

## **Board 417: Understanding Capstone Design Activity Engagement in Mechanical Engineering**

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## **Abstract**

This paper summarizes the initial findings of our ongoing work studying design activity engagement for engineering students and professionals. With this introductory study, we aim to gain a better understanding of how engineering students engage in capstone design activities, and their motivations for doing so. This paper presents the initial findings from semi-structured interviews with three engineering students and will constitute the base for further research focusing on student and professional engagement in design activity across different engineering fields.

## **Introduction**

This paper presents the initial results from a wider study funded through the NSF RFE program (Award #) exploring engineering students' engagement and motivation in capstone design activities. While ample research has studied the structures and professional implications of capstone design courses, as well as the complex nature of engineering design activity [1]–[3], little research has been done on investigating academic engineering settings, and how and why students engage in engineering design in such settings.

Our investigation is informed by the constructs of design activity engagement [4]–[7], motivation [8]–[10] and situated cognition [11]–[14]. Design activity engagement frames the social context of our investigation [4] and describes the complex cognitive [7], [15], [16] and social processes [2], [17] involved in the design process within a capstone course. These processes are a result from the structure of capstone courses, within which students engage in complex open-ended projects and collaborate with student peers as well as professional engineers sponsors. We further study student's motivation to engage in design behaviors as related to their identity construction [8]–[10]. Finally, we connect students' understanding of design activity engagement to literature in situated cognition [12], taking into account the context within which engagement in design activities occurs.

## **Summary of Project Objectives and Research Methods:**

This study constitutes the starting point of a larger study aiming to develop a model of design activity and engagement motives of students and professionals. Such a model will be built using Constructivist Grounded Theory (CGT) [18], implying an inductive approach to participant data analysis. In this preliminary study, we aim to focus on Mechanical Engineering students engaged in Capstone design courses. We aim to collect and analyze descriptions of how students engage in design activities and gain a better understanding of how the way they engage relates to their

identities as engineers. Gaining a better understanding of engagement and motivation within capstone design projects could help improve the efficacy and professional authenticity of capstone courses.

The specific research-focused aims of this project are to:

Objective 1: Develop a model of design activity engagement and identity motives of students and professionals.

Objective 2: Expand our model to account for the resistance and synergies, alignment and tension, between academic and workplace settings and across disciplines.

In this paper, we discuss our initial efforts to achieve Objective 1 by examining the identity-relevant design experiences in mechanical engineering capstone students.

### **Summary of Data Collection:**

In this paper, we report on our initial data collection efforts on interviews conducted with three participants from a mechanical engineering capstone design course. We selected the participants by convenience sampling from a mechanical engineering capstone design course roster at a large research-intensive university. The first author conducted each interview at the midpoint of a capstone design project (10 out of 20 weeks). The interview protocol for this study was developed collaboratively between the first author and both co-principal investigators, and utilized open ended questions to elicit rich descriptions from participants. The main themes focused on for this study were participant's identity, motivation to engage in engineering, description of capstone projects, and motivation to engage in specific projects. An emphasis was placed on probing participants to better understand how the ways they engaged in design activities related to their engineering identity. A preliminary analysis of each interview transcript provided valuable insights into these topics.

### **Initial findings:**

The content of the semi-structured interviews have demonstrated the potential for our methodology and interview protocol to elicit deep accounts of students' motivations and internal processes when engaging in engineering design activities. For example, Sarah gave a thorough description of the main elements of design she thought were important, such as "I want to start from scratch on my design. I want the freedom to make a lot of the design choices". Sarah also described how she navigated each task in her projects in accordance with these elements : " We [capstone team] all worked on all the design aspects. This could make the process slower but it brought a lot more diversity in our thought process." Another deep description of the internal design process was Maria's in depth description of the ways in which she stored and organized data, and how it benefited herself and her team : "I've used this personal knowledge management system I learned from the book 'building a second brain', and I adapted it to my note taking and started implementing it at school, and it changed the way I organized and produced work"

We also were able to explore participants' sense of engineering identity. For example, participants shared that their sense of engineering identity emerged as they were younger because they, as put by Sarah, "enjoyed building things" and "interested in the thought process" of designing and building projects. Students also expressed a stronger interest in aspects of the design process they already had experience with. For example, previously acquired skills such as 3D modeling : "I have a 3D printed and love to print things around the house and design and build things to make life easier" (Maria), or machine shop skill: "I got put in charge of the manufacturing person on our team because I have experience with the machine shop and I own a lot of tools myself" (David) were already a part of our participant's engineering identity, which led them to be more motivated to engage in such aspects of the design process. This identity-driven motivation contributed to define the structure of the capstone team, where each student could assume roles they were most interested in. The choice of the capstone projects also reflected student's identities, specifically their vision of themselves as future engineers, a finding reflected in Sarah's choice to engage in a product design project because she intends to work in product design in her future career.

These early findings informed us on how and why students engaged in capstone design activities, and provided useful insights on the relationship between engineering identity and motivation within this context.

#### **Future work:**

Following our early findings and expanding our investigation to engineering professionals and other engineering disciplines, we are confident that we will develop a model of design activity and engagement motives. Our initial findings will also be reinforced by the use of CGT and the collection of data from various sources. Such a model could benefit capstone course design and provide useful insights to the engineering education community. Our initial findings will also be reinforced by the use of CGT and the collection of data from various sources. Widening our study to other engineering fields such as Civil Engineering and considering the specificities of design engagement within both academic and professional settings could also benefit capstone instructors. Indeed, designing capstone courses with a deeper understanding of design engagement and motivation could improve student's experiences within capstone courses and provide a more authentic design experience.

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