Center for the Advancement of Engineering Education (CAEE)

Leadership Team:

Adams, Atman, Fleming, Leifer, Miller, Sheppard, Smith, Streveler, Stevens, Turns

Institutions:

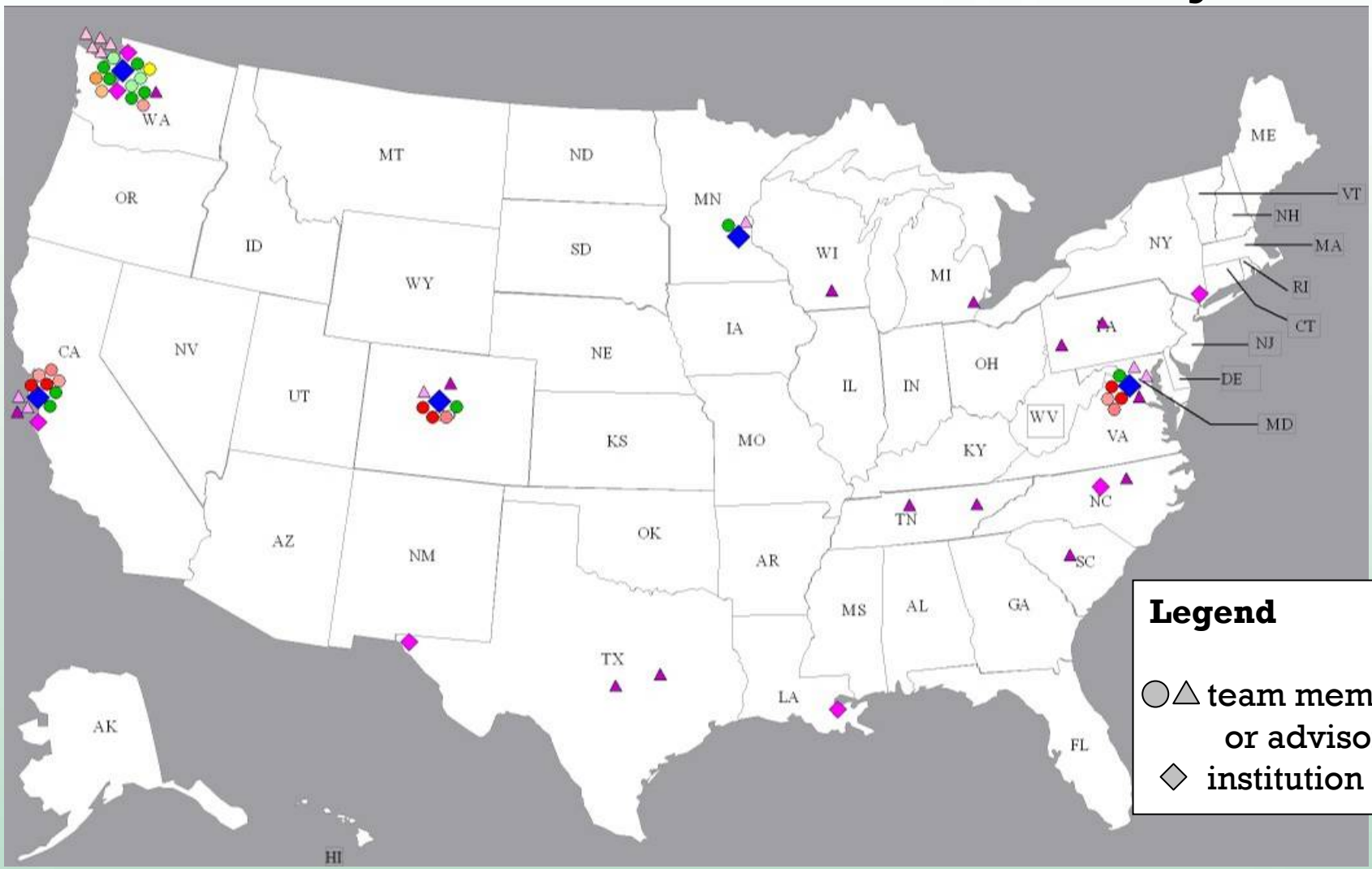
Colorado School of Mines, Howard University, Stanford University, University of Minnesota, University of Washington

National Science Foundation, Grant No. ESI-0227558

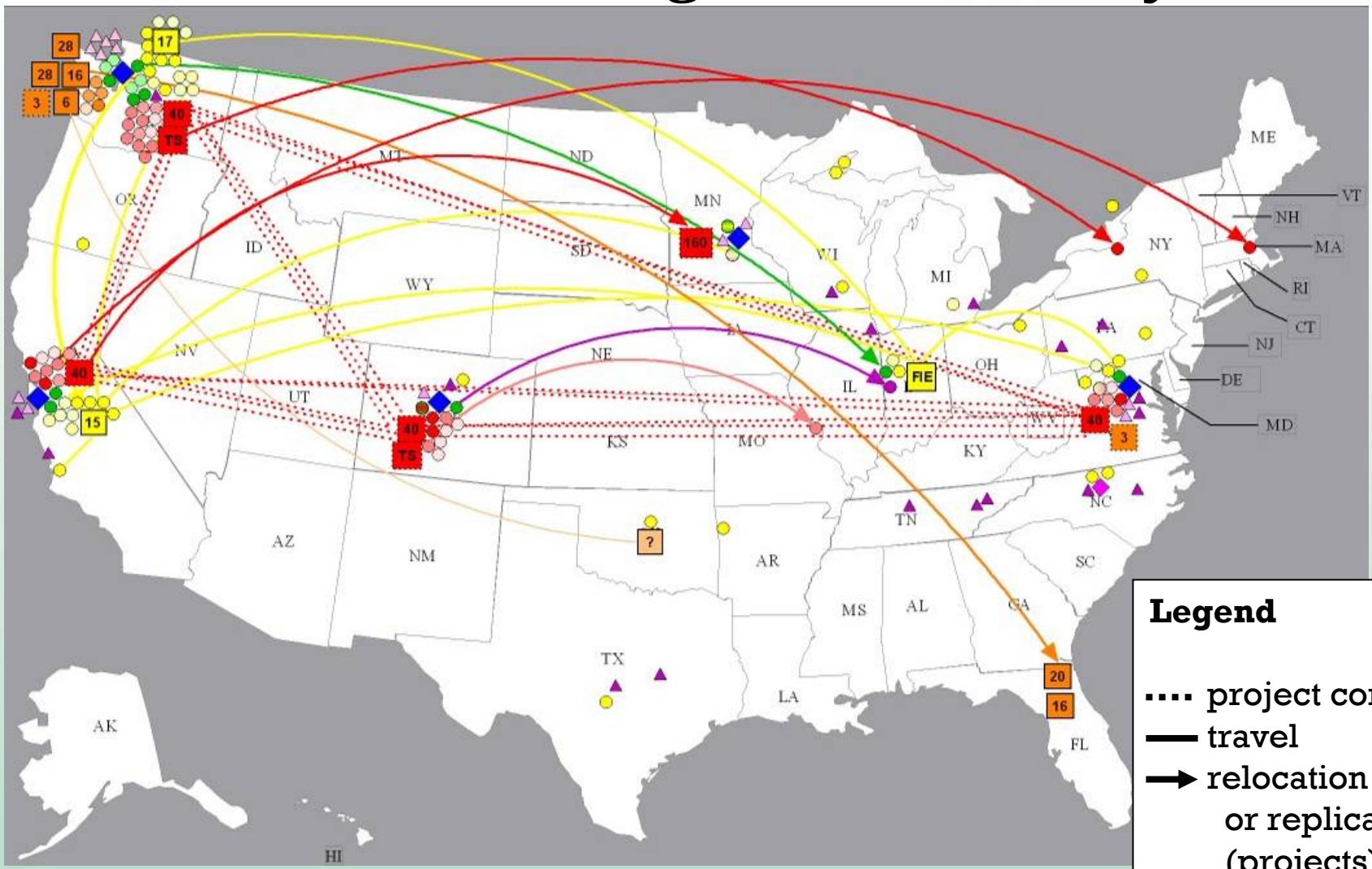
Center for the Advancement of Engineering Education (CAEE)

- **Scholarship on Learning Engineering** (Sheppard)
  - –Research on the engineering student experience
  - –Academic Pathways Study (APS)
- **Scholarship on Teaching Engineering** (Turns)
  - –Research on engineering teaching decision making and knowledge acquisition
- **Institute for Scholarship on Engineering Education** (Adams)
  - –Building the engineering education research community
  - –Year-long Institutes at UW, Stanford, Howard

CAEE's National Presence, January 2003



CAEE's Growing Presence, May 2006



Legend

- project connection
- travel
- relocation (people) or replication (projects)
- project or program

Considering APS…

Part I: Describe Academic Pathways Study (APS)

- Research questions
- Research methods
- Emerging findings

Part II:Next Steps…

APS Research Questions

- Skills
  - How do students' skills and knowledge develop and change over time?
- Identity
  - How do students come to identify themselves as engineers?
- Education
  - What elements of a student's education contribute to changes observed in skills and knowledge development?

Academic Pathways Study (APS)

- Multi-year longitudinal study of undergraduate engineering students
- Descriptive, multi-method study
- *From a student's perspective…*

- Three cohorts of students and one cohort of early career engineers
  - **Cohort 1:** 160 Students at four institutions (incoming class of 2007)
  - **Cohort 3:** Larger populations at the four institutions
  - **Cohort 4:** LARGER populations at a broader range of insitutions

  - **Cohort 2:** New engineers in the workforce

APS Research Methods

- Surveys
- Structured interviews
- Unstructured interviews and ethnographic observations
- Engineering ‘thinking and doing’ tasks
- Academic transcript evaluation
- Exit interviews

APS Research Questions by Methodology

	PIE Surveys	Structured Interviews	Unstructured Interviews	Engineering Doing
Skills	✓✓	✓✓	✓	✓✓✓
Identity	✓	✓✓	✓✓✓	✓
Education	✓✓✓	✓✓	✓✓	✓

APS Cohort 1 Description

- 160 undergraduate engineering students; 40 from each of the CAEE partner institutions
- Student demographics included 38% Female and 45% non-Caucasian
- Students participated in the Study from 2003 to 2007, beginning with their freshman year in college

Academic Pathways Study
Research Methods

	Freshman	Sophomores	Juniors	Seniors	Experts
Surveys	✓	✓	✓	✓ **6/07!**	
Structured Interviews	✓	✓	✓	✓ **6/07!**	✓ **6/07!**
Unstructured Interviews	✓	✓	✓	✓ **6/07!**	✓ **6/07!**
Engineering Doing	✓	✓	✓	✓ **6/07!**	✓ **6/07!**

Considering APS Findings…

Cohort 1:

- Engineering Thinking and Doing results
- Persistence in Engineering (PIE) results

Cohort 2: BCC Findings

Academic Pathways Study
ETD Results

	Freshman	Sophomores	Juniors	Seniors	Experts
PIE Surveys	✓	✓	✓	✓	
Structured Interviews	✓	✓	✓	✓	✓
Unstructured Interviews	✓	✓	✓	✓	✓
Engineering Doing	✓	✓	✓	✓	✓

Engineering Thinking and Doing Focus

Cindy Atman, Deborah Kilgore, Ken Yasuhara, Theresa Barker

Student conceptions of engineering and design (Engineering ‘Thinking’)

Student performance on engineering design tasks (Engineering ‘Doing’)

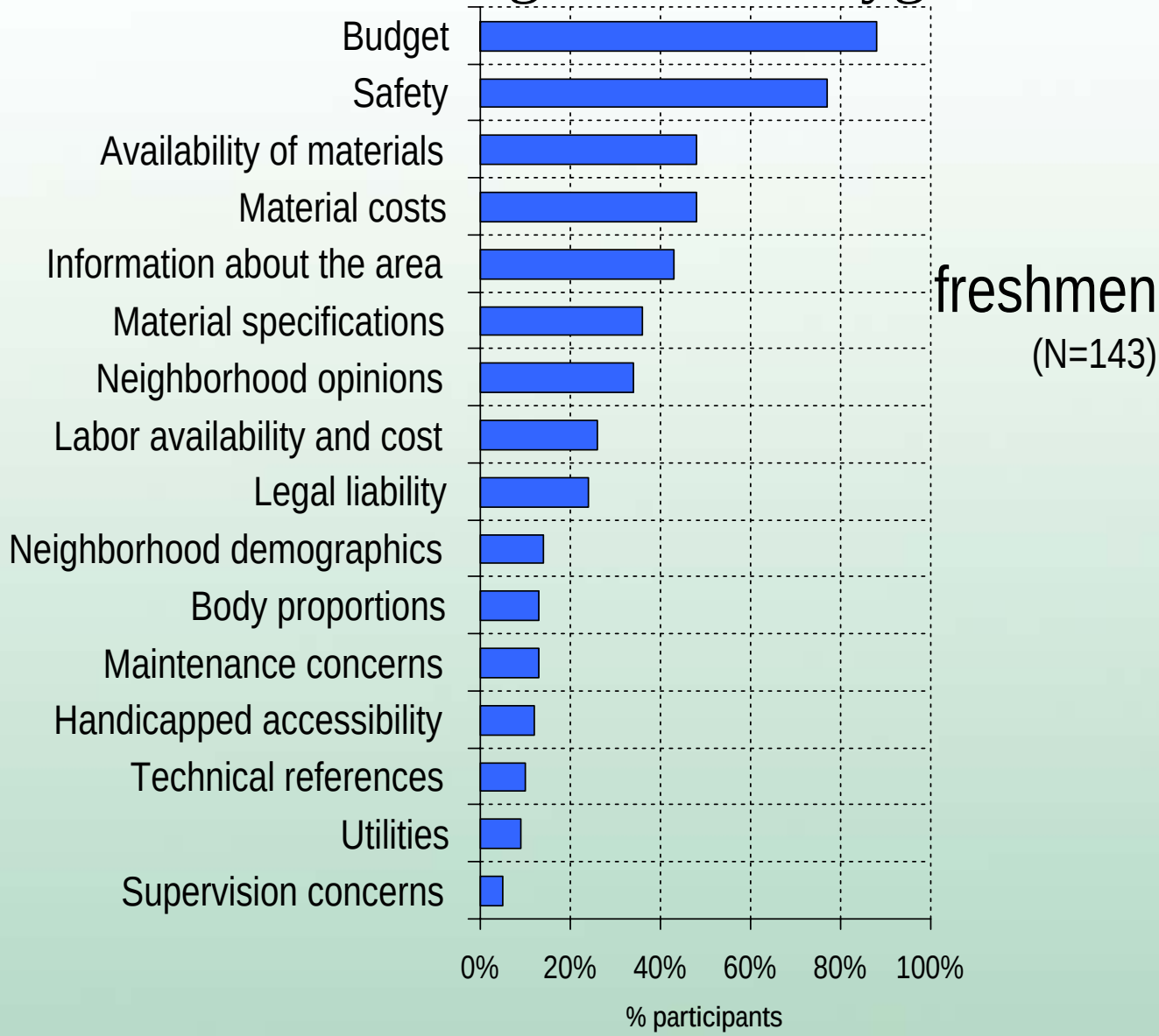
Part of CELT’s long-term research program on engineering design processes

Engineering Doing: Freshmen Take 1

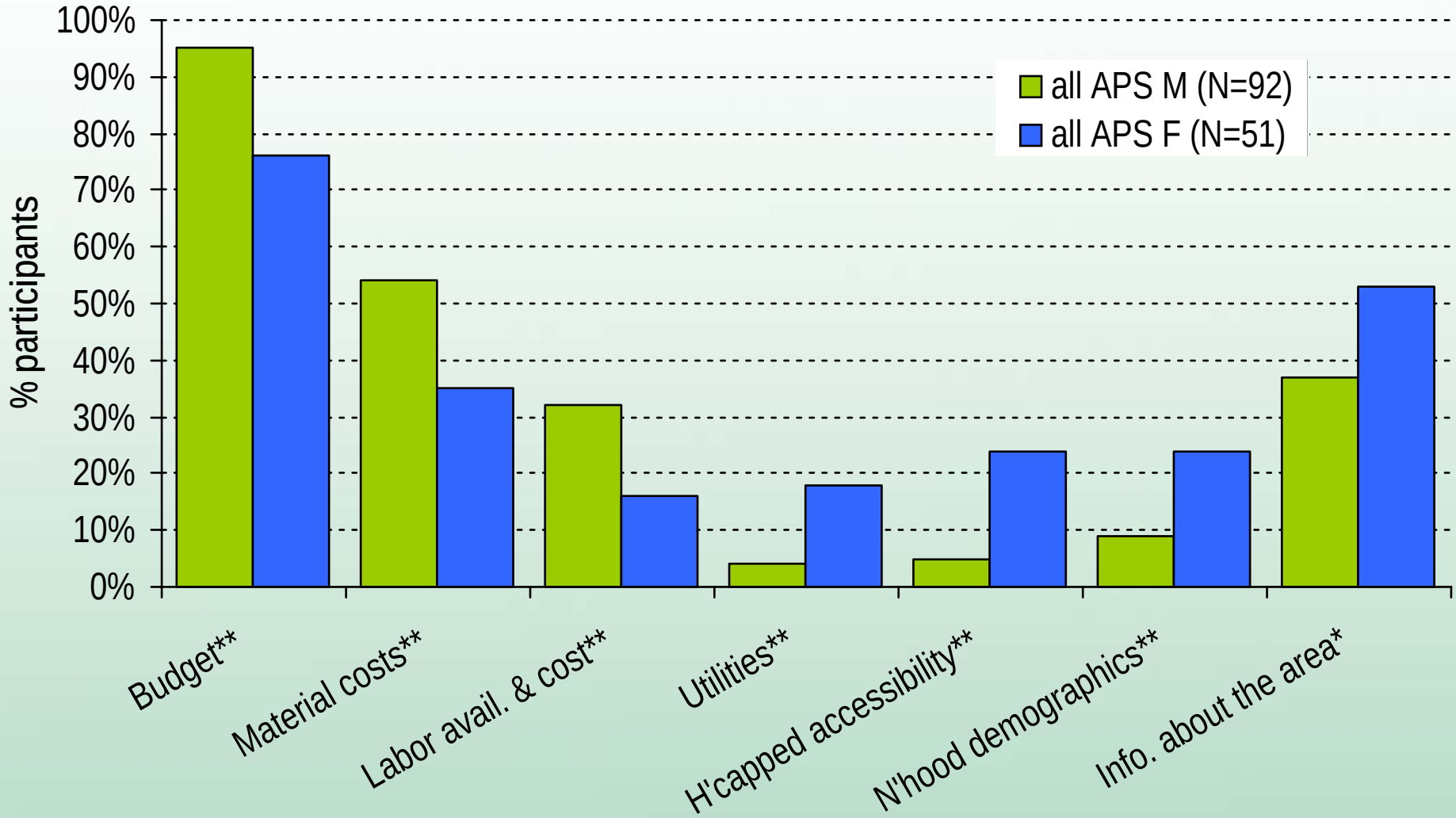
Survey Question:

You have been asked to design a playground. You have a limited amount of time and resources to gather information for your design. From the following list, please put a check mark next to the five kinds of information you would MOST LIKELY NEED as you work on your design…

Information Categories for Playground Design



Information Categories by Gender



*$p < 0.10$ or **$p < 0.05$, Fisher exact

Engineering Thinking and Doing
an emerging picture from the first year…

Considering context – gender differences

- men: emphasis on details of solution such as material, financial...
- women: emphasis on contextual factors such as social, natural...

Conceptualizing design – gender differences

- men: emphasis on building, prototyping...
- women: emphasis on gathering information, planning...

Academic Pathways Study
Persistence In Engineering (PIE) Surveys

	Freshman	Sophomores	Juniors	Seniors	Experts
Surveys	✓	✓	✓	✓	
Structured Interviews	✓	✓	✓	✓	✓
Unstructured Interviews	✓	✓	✓	✓	✓
Engineering Doing	✓		✓	✓	✓

PIE Survey Focus

Özgür Eris, Sheri Sheppard, Debbie Chachra

To identify correlates of persistence in engineering

ACADEMIC PERSISTENCE is operationalized as majoring in engineering

PROFESSIONAL PERSISTENCE is operationalized as expressing an intention to practice engineering for at least 3 years after graduating with a bachelor's degree.

PIE Constructs

1a. Academic persistence
1b. Professional persistence
2a. Motivation (financial)
2b. Motivation (family influence)
2c. Motivation (social good)
2d. Motivation (high school teacher/mentor influence)
2e. Motivation (mentor influence)
3a. Confidence in math and science skills
3b. Confidence in professional and interpersonal skills
3c. Confidence in solving open-ended problems
4a. Perceived importance of math and science skills
4b. Perceived importance of professional and interpersonal skills
5. Knowledge of the engineering profession.
6a. Exposure to project-based learning methods (individual projects)
6b. Exposure to project-based learning methods (team projects)
7. Collaborative work style
8. Extra-curricular fulfillment
9. Curriculum overload
10. Financial difficulties
11a. Academic disengagement (liberal arts courses
11b. Academic disengagement (engineering related)
11c. Academic disengagement (overall)
12. Frequency of interaction with instructors
13a. Satisfaction with instructors
13b. Satisfaction with academic facilities
13c. Overall satisfaction with collegiate experience

Emerging Findings from the First Three Years

A focus on persisters/non-persisters

- motivation
- confidence
- perceived importance of skills
- disengagement/engagement

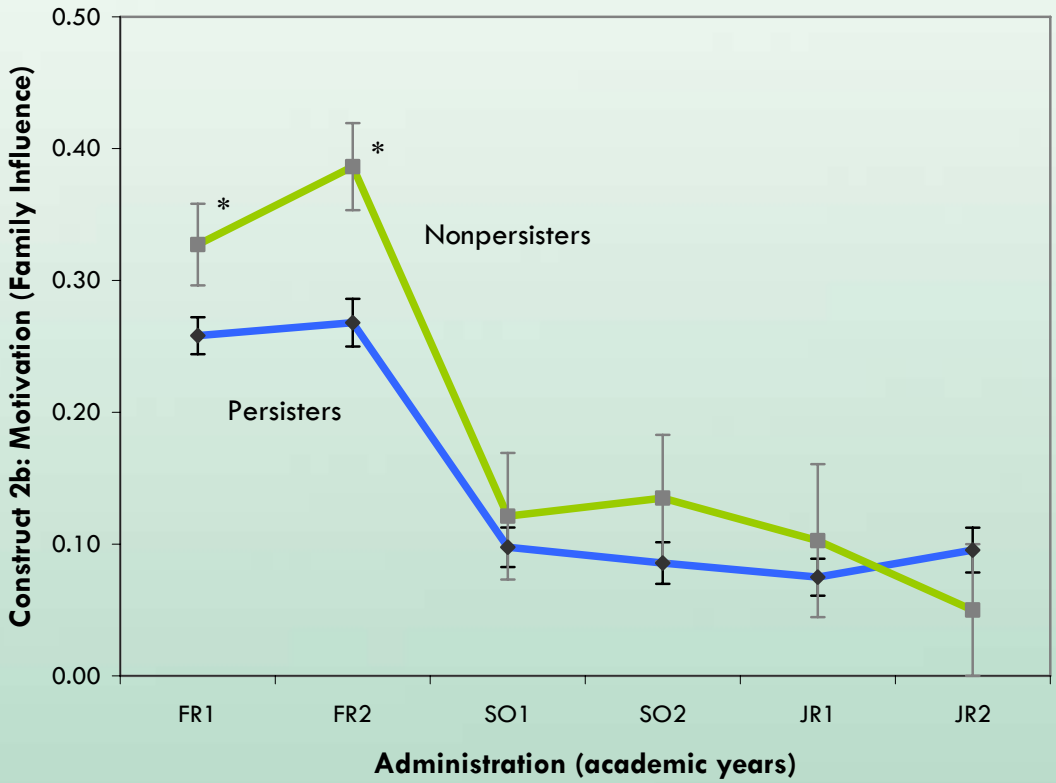
No overall difference between persisters and non-persisters in…

- Financial motivation to pursue engineering
- Social relevance as a motivation to pursue engineering
- Perception of the importance of math and science
- Confidence in interpersonal and professional skills
- Reported familiarity with the field of engineering in freshman and sophomore years

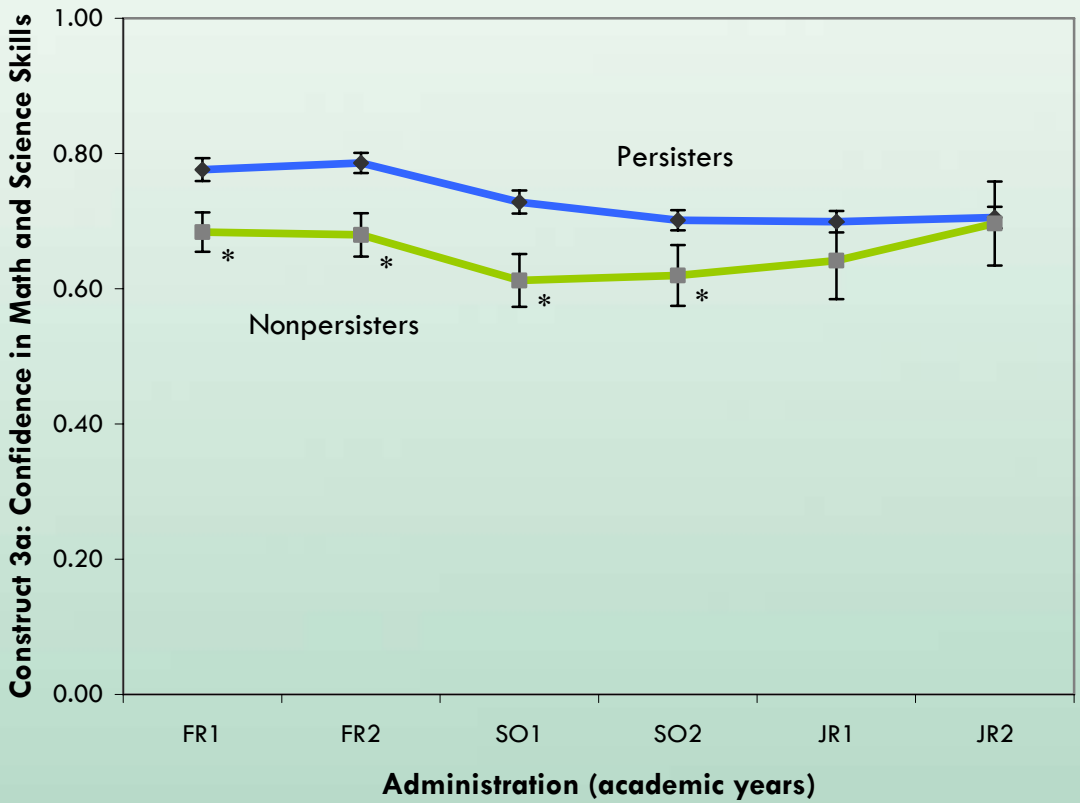
Non-persisters, compared to persisters report…

- On motivation to pursue engineering
  - At the start of their academic career, a greater degree of family influence
  - Lower degree of a mentor's influence
- Lower confidence in math and science skills
- Lower rating of the importance of interpersonal and professional skills
- More academically disengaged in both engineering and liberal arts courses

Motivation: Family Influence
Persisters/Non-persisters



Confidence in Math and Science Skills Persisters/Non-persisters



APS Cohort 2 Description

- Practicing Engineers in public and private firms
- Semi-structured and observational data collection
- Focused on issues around use and acquisition of technical information, and socialization
- Key is connection back to educational practices

Academic Pathways Study
Cohort 2 Studies

	Freshman	Sophomores	Juniors	Seniors	Experts
Surveys	✓	✓	✓	✓	
Structured Interviews	✓	✓	✓	✓	✓
Unstructured Interviews	✓	✓	✓	✓	✓
Engineering Doing	✓		✓	✓	✓

Example:
The Socialization of New Engineers at BCC

a Cohort 2 study by R. Korte, S. Sheppard, W. Jordon

Subjects at BCC

- 36 people interviewed
  - 17 new grads
  - 13 experienced hires
  - 6 supervisors
  - New hires: 9 female, 21 male
  - New hires: 13 non-white, 17 white
- Five locations
  - 12 Location 1
  - 14 Location 2
  - 2 Location 3, 1 Location 4, 1 Location 5

Primary Findings

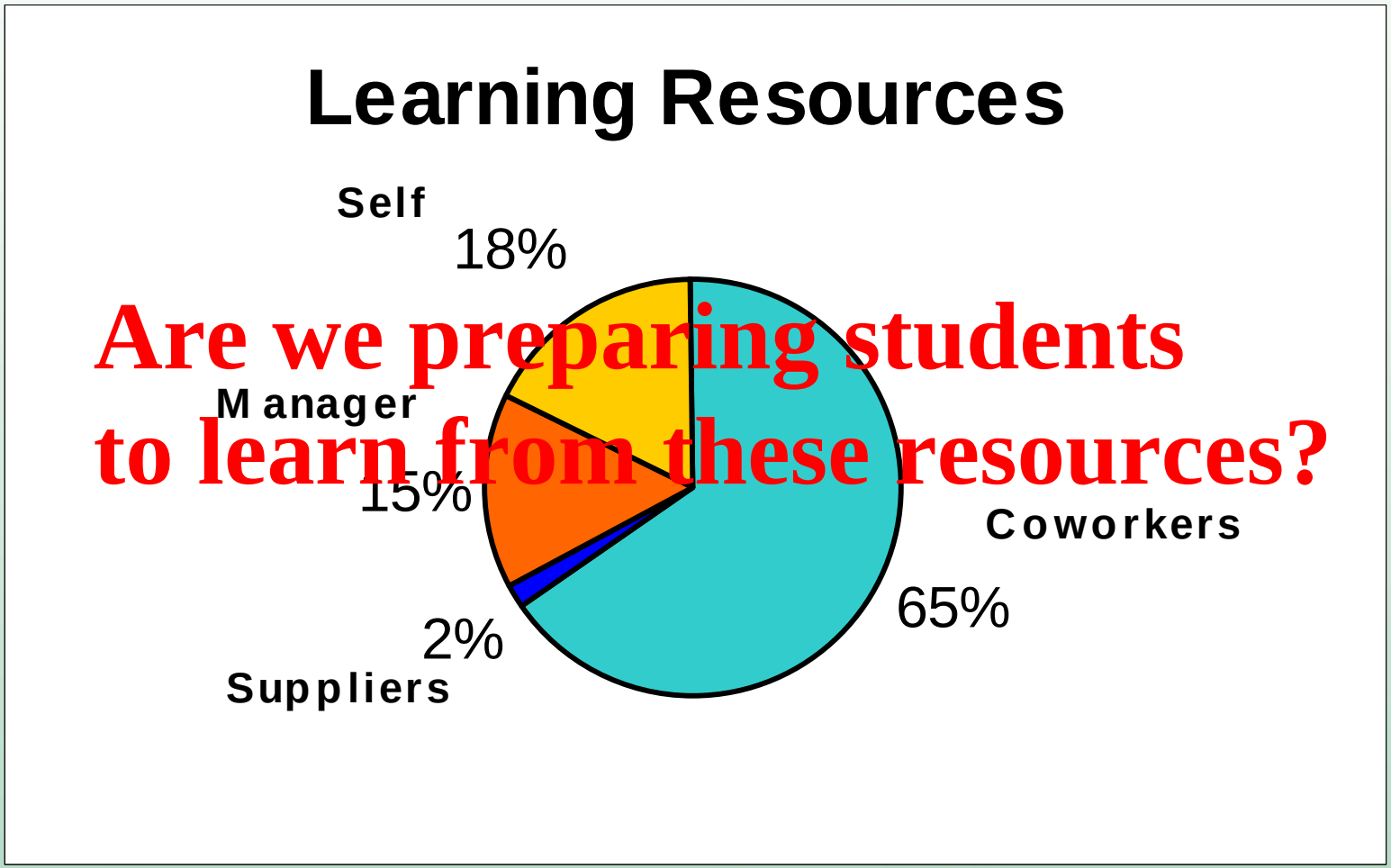
Technical Skills X Social Skills = Performance

- ***Relationship building*** is a primary driver of socialization.

- ***Workgroups,*** not the organization, are primary contexts for socialization.

  - ***It's about the social skills of the workgroup, as well as the individual new hire.***

Social interactions as a source of learning.



Cohort 1 and 2 results,

an emerging picture leads to more questions…

Are our programs giving our students the support they need to be *successful and stay in engineering*? *…to be successful in practice?*

Why are some students *engaged* and others *disengaged*? Are some engineers *engaged* and other *disengaged*?

Are our programs helping students understand the importance of solving problems in *context*?

Do our students know enough about engineering to make *informed decisions* to stay or go?

APS Papers at ASEE…

Date	Time	Session	Location	Papers/Posters/Meetings
26-Jun				
	7:00-8:15 am	1130	HCC 303A	APS Overview session
	7:00-8:15	1131	HCC 318B	(3/5) Geeks are Chic; (4/5) Should I Stay/Go?; (5/5) Eng as Lifestyle-Meritocracy of Difficulty
	10:30-12:00	1330	HCC 318B	(2/4) Correlates of Engineering Persistence; (4/4) Academic Experiences of Students
	2:15-4:00 pm	1531	HCC 318B	(3/5) Competition/Confidence/Challenges in Eng Classroom-Amer. and Interntl Students
	2:15-4:00	1553	HCC 316B	(2/4) Performance Tasks-Confidence, Gender, Persistence
	2:15-4:00	1576	Exhibit Hall 1s	CAEE Overview (NSF Grantees Poster Session)
27-Jun				
	12:30-2:00	2431	HCC 316A	(3/5) Creative/Contextual/Engaged-Are Women the Engs of 2020?
28-Jun				
	12:30-2:00	3430	HCC 313B	(1/4) Breadth in Design Problem Scoping-Experts & Students
	2:15-4:00	3531	HCC 313C	(3/5) Role of Doggedness in Engineering Degree Completion
	2:15-4:00	3575	HCC 306A	(3/5) Storytelling in Engineering Education
	4:30-6:00	3630	HCC 316C	(3/4) Sponsorship-Engineering's Tacit Gatekeeper

Considering APS…

Part I: Describe Academic Pathways Study (APS)

- Research questions
- Research methods
- Emerging findings

Part II: Next Steps…

APPLES Overview and Lessons Learned

11 June 2007

APPLES Overview

Who Undergraduate students studying or were interested in studying engineering at some point in time

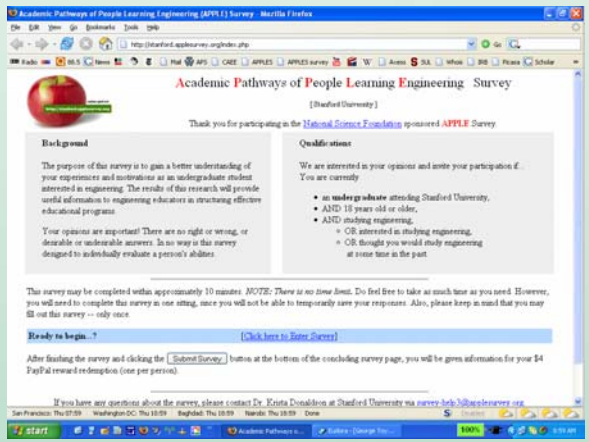
- Pre-engineering students
- Engineering students
- "Non-persisters"

What ~10 minute web-based survey

When (1) 2-9 April 2007, (2) early 2008

Where (1) Cohort 3 (Four Cohort 1 institutions), (2)Coort 4 (18-21 American institutions)

Why To validate APS findings relating to academic and professional persistence in engineering at a broader range of institutions



Screen shot from APPLES 1

Sample APPLES Constructs

- Academic and professional persistence
- Motivation to study engineering
- Confidence in math and science skills
- Knowledge of engineering profession
- Academic disengagement
- Research experiences
- Overall satisfaction with collegiate experience

Sizing Sample and Strata

per Institution

Sample size determined using the power calculation

- Alpha = .05
- Effect size = .378
- Predictors = 3

Minimum total sample size of 88 subjects necessary to yield a power of .95.

Primary strata

Strata	*Target*
All	*140*
Freshmen	*25*
Sophomore	*25*
Juniors	*25*
Seniors	*25*
Non-persisters	*25*
Transfer students	*10*
Male students	*70*
Female students	*25*
Ethnic minority students	*25*
International students	*25*

APPLES Incentives

- **Broad appeal:** flexibility for the student in spending
- **Online transaction:** available immediately (or shortly after) the student's participation in the survey
- **Scalability:** appropriate for APPLES2, consistent with local laws and required minimal logistical work
- **Confidentiality:** offered and redeemed without compromising student confidentiality
- **Accountability:** ability to track payments to meet university disbursement requirements.

Incentive candidates

Electronic gift certificate

Giftcard

Cash

Raffle

“Piloting”

Three (and some) rounds of piloting

1. Round 1: Ten graduate students and researchers , 22.5 minutes
2. Round 2: 58 undergraduate students from five non-Cohort 1 institutions, 14 minutes
3. Cohort 3: 900+ undergraduates at 4 Core APS Schools

Cohort 3: Submissions by the numbers

Total submissions: 914

Claims of incentives: 748

Declines of incentives: 137

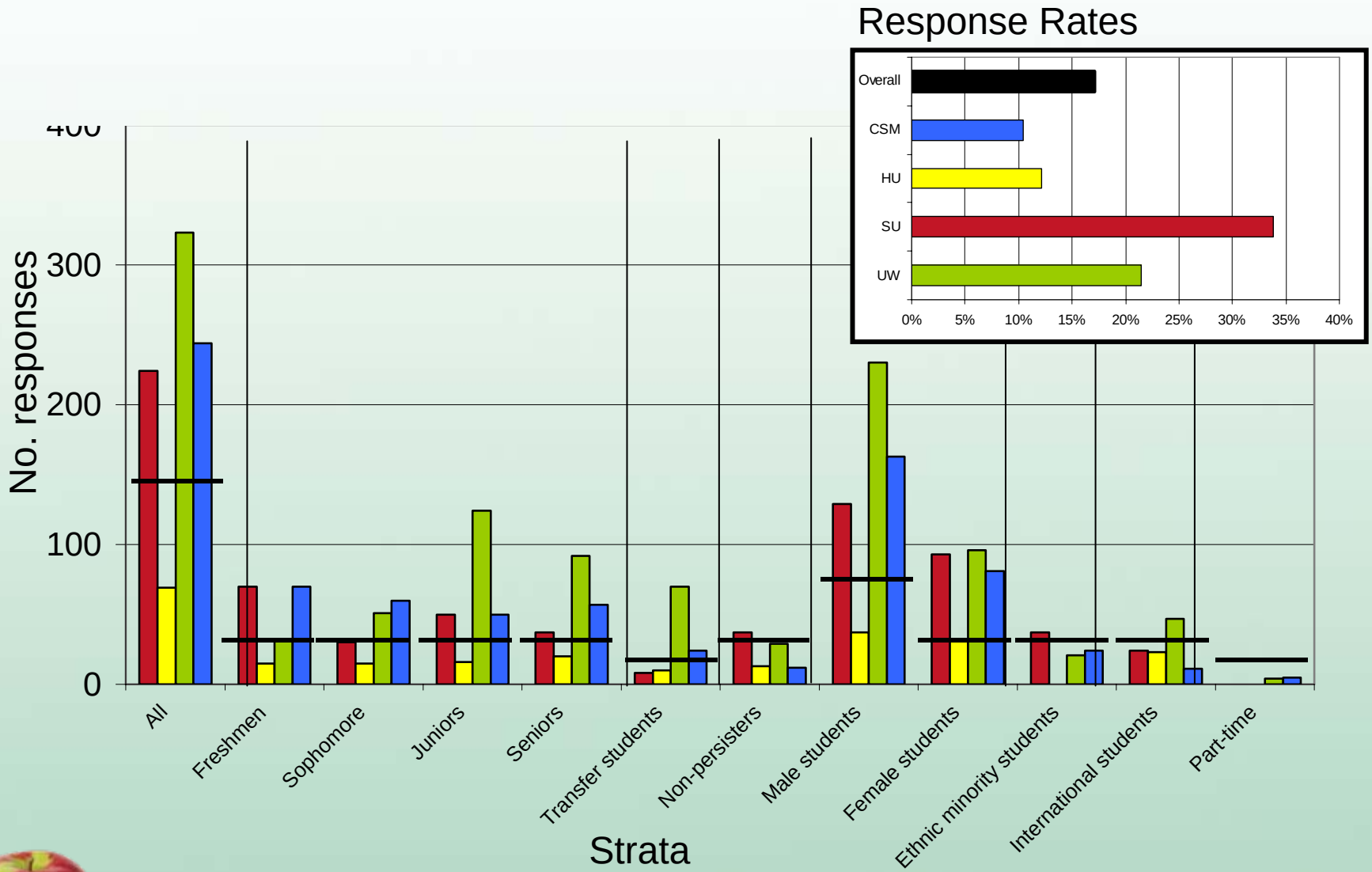
Estimated fraud: 3%

Cleaned data set: 843*

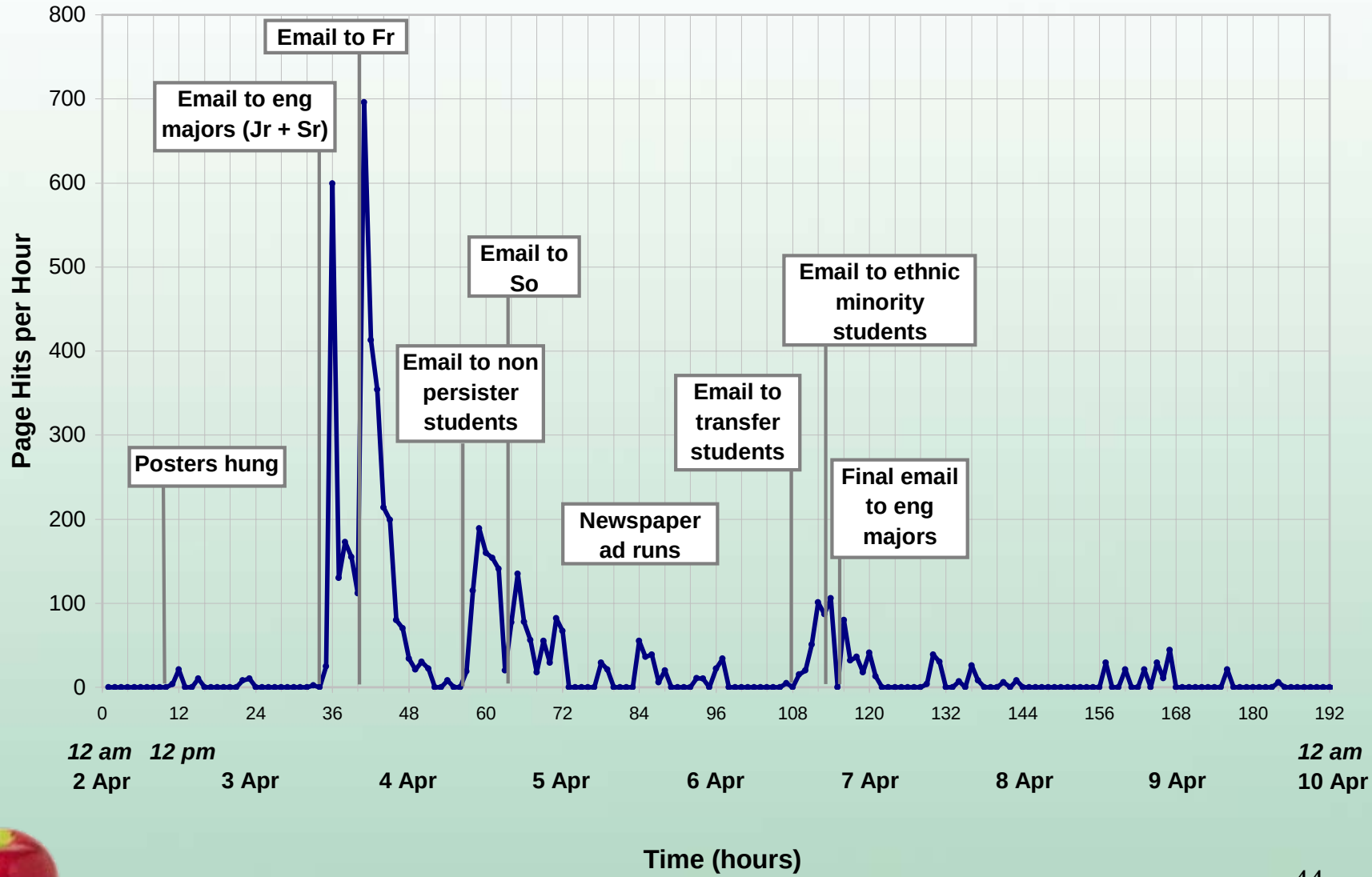
*Preliminary

(Preliminary analysis)

APPLES Responses – Strata and rates



APPLES Responses to Recruitment – *School A*



APPLES--Cohort 4 Schools

Sample* APPLES Institutions Milestones

Date	Est. time (h)	Milestone
15 Aug 2007	1	Participation commitment, Coordinator named
15 Sept 2007	2	Coordinator submits overview information
15 Nov 2007	2	Coordinator submits recruitment plan
11-15 Feb 2008* -- APPLES deployment		
10-15 Feb 2008*	4-12	Recruitment and targeted recruitment
June 2008		Reports sent to institutions

* Institutions will be able to choose one of three deployments in January and February of 2008.

Expectations - Who does what?

What APPLES schools do:

- Designate a coordinator who will work with the APS team to develop and implement a plan for recruiting undergraduate engineering participants
- Coordinate local campus recruitment

What the APS team does:

- Provides guidance and assistance in developing a recruitment plan
- Administers surveys
- Manages incentives
- Collects and analyzes data
- Writes and delivers institution-specific reports

What the student participants do:

- Log on to the APPLES website to “accept” informed consent to participate
- Complete the online survey (about 10 minutes)
- Receive a small incentive ($4 through PayPal)

APPLES Institutions' reports

apple survey

ORCHARD UNIVERSITY

SAMPLE COHORT 4 REPORT

prepared for prospective cohort 4 participants, June 2007

academic pathways of people learning engineering survey

CAEE
RESEARCH · LEARNING · TEACHING · DIVERSITY · COMMUNITY
CENTER FOR THE ADVANCEMENT OF ENGINEERING EDUCATION

NSF

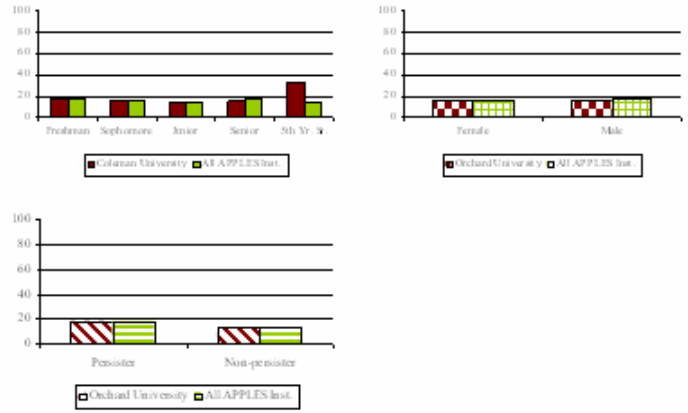
2. Motivation (Family Influence) Description and Items (Alpha = .87)

Motivation to study engineering due to family influences.

- *My parents would disapprove if I chose a major other than engineering.*
- *My parents want me to be an engineer.*

Means, Standard Deviations, Number of Respondents
Scale: 0 (low) – 100 (high)

	Orchard University	All APPLES Institutions
Overall Mean	171 (27.4), N = 217	163 (26.3), N = 842
Freshman	180 (27.6), N = 75	176 (27.1), N = 185
Sophomore	161 (23.0), N = 31	165 (26.9), N = 155
Junior	134 (23.3), N = 61	133 (23.6), N = 241
Senior	158 (27.9), N = 38	171 (25.9), N = 201
Fifth-year senior or more	333 (38.0), N = 6	142 (22.2), N = 40
Female	160 (23.3), N = 96	165 (26.9), N = 155
Male	159 (27.2), N = 121	171 (25.9), N = 541
Persister	180 (26.6), N = 180	176 (27.1), N = 754
Non-persister	134 (22.3), N = 37	133 (23.6), N = 88



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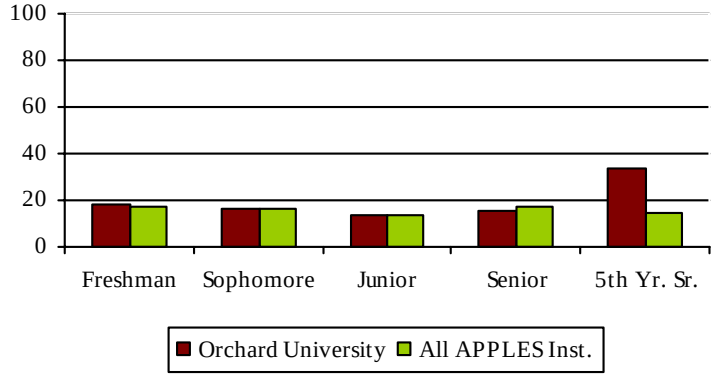
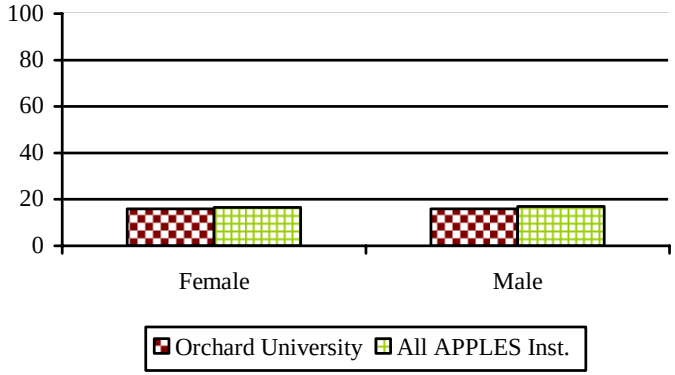
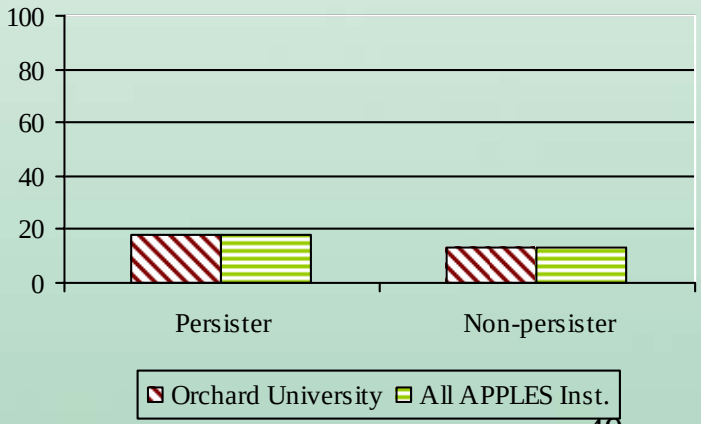
Freshman	18.0 (27.6), N = 75	17.6 (27.1), N = 185
Sophomore	16.1 (23.0), N = 31	16.5 (26.9), N = 155
Junior	13.4 (23.3)), N = 61	13.3 (23.6), N = 241
Senior	15.8 (27.9), N = 38	17.1 (25.9), N = 201
Fifth year seniors	33.3 (38.0), N = 6	14.2 (22.2), N = 40
Female	16.0 (23.3), N = 96	16.5 (26.9), N = 155
Male	15.9 (27.2), N = 121	17.1 (25.9), N = 541
Persister	18.0 (26.6), N = 180	17.6 (27.1), N = 754
Non-persister	13.4 (22.3)), N = 37	13.3 (23.6), N = 88

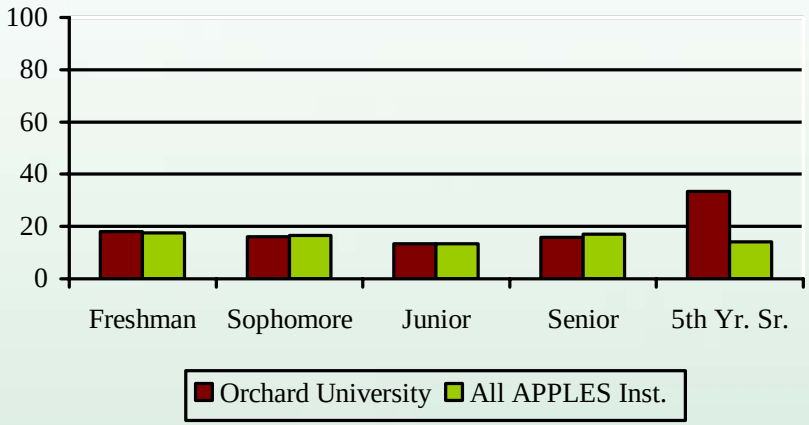




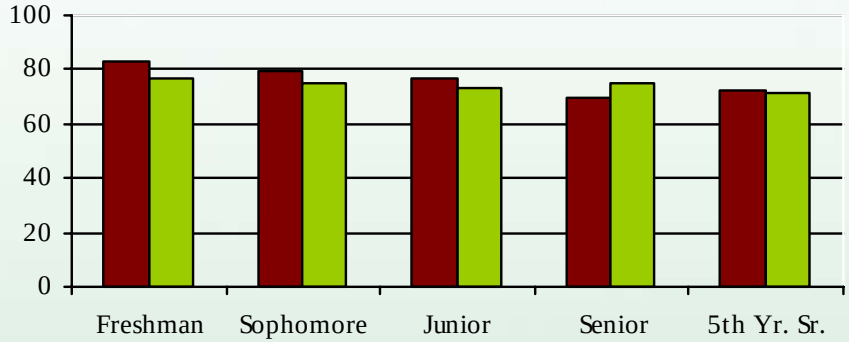


Motivations for Studying Engineering

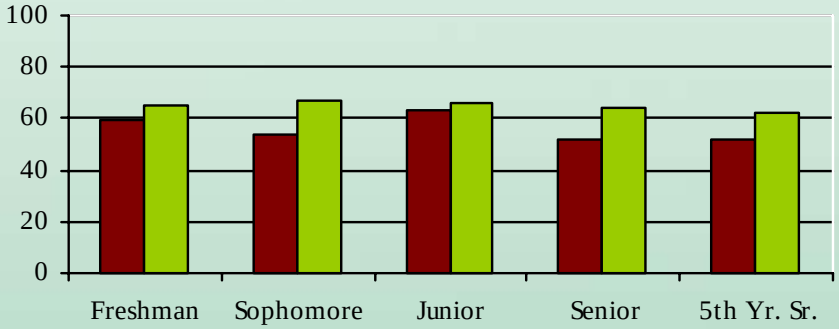
Family influence



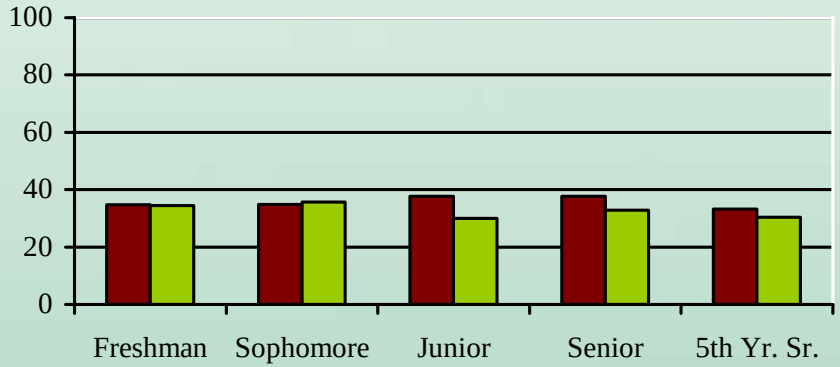
Social good



Financial



Mentoring



Open-ended Comments

32. Is there anything you want to tell us about your experiences in engineering that we haven't already asked you about?

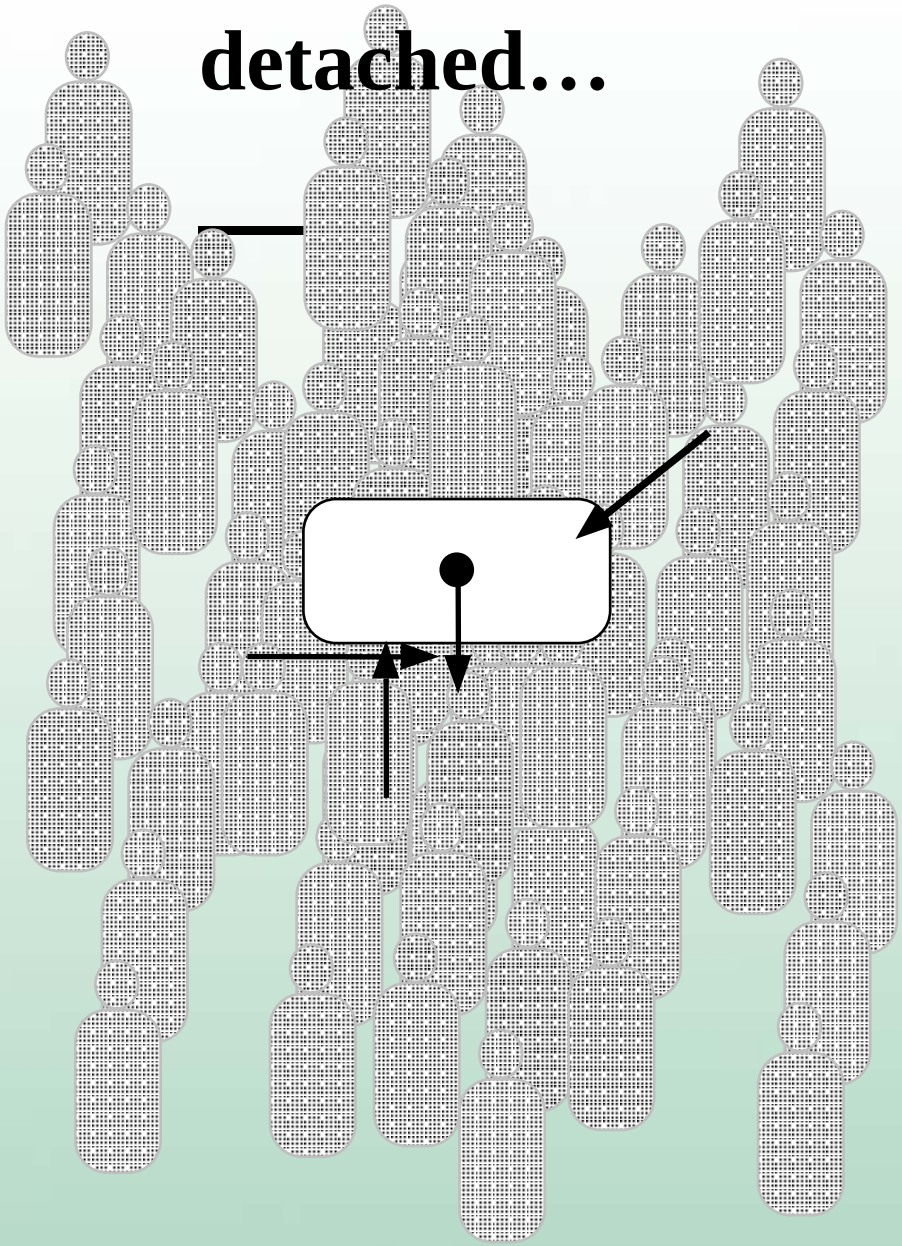
- I love Engineering, but sometimes it feels like it does not address the big issues of life. Like why can't there be more Engineering classes opening students eyes to world issues, like using Engineering to create clean water solutions, or food distribution solutions.
- I came in thinking I'd go for Math, but the CS department had so much more enthusiasm and obvious interest in what is happening in technology that I was drawn toward it, while the math department seemed to be actively pushing people away (in the R series, especially).
- As a senior, I look back and wonder if I made the right choice. I don't think that EE is my favorite major at Orchard, and I'm not even sure how much I like it. I just figured it closed the least doors to me and that undergrad was a good time to put in the effort to learn technical knowledge. I never really found my "passion" academically, but I suspect it would have been history, biology, or international relations. The benefits of being an EE major (which have been really great, I must admit) convinced me to force myself through the coursework -- but I didn't enjoy it that much.
- I chose not to major in engineering because there were too many classes to take. I did physics instead because there were half as many units required for graduation.

More information

www.applesurvey.org

Questions?

detached…



attached…