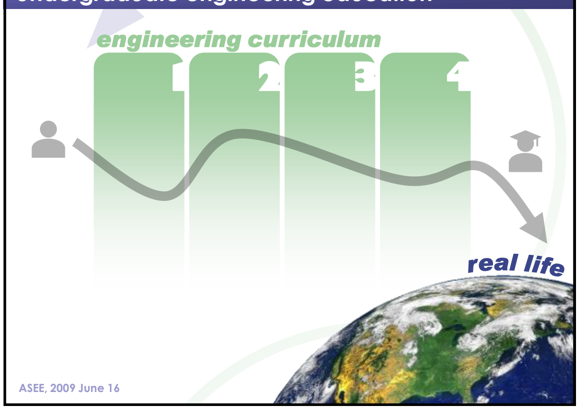
Plan for session

- 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

Undergraduate engineering education



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*

Sampling of APS findings: Large variation in student pathways

- A. Getting in
  - Reasons for choosing engineering
  - Perceptions of engineering
- B. Getting through
  - Proficiency and confidence in engineering skills
  - Experiences in courses
- C. Getting out
  - Preparation for "the real world"
  - Perceived importance of aspects of engineering
  - Post-graduation plans

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Research methods & samples

- **A. NSSE national sample**
  - National Survey of Student Engagement; 2002, 2006–2007
  - *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**
  - APPLES2 survey, Spring 2008
  - *N* = 4,266, cross-sectional sample from 21 engineering colleges
  - Oversampled for underrepresented groups

Three findings for discussion

A B C

- **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)

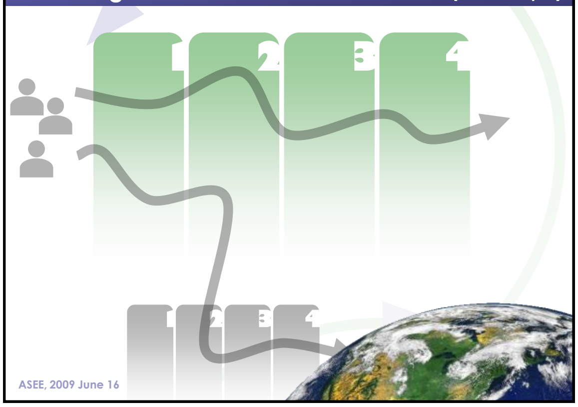
Discussion preview

- 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

(NSSE sample)



A. Getting in: APS-NSSE partnership

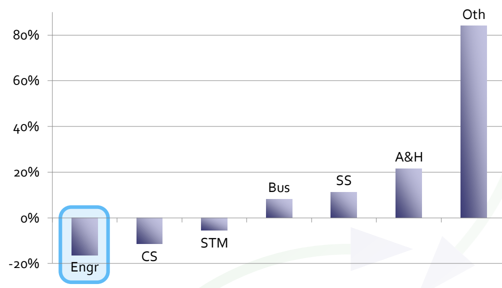
- How does persistence in the engineering major compare to persistence in other major groups?
- What are the migration patterns into and out of engineering and non-engineering majors?
- In what ways are engineering majors like and not like students in other major groups?

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

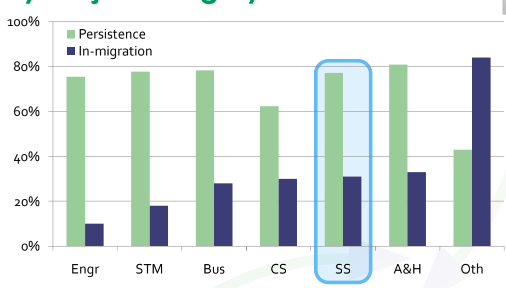
Migration terminology

- **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)

Net migration by major category



Persistence and in-migration by major category

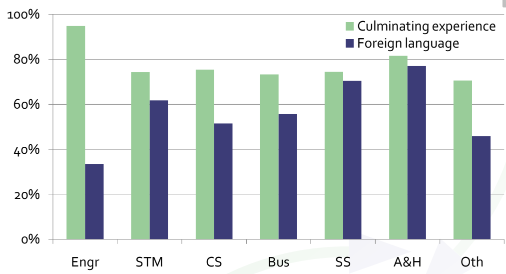


Engineering vs. other majors: Enriching educational experiences

HIGH		LOW	
Culminating senior experience	95%	Study abroad	22%
Practicum/co-op/internship/field experience	86%	Indep. study/self-designed major	23%
		Foreign language coursework	34%

(% seniors)

Engineering *vs.* other majors: Enriching educational experiences

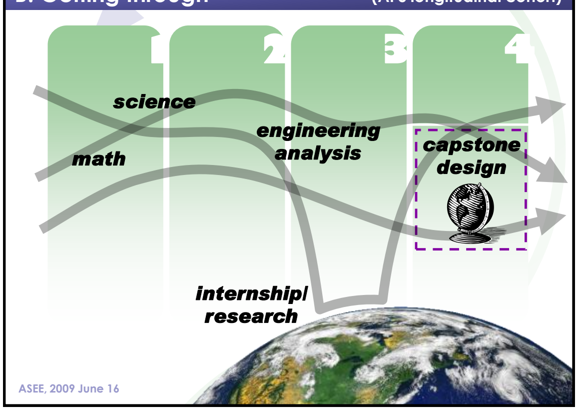


Engineering *vs.* other majors: Engagement and outcomes scales

HIGH		LOW	
FY higher order thinking practices	71	FY Gains, gen ed	62
FY gains, practical competence	73	Sr Gains, personal & social developm't	49
Sr gains, practical competence	82	Sr Integrative learning practices	55
		Sr Reflective learning practices	54

(0–100 scale)

B. Getting through (APS longitudinal cohort)



B. Getting through: Conceptualizing design

- How do students conceptualize engineering design?
- APS Longitudinal cohort
  - Survey question
  - Years 1 and 4

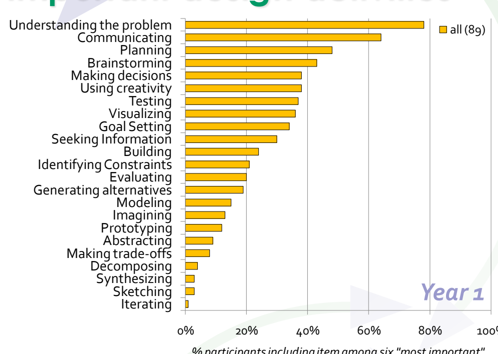
(See Atman, Kilgore, & McKenna, 2008, and Chachra *et al.*, 2008.)

Important design activities

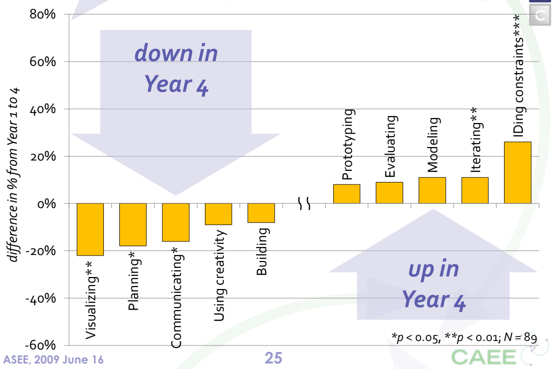
"Of the twenty-three design activities below, please put a check mark next to the SIX MOST IMPORTANT:

- ❑ 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

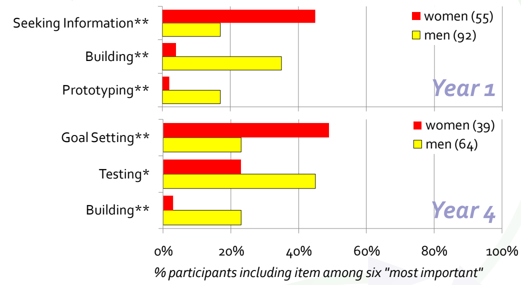
Important design activities



Important design activities, changes

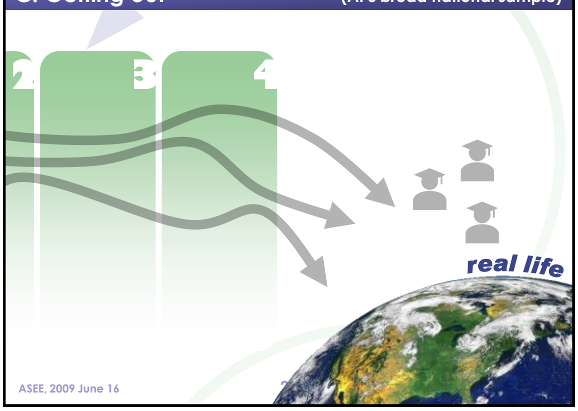


Important design activities, by gender



*p < 0.05, **p < 0.01

C. Getting out (APS broad national sample)

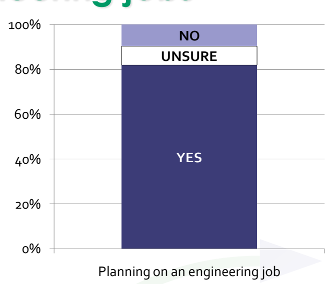


C. Getting out: Post-graduation plans

- What do students plan to do after completing their engineering degrees?
  - Engineering jobs PURPLE
  - Non-engineering jobs GREEN
  - Engineering graduate study BLUE
  - …

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

Students' post-graduation plans: Engineering jobs



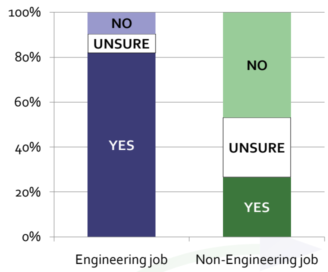
Factors that predict engineering work plans

Student-level independent variables	Engr. job
1. Financial motivation	+
2. Exposure to engineering profession	+
3. Academic involvement: Engineering	+
4. Intrinsic psychological motivation	+
5. Confidence in professional and interpersonal skills	−
6. Extracurricular participation: Non-engineering activities	∅
7. GPA (self-reported)	−

positive predictor

negative predictor

Post-graduation work plans



Factors that predict work plans

Student-level independent variables	Engr. job	Non-Engr. job
1. Financial motivation	+	∅
2. Exposure to engineering profession	+	–
3. Academic involvement: Engineering	+	–
4. Intrinsic psychological motivation	+	–
5. Confidence in professional and interpersonal skills	–	+
6. Extracurricular participation: Non-engineering activities	∅	+
7. GPA (self-reported)	–	∅

Factors that predict engineering plans

42% of students

Student-level independent variables	Engr. job	Engr. grad school
1. Financial motivation	+	∅
2. Exposure to engineering profession	+	∅
3. Academic involvement: Engineering	+	∅
4. Intrinsic psychological motivation	+	+
5. Confidence in professional and interpersonal skills	–	–
6. Extracurricular participation: Non-engineering activities	∅	∅
7. GPA (self-reported)	–	+

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Summary:
A. Getting in

- Retention is not the issue (>70%).
- Engineering needs more pathways for inward migration.
- Engineering *vs.* other majors
  - **Strong:** practical competence, higher-order thinking, culminating senior experience
  - **Weak:** personal and social development, reflective learning, foreign language, independent study

Summary:
B. Getting through

- Student conceptions of design become more engineering-specific.
- Women's conceptions of design emphasize building less than men's.

Summary:
C. Getting out

A B C

- 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.

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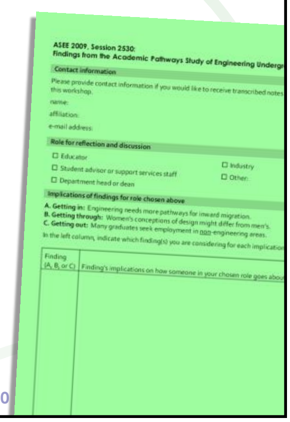
What does this mean for you?

- 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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Contact information

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this workshop.

name:

affiliation:

e-mail address:

Role for reflection and discussion

☐ Educator
☐ Student advisor or support services staff
☐ Department head or dean
☐ Industry
☐ Other:

Implications of findings for role chosen above

A. Getting in: Engineering needs more pathways for inward migration.
B. Getting through: Women's conceptions of design might differ from men's.
C. Getting out: Many graduates seek employment in non-engineering areas.

In the left column, indicate which finding(s) you are considering for each implicatio

Finding (A, B, or C)	Finding's implications on how someone in your chosen role goes abou

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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.

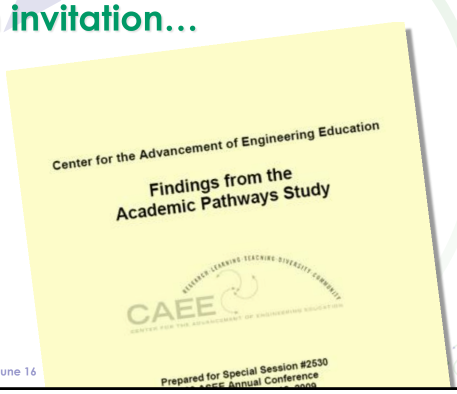
Wrapping up

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?

An invitation…



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- **C. Getting out**
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  - Lichtenstein, G., Loshbaugh, H. G., Claar, B., Chen, H. L., Jackson, K., & Sheppard S. D. (in press, 2009). An engineering major does not (necessarily) an engineer make: Career decision-making among undergraduate engineering majors. *J. of Engineering Education*, 98(3).

Don't forget to give us your green sheet! Thanks!

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