


## Enabling Engineering Student Success

### Using Research to Inform Engineering Education Decisions

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 Center for the Advancement of Engineering Education  
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## Center for the Advancement of Engineering Education

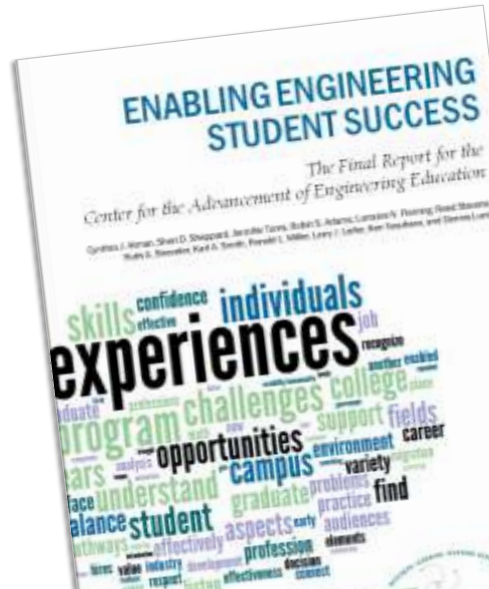
- ▶ Academic Pathways Study
- ▶ Studies of Engineering Educator Decisions
- ▶ Engineering Teaching Portfolio Program
- ▶ Institute for Scholarship on Engineering Education
  
- ▶ 7-year grant
- ▶ 100+ researchers at 16 institutions

**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](http://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

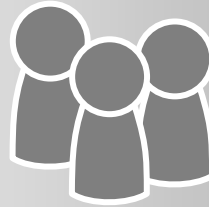
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**Studies of Engineering  
Educator Decisions  
(SEED)**

### 2. STUDENTS



**Academic Pathways Study  
(APS)**

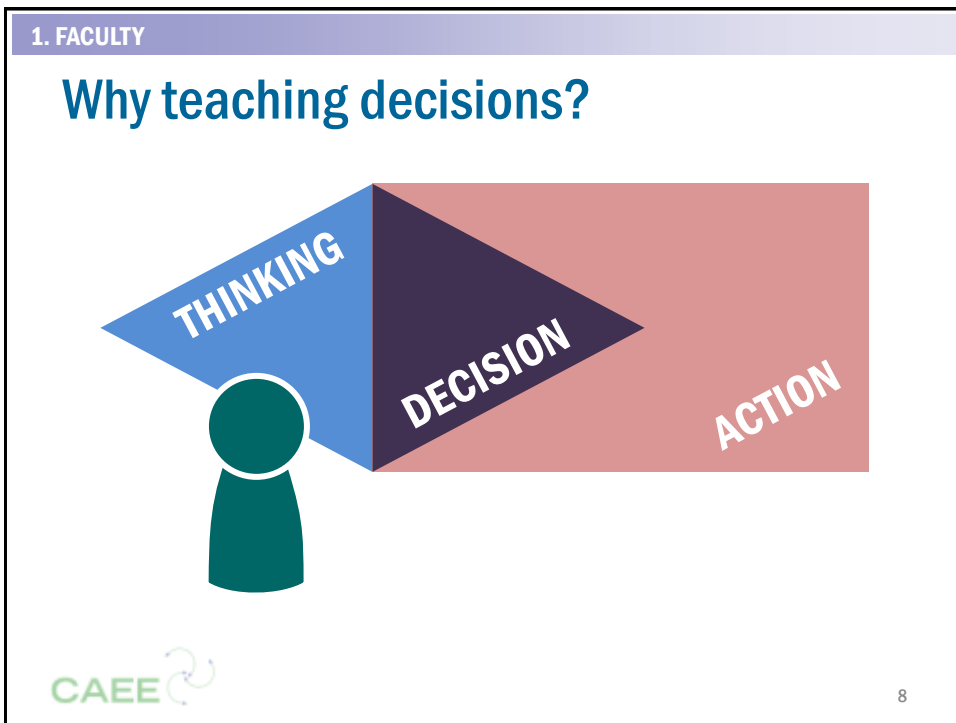
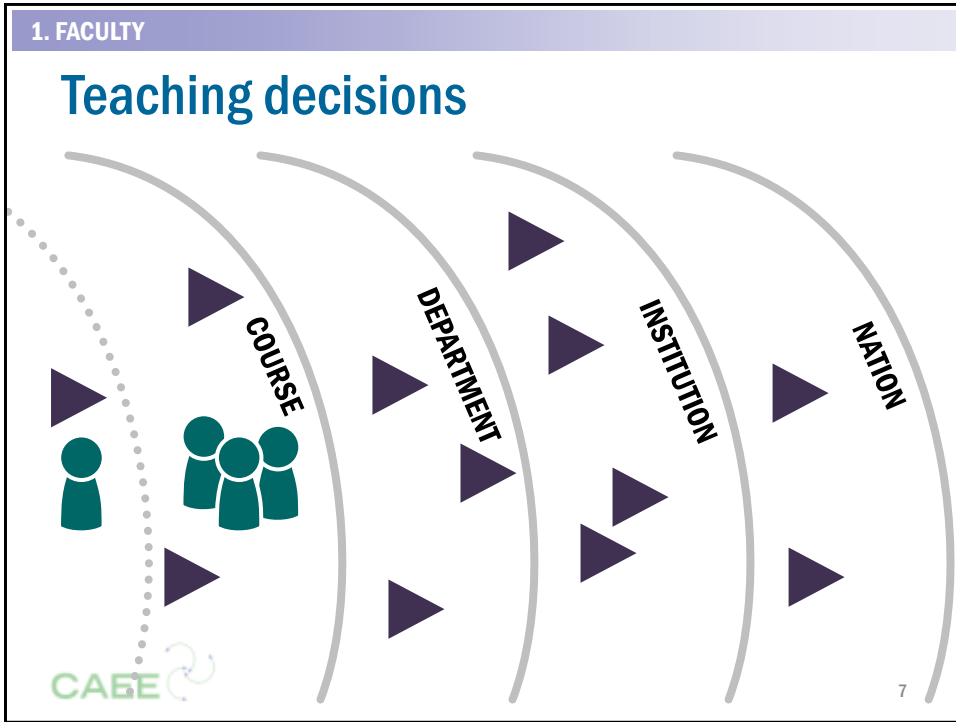
### 3. INFORMING TEACHING DECISIONS

#### 1. FACULTY

## Teaching decisions



- ▶ Decision as a commitment to action
- ▶ Outline
  - What and why
  - Our Study
  - Findings



## 1. FACULTY

## 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



9

## 1. FACULTY

## 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.



10

## 1. FACULTY

## 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?



11

## 1. FACULTY

## 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?...



12

## 1. FACULTY

## 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?

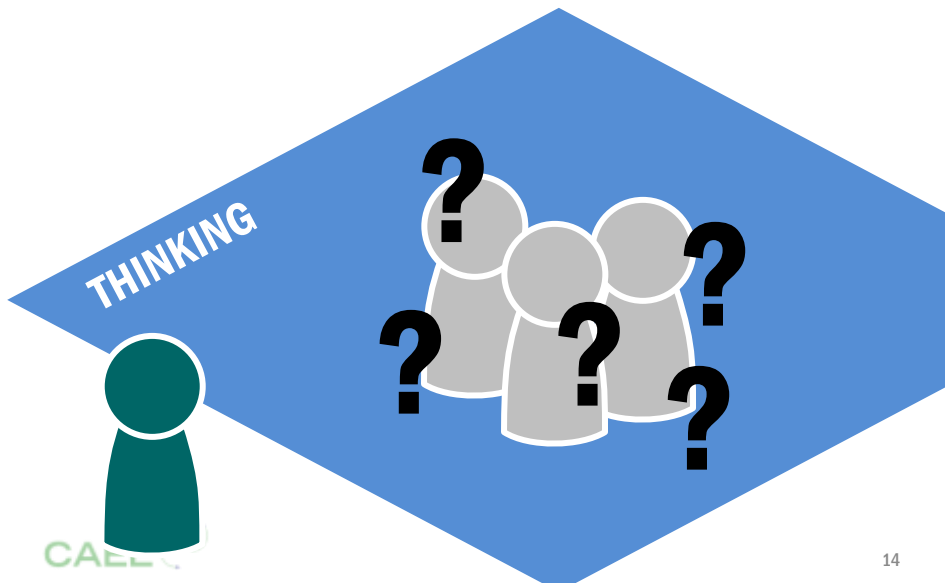


13

## 1. FACULTY

## 2. STUDENTS

## What can we know about students?



14

## Talk overview

### 1. FACULTY



Studies of Engineering  
Educator Decisions  
(SEED)

### 2. STUDENTS



Academic Pathways Study  
(APS)

### 3. INFORMING TEACHING DECISIONS

#### 2. STUDENTS

## Academic Pathways Study (APS)

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



## APS research methods & samples

- N** **NSSE national sample (2002, 2006–2007)**
  - National Survey of Student Engagement
  - $N = 11,819$ ; matched pairs (first-year and senior) from 247 institutions
- L** **Longitudinal cohort (2003–2007)**
  - Surveys, structured interviews, ethnographic interviews and observations, engineering design tasks
  - $N \approx 160$ ,\* from four campuses
- B** **Broad national sample (Spring 2008)**
  - APPLES2 survey
  - $N = 4,266$ ,\* cross-sectional sample from 21 engineering colleges
- W** **Workplace cohort (2007–2008)**
  - 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

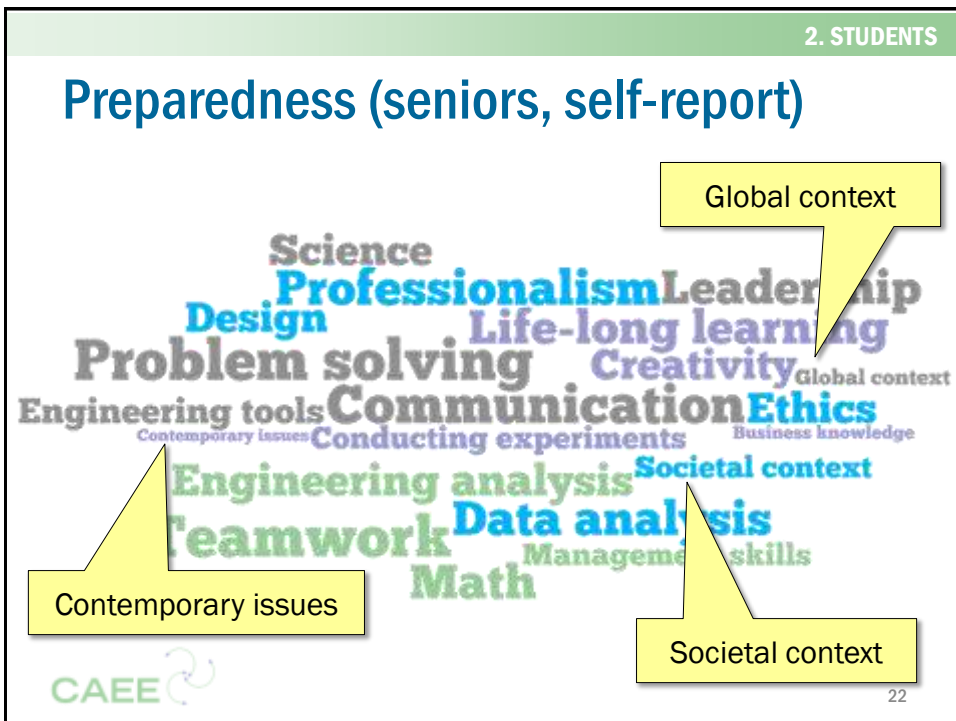
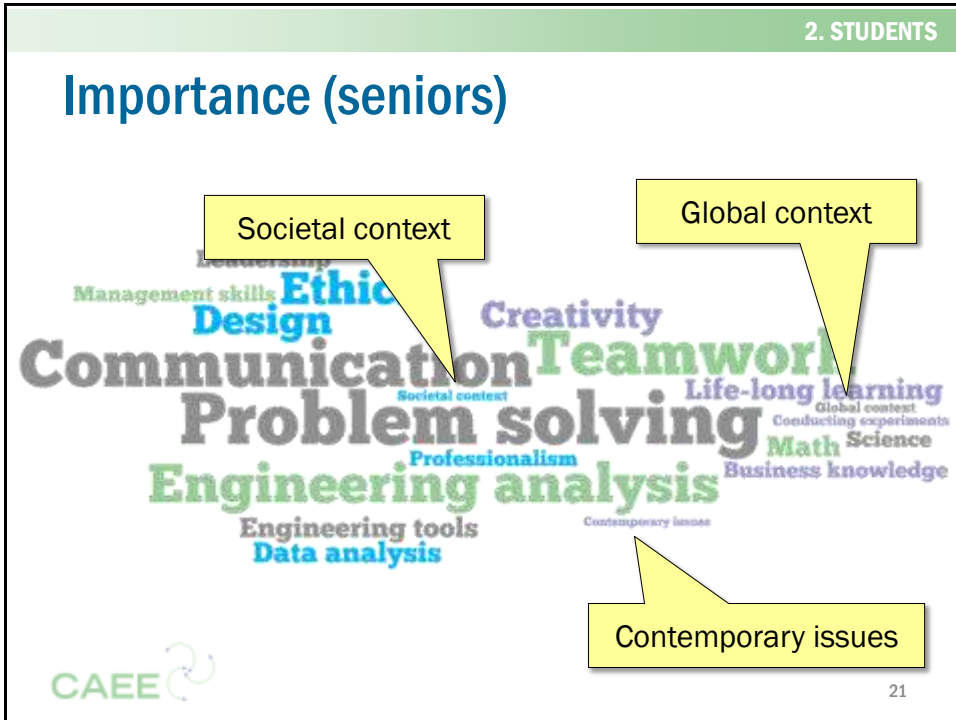
- ▶ Heavy workload, competitive culture
- ▶ Disconnect between early math/science courses and “real engineering”
- ▶ Difficult transition from individual work on “textbook” problems to teaming on open-ended problems
- ▶ Gendered experiences, confidence



## Which three are the most important?

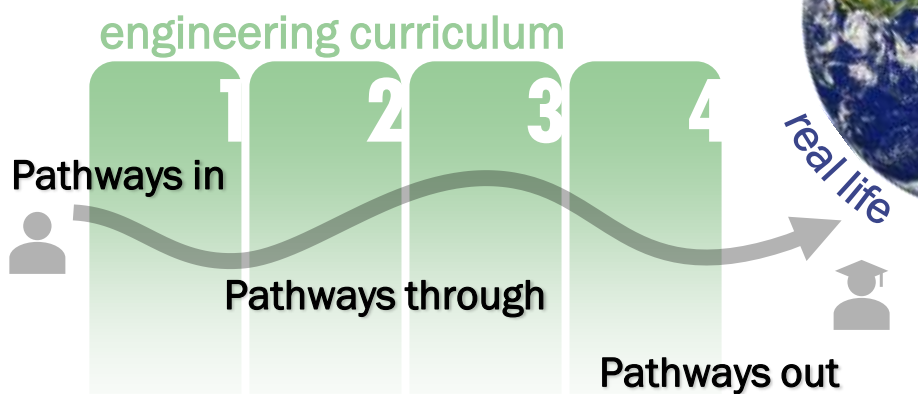
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|------------------------|----------------------|
| Contemporary issues    | Life-long learning   |
| Societal context       | Data analysis        |
| Global context         | Math                 |
| Conducting experiments | Creativity          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

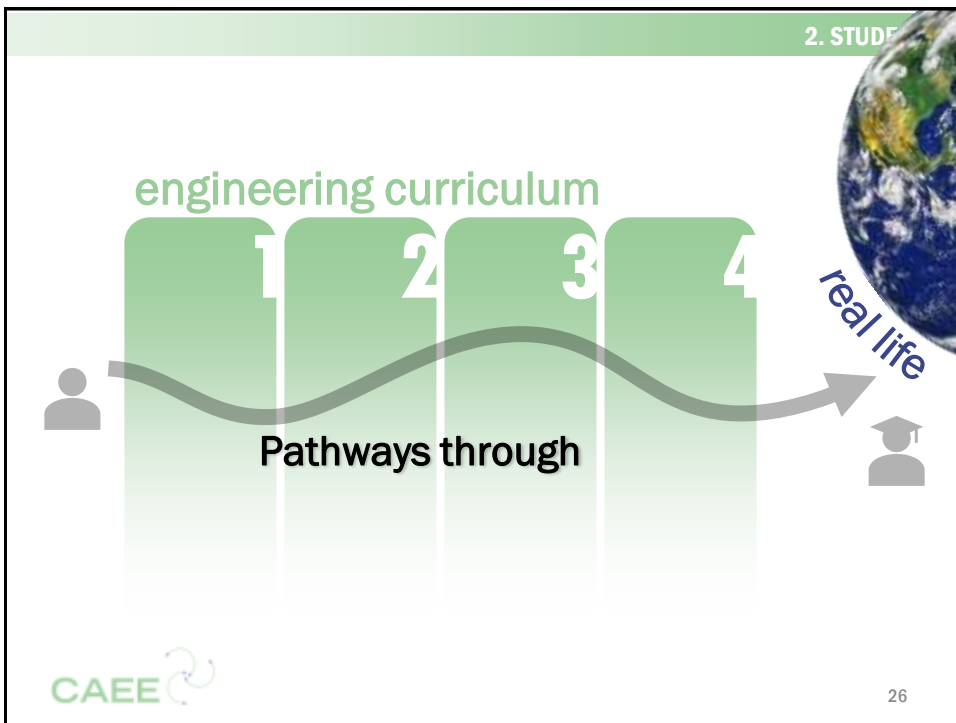
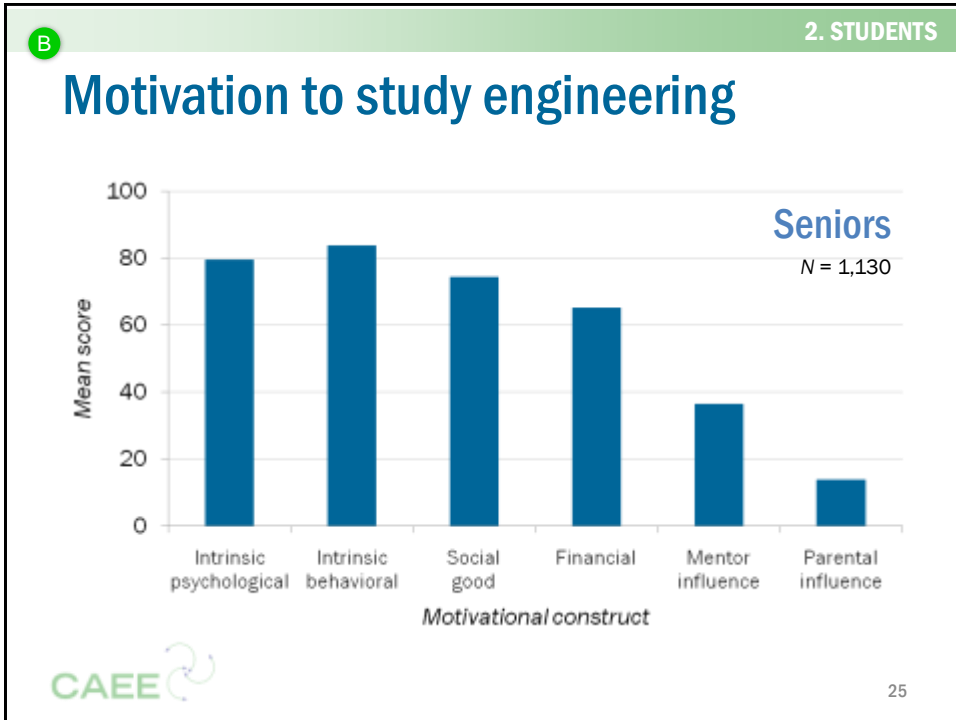




## The well-rounded engineer

- ▶ 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

**What counts as engineering?**

**“idealized world”**

well-defined problems  
individual  
single solution

**“real world”**

open-ended problems  
teams  
multiple solutions

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27

2. STUDENTS

**ENGINEERING COMPARED WITH OTHER MAJORS**

**Engagement and outcomes scales**

HIGH	LOW
First-year higher order thinking practices	First-year gains, general education
First-year gains, practical competence	Senior gains, personal & social development
Senior gains, practical competence	Senior integrative learning practices
	Senior reflective learning practices

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28

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
- ...

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



29

2. STUDENTS

## Alternating design tasks

1

Midwest floods

2


Street crossing

3

Midwest floods

4

Street crossing



30


2. STUDENTS

**L**

## 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?”

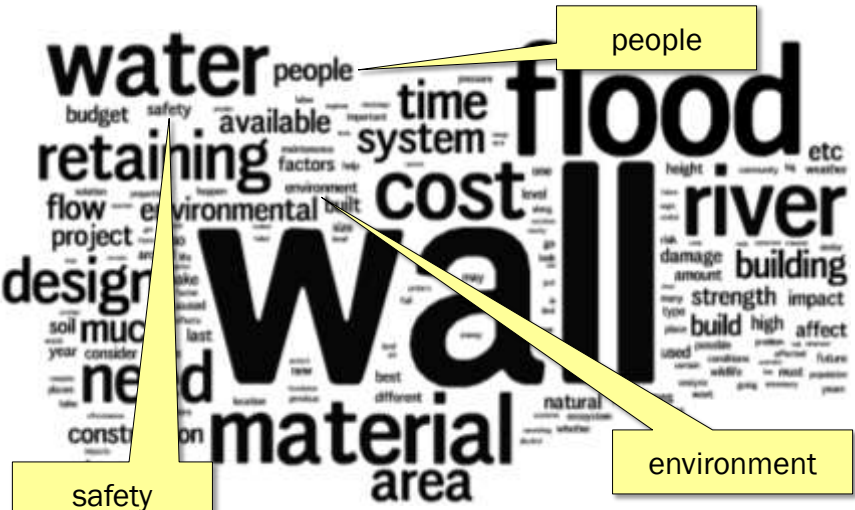
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**L**


## Year 3 floods task responses



people

safety

environment

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32



2. STUDENTS

## Floods coding scheme

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33

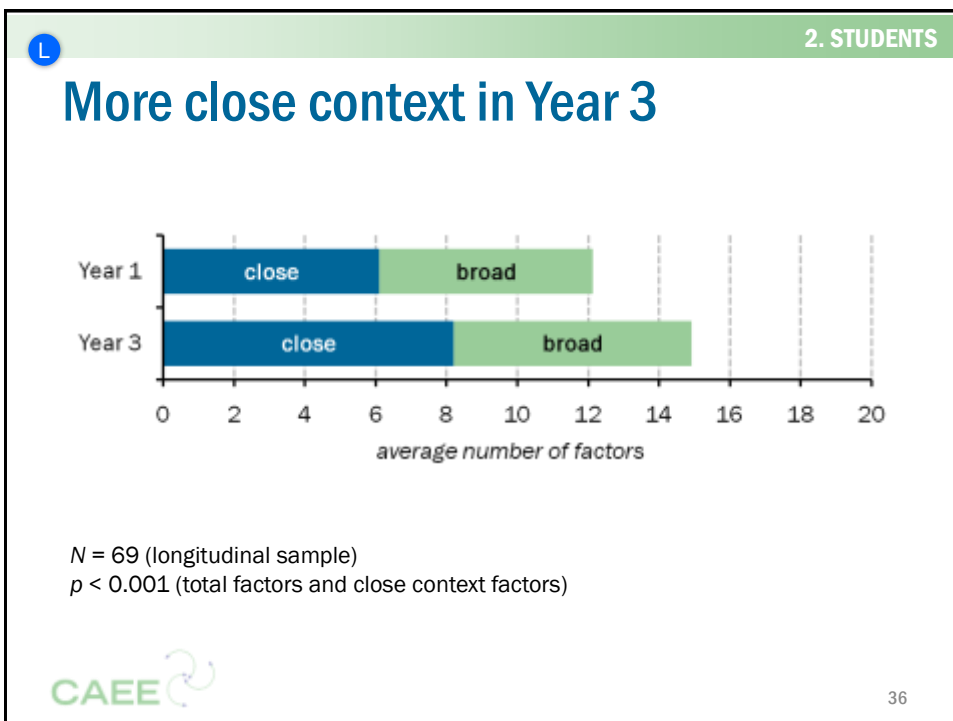
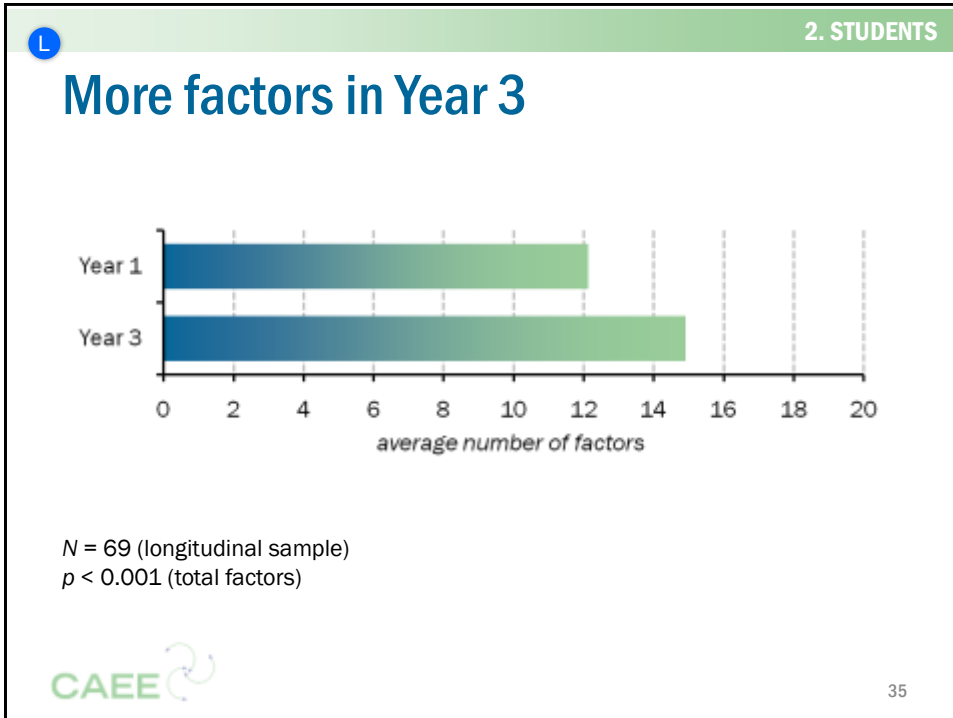
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## Close/broad contextual factors

- ▶ **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”

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34




2. STUDENTS

**L**

## Gender differences

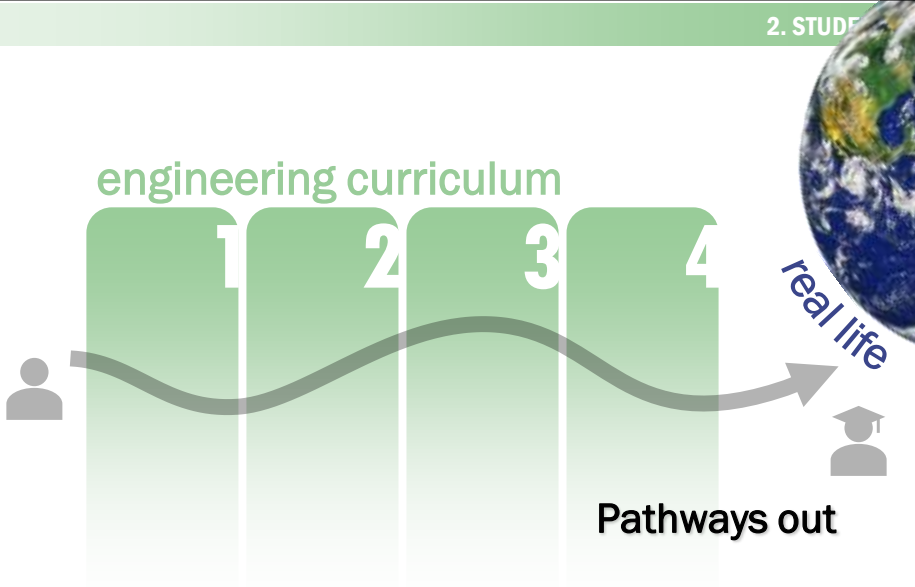
- ▶ Important design activities
  - Women were less likely to select *Building*, more likely to select *Seeking information* and *Goal setting*.
- ▶ Midwest floods
  - Women cited more factors than men.
  - Specifically, women cited more *broad context* factors than men.

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37


2. STUDENTS

engineering curriculum



real life

Pathways out

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38



## Early career engineers

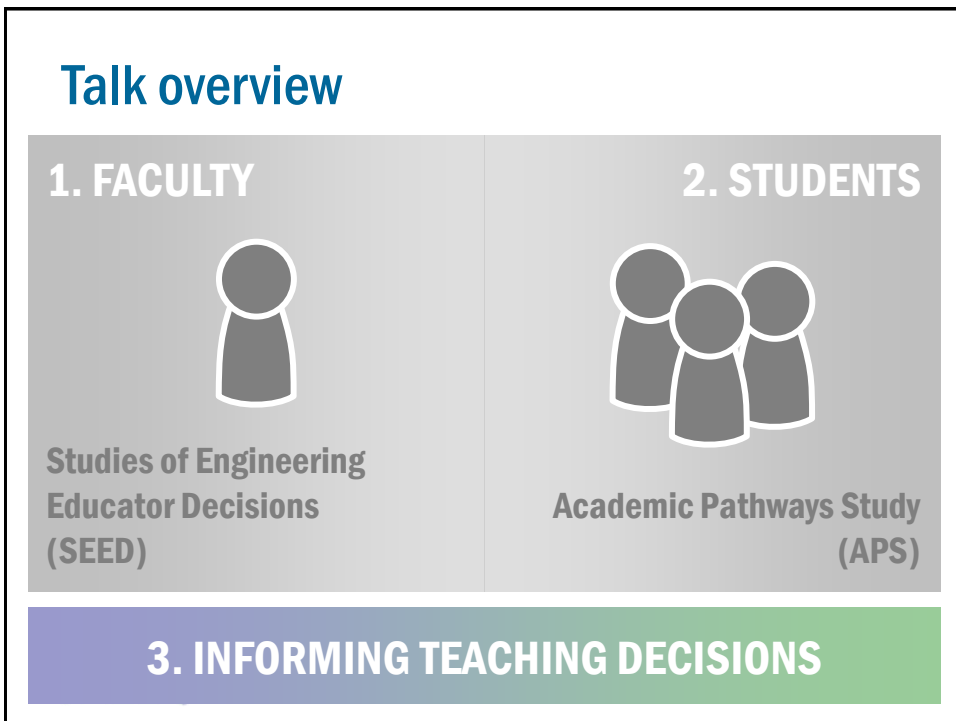
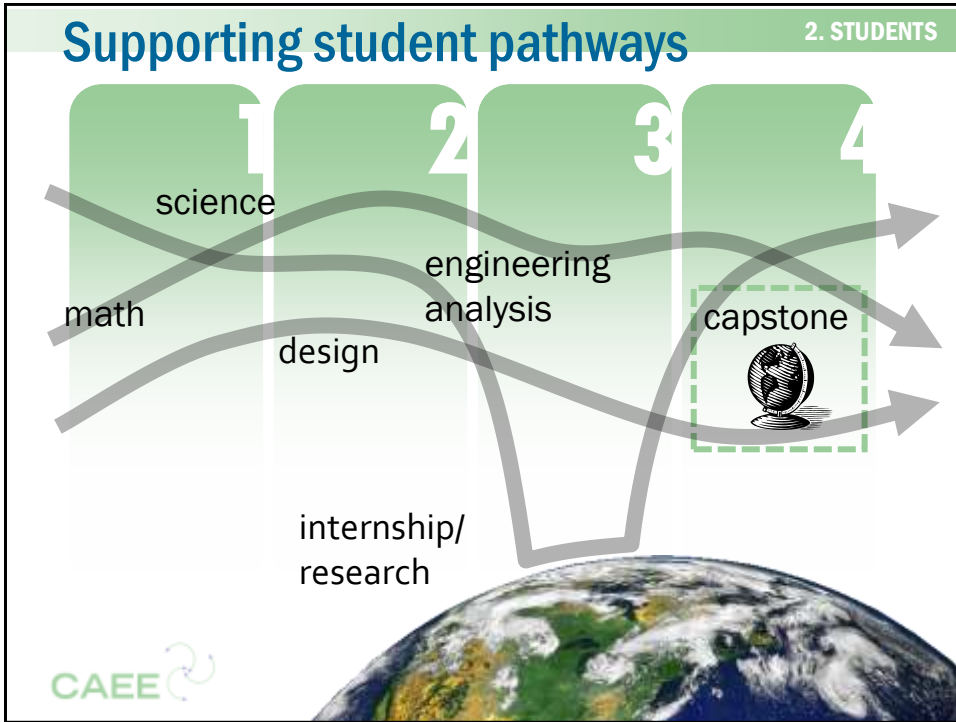
- ▶ Perception of not doing a lot of “real engineering”  
“I don’t feel like I’ve had to actually do engineering”
- ▶ Problems highly uncertain, ambiguous, complex  
“In the real world, it’s a lot more difficult to model things...There’s a lot more variables involved...”
- ▶ More practical, hands-on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

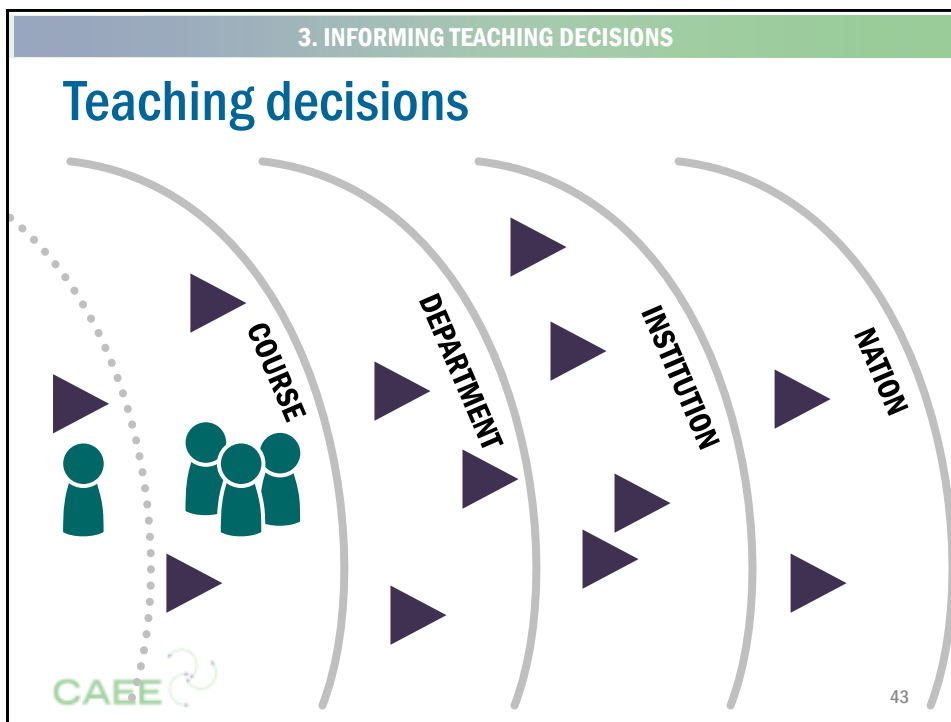


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3. INFORMING TEACHING DECISIONS

## Local Inquiry Questions

See Appendix D

- ▶ **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?

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44

## 3. INFORMING TEACHING DECISIONS

## Local Inquiry Questions

See  
Appendix D

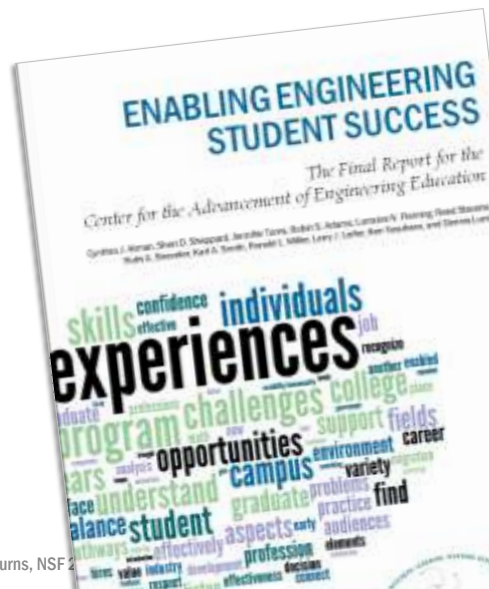
- ▶ Do your students consider global, environmental, societal, economic, and cultural **context in engineering design**?
- ▶ When and where do your students develop the skills required to be **self-directed learners**?
- ▶ Do you help your students **reflect** on their industry (e.g., internship) and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



45

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Atman &amp; Turns, NSF 2



See the final report for references:

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