

Student's Conceptualization of Engineering Design Over Multiple Design Experiences

Caitlyn Berryhill & Dr. Amanda Emberley

Mechanical Engineering Department, California Polytechnic State University, San Luis Obispo, CA



Introduction

- Cal Poly has a unique engineering program in which requires a design experience in each of the four years of undergraduate study.
- The goal of this project is to better understand how student's conceptualizations of engineering design changes over their undergraduate career.
- This information can lead the optimization of courses to better support student learning of engineering design.

BACKGROUND.

Literature Review

- Built a greater understanding of design thinking and how to teach it in order to supplement analysis of the survey responses [1].
- There are contrasting patterns between beginning and informed designers (e.g. "Skipping [Research] vs. Doing Research"). These patterns include the design strategies used by both and reveal teaching strategies to elevate a beginner designer to an informed one [2].

Methods

SURVEY.

A survey was given to 73 engineering students in the Spring Quarter of 2023 which included:

- Questions related to engineering design (Table 1)
 - 4 open-ended.
 - 7 close-ended.
- Course history questions.
- Demographic information questions.



Figure 1. Demographic Information Summary.

Table 1. Engineering Design Experience Questions.

Open-Ended Questions

Targeting Students Conceptualization and Relationship with Design.

Question ID	Description
O1	In your own words, what is engineering design?
O2	Describe up to two components of engineering design that you consider to be especially challenging.
O3	Describe up to two components of engineering design that you consider to be straightforward or simple.
O4	How and to what extent do you think you will use the engineering design process in your future career?

Close-Ended Questions

Recording how many times students experienced the following.

Question ID	Description
C1	Worked with a team on a design project.
C2	Had an idea you developed that failed.
C3	Tested and refined a solution idea.
C4	Considered ethical implications of your solution idea.
C5	Considered sustainability implications of your solution idea.
C6	Communicated your design ideas directly to a client or customer.
C7	Communicated your design ideas in multiple ways (e.g. written report, oral pres., etc.).

ORGANIZATION.

- Open-ended questions were categorized using a thematic coding system.
 - Thematic codes are recurrent patterns among a survey question which are identified after initial readings of the question's responses (e.g. Table 2).
- Closed-ended questions, the demographic information, and course history information were only tallied.

Table 2. Question O4 Thematic Codes.

Code	Description
Want to Become a Design Engineer.	Specify that they wish to work in design or be a design engineer and that they'll use Engineering Design Process a lot.
Will use it.	Specify that they are or expect to use the Design Process in their future.
Maybe / Unsure.	Unsure whether they will use the Design Process or are unsure of what they'll be doing in the future.
Engineering Design Process is Useful.	Doesn't specify that they will use it in their future career, but mentions that it is useful either in the mechanical engineering field to life's problem.
Not Very Much.	Specify that they will not use the Engineering Design Process that often in the future.
Other.	Too vague and/or too different from established codes, miscellaneous.

COMPARISON.

After the organization of the open-ended responses into thematic codes, questions and their responses were compared against each other.

- E.g. O4 thematic codes against demographic information.

Results

QUALITATIVE RESULTS.

- Most frequent thematic codes for each questions are:
 - About 60% said "Problem & Find Solution" for O1.
 - Around 18% said "Ideation & Brainstorming" for both O2 & O3.
 - About 70% said "Will use it" for O4.
- Made 4 separate comparisons between the open-ended questions, closed-ended questions, demographics, and course history.
- Students who responded something related to "Technical Work" for either O2 or O3 were all male and in ME 328 Design for Strength and Stiffness.

QUANTITATIVE RESULTS.

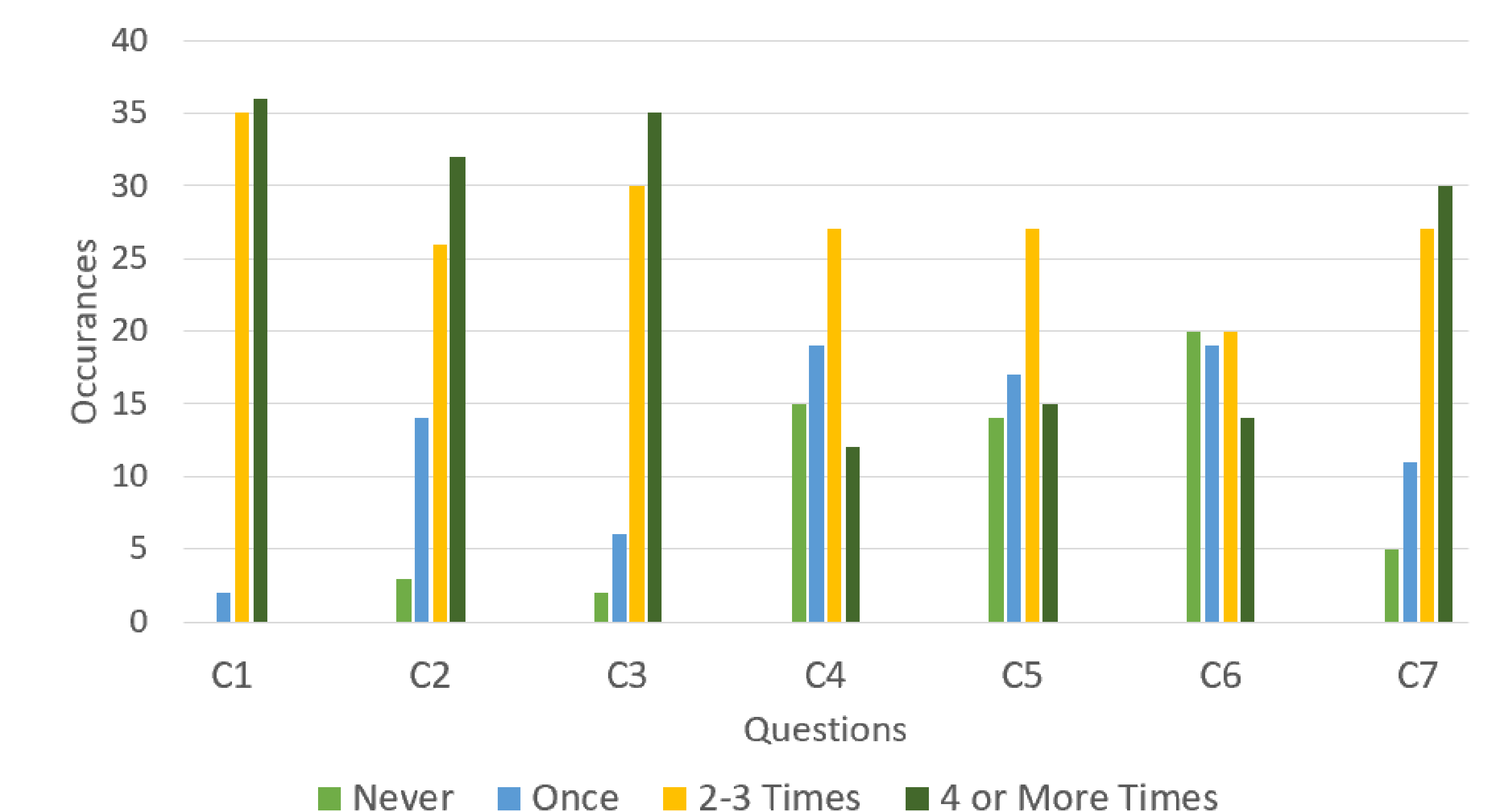


Figure 2. Closed-Ended Responses Summary.

Discussion

- Data shows that student's conceptualization of engineering design is influenced by what course they are currently taking, especially ME 328.
- Results point to areas where students may need additional help in design thinking.
- Thematic codes help reveal what students are considering when they are thinking about engineering design.
- Good representation of Cal Poly engineering demographics.

NEXT STEPS.

- Developing an interview protocol and conducting follow-up interviews.
- Further interpret the results and identify ways to improve courses and support student learning of engineering design.

Acknowledgements

This research was funded by Paul and Sandi Bonderson.

REFERENCES

- D. P. Crismond, R. S. Adams, "The Informed Design Teaching and Learning Matrix," *Journal of Engineering Education*, vol. 101, no. 4, pp. 738-797, 2012.
- S. D. Sheppard, et. al., "Knowing To" in *Educating Engineers: Designing for the future of the field*, Carnegie Foundation for the Advancement of Teaching, 2008, pp. 99-107.