Bringing Design Research into Engineering Classrooms

Jim Borgford-Parnell
Cindy Atman
Kate Deibel
Center for Engineering Learning and Teaching
UW College of Engineering

Acknowledgements

Drawn from research by:

Cindy Atman, Kate Deibel, Robin Adams, Monica Cardella, Allison Kang, Deborah Kilgore, Andrew Morozov, Susan Mosborg, Jason Saleem, Ken Yasuhara and Jim Borgford-Parnell.

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CELT Design Research

- What do freshmen and senior students' engineering design processes look like?
- What do experts' engineering design processes look like, and how do they compare with students?
- When do students and experts gather information in the design process?
- How much and what kinds of information do they gather?
- How broadly do they scope design problems?

Engineering design is a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints.

Source: Dym, et al. (2005). *JEE 94(1).*

Session Agenda

- Present aspects of CELT's Design Research.
- Interact with participants on possible implications for engineering pedagogy and student learning.

Playground Design

- Participant groups
  - Freshmen (n = 26)
  - Seniors (n = 24, from CE, IE, and ME)
  - Experts / Practicing professionals (n = 19)
- Solved "Playground Problem" thinking out loud
- Asked experiment administrator for information while solving the problem
- Took 2 – 3 hours

Why a playground?

Problem Statement: Design a Playground

You live in a mid-size city. A local resident has recently donated a corner lot for a playground. Since you are an engineer who lives in the neighborhood, you have been asked by the city to design a playground.

You estimate that most of the children who will use the playground will range from 1 to 10 years of age. Twelve children should be kept busy at any one time. There should be at least three different types of activities for the children. Any equipment you design must be safe for the children, remain outside all year long, not cost too much, and comply with the Americans with Disabilities Act.

The neighborhood does not have the time or money to buy ready made pieces of equipment. Your design should use materials that are available at any hardware or lumber store. The playground must be ready for use in 2 months.

Verbal Protocol Analysis

1. Record audio from think-aloud protocol
2. Transcribe audio
3. Segment into codable "chunks" of subject statements (reliability check)
4. Code transcript (reliability check)
5. Analyze to answer specific research questions

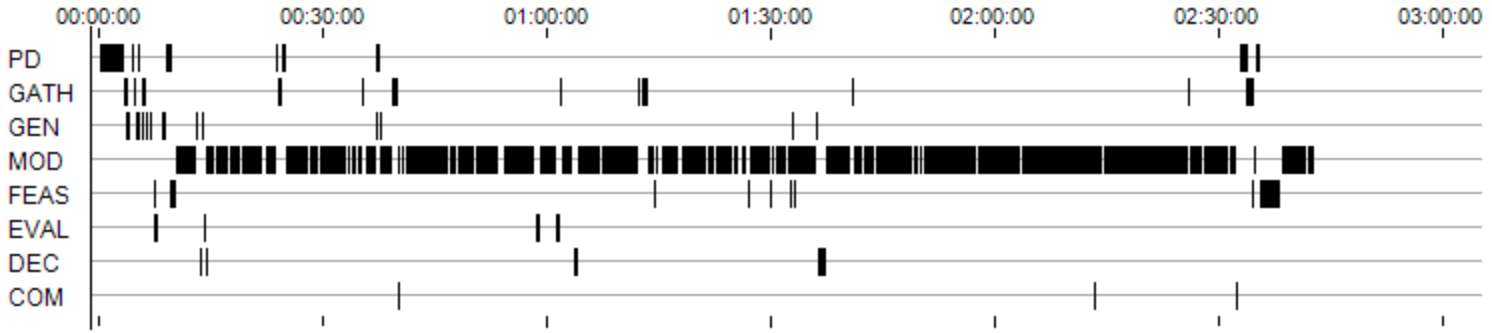
Design Process Activities

Derived from analysis of 7 engineering texts

Design Activities	Design Stages
(Identification of a Need) Problem Definition Information Gathering	Problem Scoping
Generation of Ideas Modeling Feasibility of analysis Evaluation	Developing Alternative Solutions
Decision Communication (Implementation)	Project Realization

Design Process Timelines

Freshman (Quality Score = 0.45)



PD:	Problem Definition	FEAS:	Feasibility Analysis
GATH:	Gathering Information	EVAL:	Evaluation
GEN:	Generating Ideas	DEC:	Decision Making
MOD:	Modeling	COM:	Communication

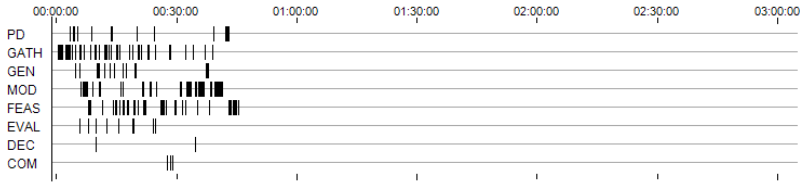
Activity 1

Individually, take a few minutes to answer Activity 1 questions on the worksheet:

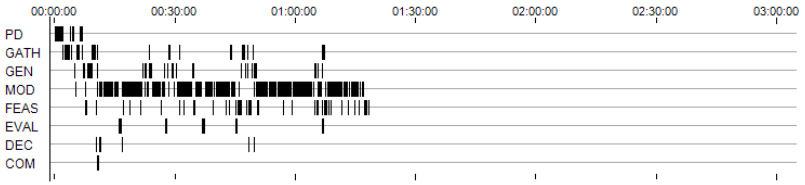
- In the design process timelines shown on the worksheet, what similarities and differences do you see between the freshmen and senior engineering students?
- Do these similarities also involve the quality scores? How so?

Discussion

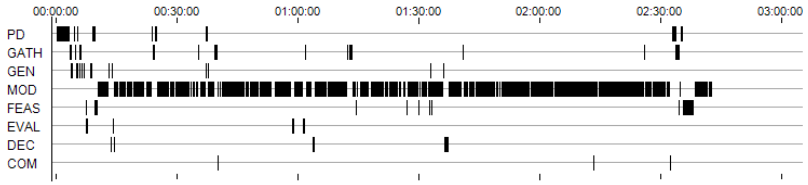
Freshman #1 (Quality Score = 0.37)



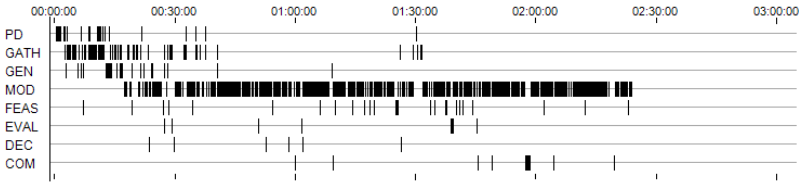
Senior One (Quality Score = 0.38)



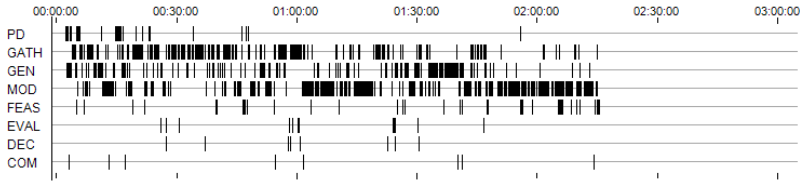
Freshman #2 (Quality Score = 0.45)



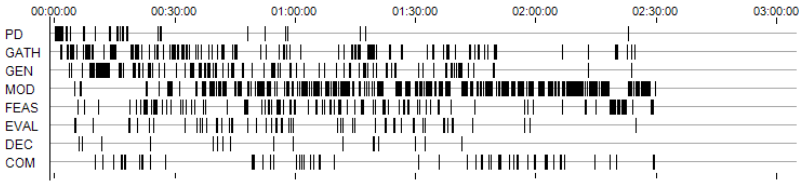
Senior Two (Quality Score = 0.53)



Freshman #3 (Quality Score = 0.62)



Senior Three (Quality Score = 0.63)



When asked the same questions seniors in a capstone design course reported:

- Everyone spent a lot of time on modeling.
- The people who spent time on multiple activities generally scored higher.
- The students who scored the highest did not spend large blocks of time on only one activity.
- Little time was spent on decision making.
- Seniors spent more time on feasibility analysis and evaluation.
- Seniors spent more time on project definition.
- For seniors, less continuous time spent modeling resulted in increased score.

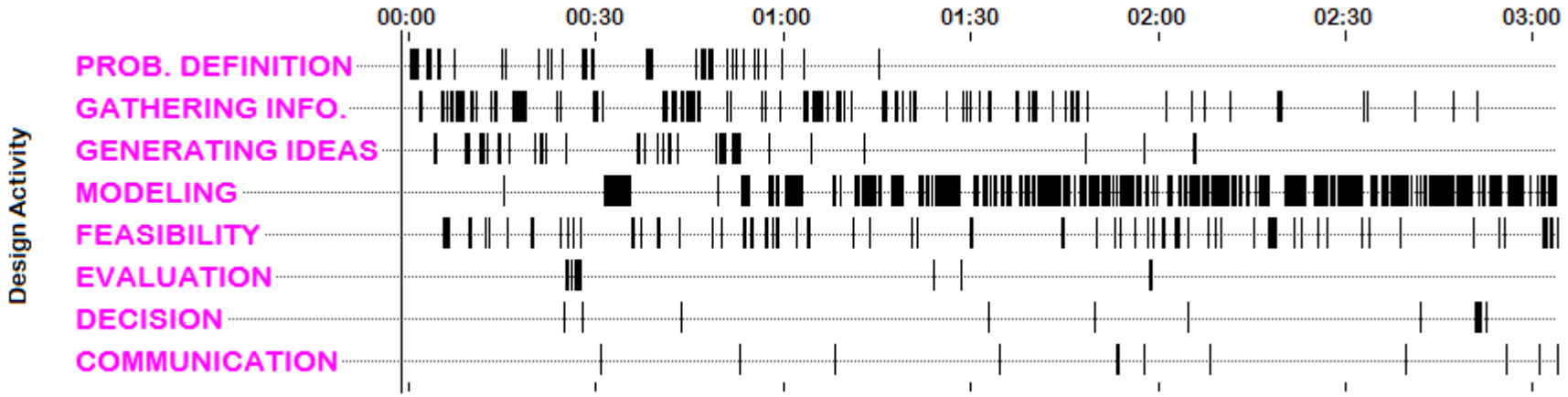
Our Findings: Freshmen vs. Seniors

Compared to freshmen, seniors…

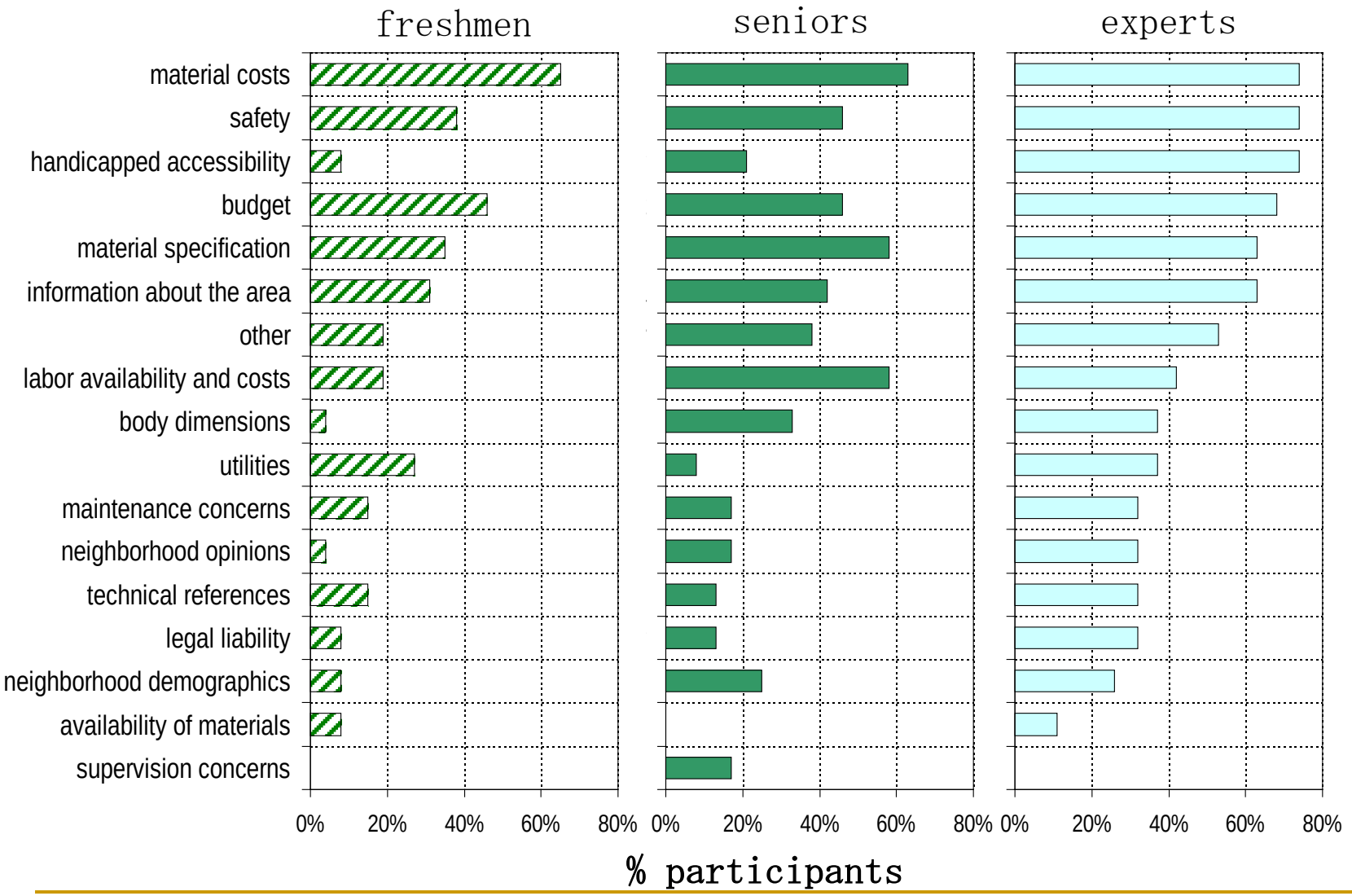
- …have higher quality designs. (whew!!)
- …scope the problem more effectively by considering a broader range of information categories.
- …make more transitions among design activities.
- …spend more time iterating.
- …progress farther in the design process.

Our Findings: Experts and Time

- Experts spend more time solving the problems in all design stages.
- Experts also tend to exhibit a ‘cascade’ pattern of transitions.

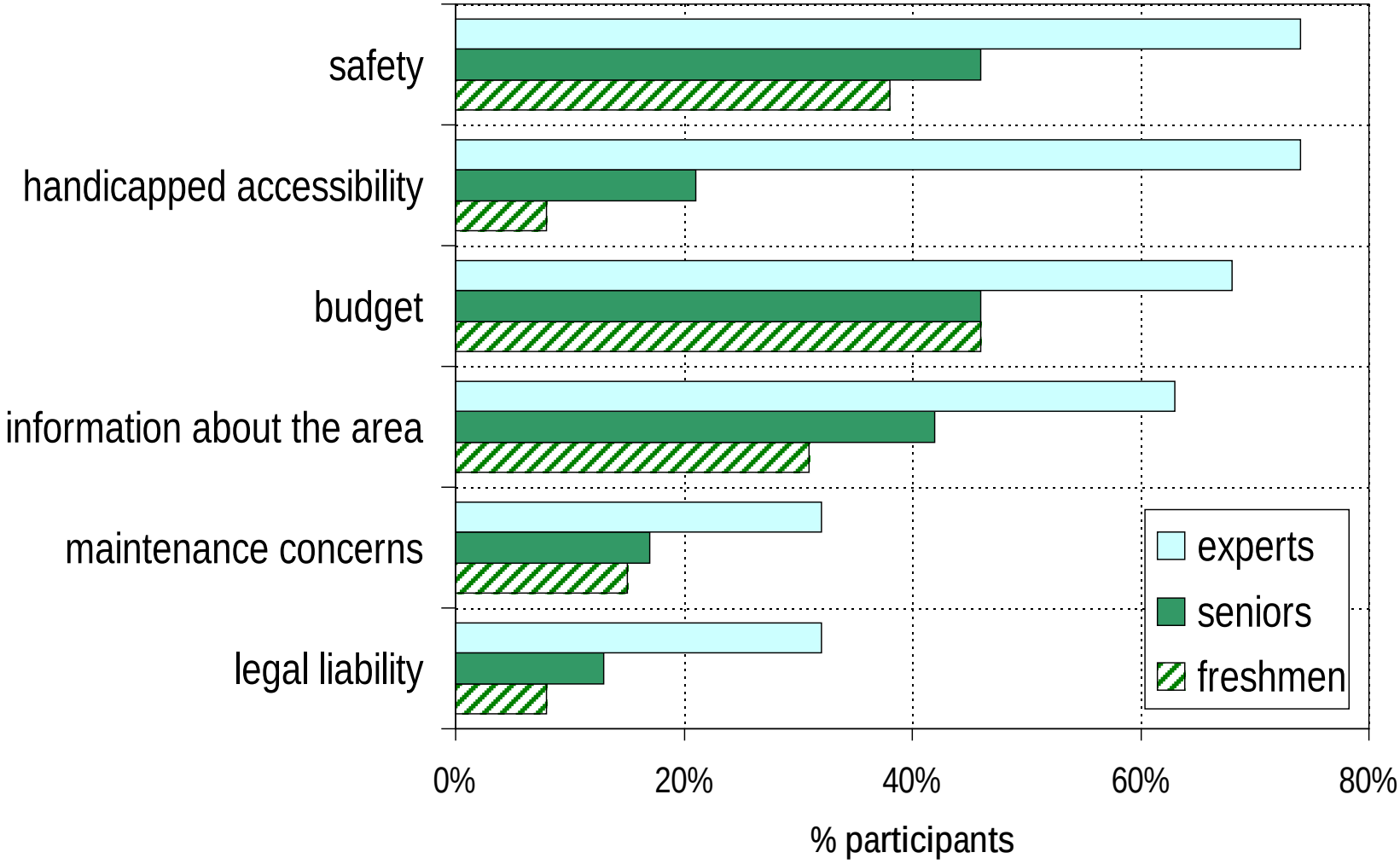


Information Categories for Playground Design



Information Categories for Playground Design

Focus on Selected Differences

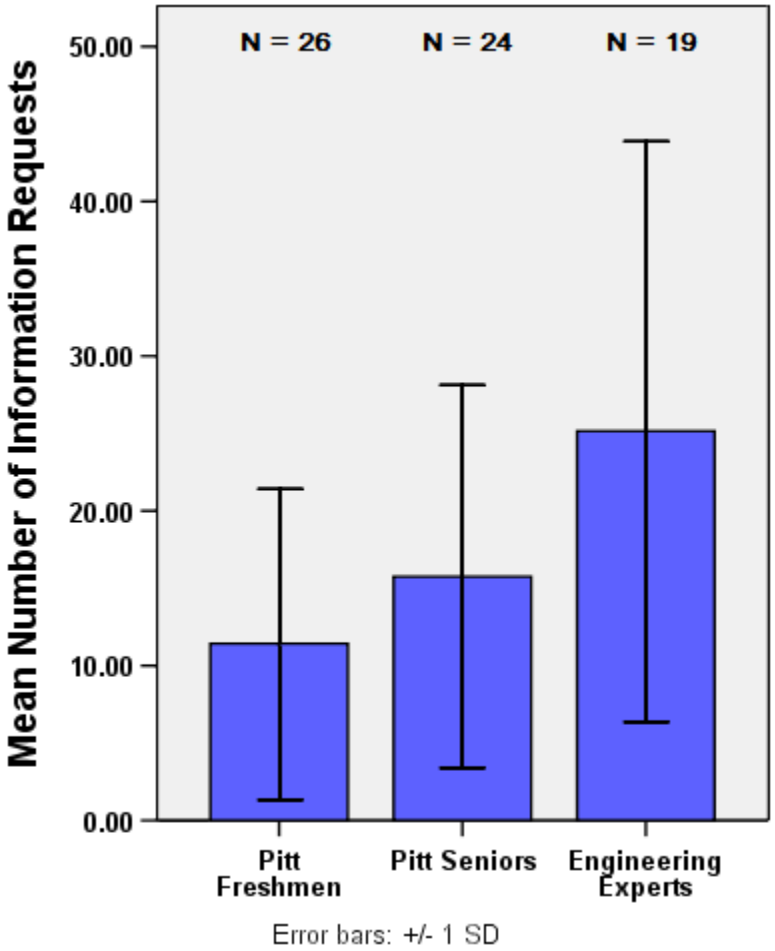


Our Findings: Experts and Information Gathering

Experts "scope" the problem more effectively by…

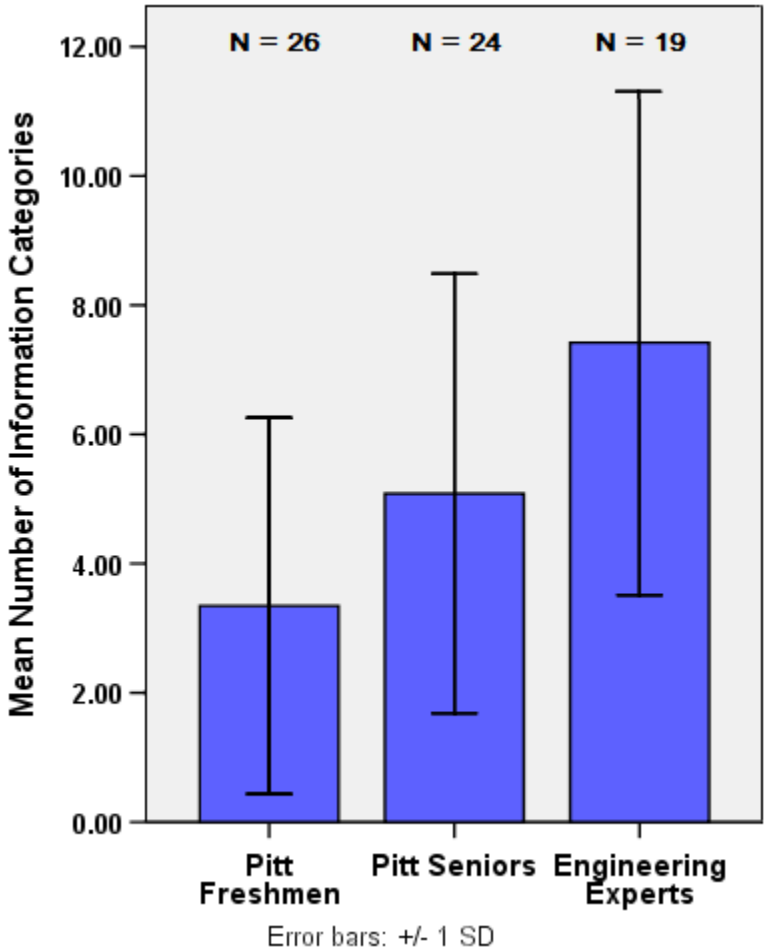
- …gathering more information than seniors and freshmen.
- …covering more categories of information than seniors and freshmen.

Number of Information Requests and Categories



Freshmen = Seniors < Experts

(p = .137) (p = .048)



Freshmen < Seniors < Experts

(p = .035) (p = .028)

Activity 2: Group Discussion

1. What are some possible implications for engineering education?

2. What are some ways that this might be used in the classroom?

Reference List

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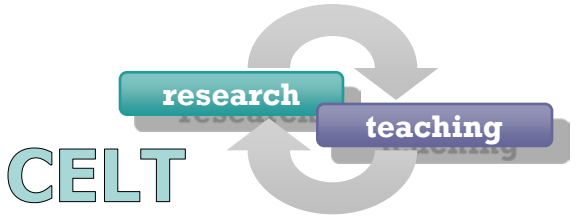
Bursic, Karen M. and Cynthia J. Atman, "Information Gathering: A critical Step for Quality in the Design Process," Quality Management Journal, vol. 4, no. 4, pp. 60-75, July 1997.

Reflection Exercise

Please take a moment to answer the reflection questions:

- What did you find most interesting or important? Why?
- How can this workshop be improved for future audiences?



THANKS!