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# Crafty Engineers: Undergraduate Engineering Students' Perspectives on the Relationship Between their Crafting And Engineering Practices

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## Abstract

In this work-in-progress paper, we explore how undergraduate engineering students perceived connections between their engineering education and crafting practices through semi-structured interviews and grounded theory analysis. Preliminary findings from this pilot study suggest that students see their crafting skills as beneficial to their engineering education because their previous crafting experiences have made them more creative and open to experimentation, failure, and hands-on education.


## Introduction

Design processes in crafting practices, such as sewing, are directly tied to STEM competencies and may present an avenue for the creation of novel education experiences that promote the importance of creativity and diverse ways of thinking in STEM [1], [2], [3]. Creativity is a key aspect of engineering education, but is rarely positioned as central to the training of engineers [4], despite its necessity in formulating ideas during the iterative process of designing, creating, and testing products. The work of engineers is critical to the development of real-world solutions focused on the needs of users, and an increased focus on creativity could play a major role in novel engineering designs.

Our work draws on the connections between engineering education and crafting practices to investigate the role of crafting in engineering. In this work-in-progress paper, we seek to understand engineering undergraduates' crafting and disciplinary practices, connections between the two, and how their experiences in both inform their pursuit of "creative" engineering. From this pilot study, we address the following research questions: (1) How do engineering students who are also crafters situate connections between these practices? and (2) How might drawing on crafting practices enhance undergraduate engineering education?

## Background

Despite similarities between crafting and engineering, work historically labeled as "crafting" has often gone unrecognized in its importance and relation to engineering [5]. Consider the "Little Old Ladies" who were primarily responsible for weaving the memory for the Apollo Guidance Computer which, unlike computer memory formats of today, consisted of wires hand-woven into patterns representing zeros and ones, the binary data which held the instructions necessary for taking us to space. This act of weaving, a subset of textile and fiber arts which has historically been seen as a "feminine" craft, was not considered engineering at the time, despite the skill involved and its importance in early computing. In recent years, researchers have tried to recreate this woven core memory, and, in doing so, discovered the difficulty of the task and recognized the importance of bringing previous, related, and often embodied knowledge connected to hands-on textile skills to engineering work [6].

Research into funds of knowledge highlights the importance of bringing knowledge and competencies from what is considered typically non-academic areas into engineering. Notably, research on Latino/a funds of knowledge has shown that high school students can bring their experiences with sewing at home into engineering projects, contributing valuable insights about design decisions to their teams [7]. These students participated in engineering work by drawing on previous crafting experiences to engineer novel watertight products using methods that might have not been considered otherwise.

Overlaps between practices of and access to crafting and engineering are also seen in makerspaces and maker education [8], [9], often done so intentionally to bring in more makers and crafters into the space. The maker movement draws on playfulness, a growth mindset, positive experiences with failure, and collaboration [10], all skills seen in creative making practices that are also beneficial to engineering. Prior work on maker education and crafting found that engaging in crafting allowed participants to develop a lifelong connection to applied math in real-world contexts [1]. Additionally, in an e-textiles workshop focused on the use of a sewable microcontroller, students with varying levels of previous experience with textiles and programming were able to learn new skills while leveraging existing ones and come out of the workshop with meaningful artifacts [2]. This suggests that combining electronics and sewing tools specifically designed to encourage making connections between the two can help students with differing backgrounds achieve positive outcomes and increased knowledge of both types of work [2].

These intersections between crafting and engineering practices from prior research inspired us to interview undergraduate engineering students to see if they saw those connections and, if so, how they appeared in their crafting practices and engineering studies to explore ways of improving undergraduate engineering education.

**Methods**

Our research questions examine how engineering students see overlaps between crafting and disciplinary practices and how their insights might inform how creativity is valued in engineering education. For this study, eight engineering undergraduates with crafting experience were recruited via email, class announcements, and through flyers in makerspaces and common areas across campus from a private, four-year university located in the United States. Potential participants first filled out a screening survey and, if they met the necessary criteria (undergraduate engineering student, at least 18 years old, participation in at least one type of crafting), were contacted via email to re-assess interest and schedule interviews. Of the 15 students who completed the survey, eight responded to our interview requests. Participants included one non-binary and seven female students in their first, third, and fourth years of study across majors in Mechanical Engineering, Human Factors Engineering, Computer Science and Engineering, Biomedical Engineering, and Environmental Engineering.

Students were asked about their experiences with and practices in engineering and crafting, and how, if at all, they saw overlaps between these two areas. Interviews were conducted by two researchers, recorded, transcribed with automated tools, and cleaned for clarity. From the transcripts, we initially identified reasons for learning crafting and engineering, how students see overlaps between their experiences, and students' desire to engage in creative, hands-on skills as

common factors using grounded theory methods [11]. For each interview, we assigned codes to each utterance, then collapsed the resultant set of codes into 16 overarching categories, from which four key themes relevant to the scope of this paper emerged: perceived beneficial connections between crafting and engineering, willingness to experiment and fail, spaces for creating and making, and factors leading to majoring in engineering.

## Results

### *Perceived Beneficial Connections between Crafting and Engineering*

This theme encompasses connections that students made between their experiences with crafting have helped them in their engineering studies and vice versa. All participants shared examples of advantageous links between their engineering education and crafting practices. Marissa commented on how her experiences with art have prepared her for problem solving in her STEM classes and also talked about how her classes help her in crocheting, stating, "I think my math classes have definitely helped with my crocheting because there are times where using an equation is so much easier than counting it [the number of stitches needed per row]." Additionally, Avery said that her prior experience in making crafts for others as gifts helps her in her Human Factors Engineering classes because she is already familiar with how others will perceive the products she designs. These comments from these two students show how crafting and engineering skills can influence each other in beneficial ways.

### *Willingness to Experiment and Fail*

Another emergent theme was how students described direct effects of crafting on their willingness to experiment and fail in their engineering coursework. Avery commented, "Doing a lot of crafts makes me more open to just making mistakes and just going in and getting my hands dirty." She also referred to herself as a "crafty engineer," and shared that she thought that "crafty engineers are better at picking up skills and making mistakes." Similarly, Zoe mentioned that their experience with crocheting 3D objects and knowing how to adjust when "something doesn't look right" helps them in their robotics class because they are comfortable with replacing pieces of the robot and trying something new to achieve their objectives more than other students on their team. Here, students demonstrate how they are prepared to handle failure and find novel solutions in their engineering work due to their crafting experiences.

### *Spaces for Creating and Making*

Students also considered how makerspaces allowed them to creatively learn and practice their crafting skills in conjunction with engineering. Sophia recalled how a friend helped her learn how to use a sewing machine in the university's makerspace so that she could alter clothes and then later used her soldering skills from her electronics and controls class to make jewelry there. Avery said that she thinks that, because there are two professional sewing machines in a makerspace on campus, "[it] inspires engineers to get involved in more textiles, because it's just in the shop. [They can] make less obvious things where it's the same process of using a material to make something that not necessarily solves a problem, but just making things. I think all crafting is kind of united on that front." The presence of "atypical" machines in an engineering makerspace not only brings students with crafting experiences into engineering spaces, but

encourages engineering students to explore different materials and processes in their product designs through different creative methods.

### *Factors Leading to Majoring in Engineering*

Students mentioned a wide range of factors related to their choice to major in engineering, namely prior K12 experiences with engineering and family influences; however, crafting appeared several times as well. Across interviews, students described how their hands-on crafting practices led them to want to choose a major, in this case, engineering, that would allow them to continue using their hands-on skills. Avery stated, "The reason I really wanted to do mechanical engineering or human factors engineering is because I wanted to be in an engineering profession where I was working with my hands. Because I know I love doing stuff like this where I'm just making little knots and just knitting." Similarly, Madison talked about how she sees her sewing projects as a part of engineering, saying, "I'm always going to be crafting in whatever medium, but the want to do something with your hands and just make something is definitely connected to engineering." These statements illustrate that prior experience with crafting may be a pathway for students into engineering disciplines that students perceive as hands-on and correlates with prior research that exposure to craft technologies can shift students' mindsets about who can be a programmer or engineer [13].

## Discussion and Conclusion

From these responses, students have shown a variety of connections between their engineering and crafting practices. They reported these connections as being beneficial in a number of ways, including helping them choose their majors in college, form resilient mindsets, and be more creative engineers due to the skills and ways of thinking that come from their crafting experiences.

An area needing further exploration is that we were unable to recruit any male students. Even though the university where this study took place has 10% more male than female students enrolled in engineering courses and recruitment took place in the university's makerspaces and large introductory engineering courses, there was a lack of male students who expressed interest in both crafting and engineering, potentially because crafting is a historically female-dominated practice. In future data collection for this project, we will strive to include them in our sample to understand if there are any potential gendered differences in how this group perceives the effect of their crafting practices on engineering and also explore if the label of "crafting" within makerspaces attracts primarily female and non-binary participants.

From these preliminary interviews, there is evidence that crafting practices influence undergraduates' engineering education experiences. This research suggests implications for pathways into engineering, student persistence in the major, increasing creativity in engineering, makerspace design, and potential curriculum development specifically related to the crafting practices of underrepresented students. Undergraduates' prior experiences with crafting may be a positive factor in their undergraduate engineering education and could provide a way to help students explore more creative aspects of engineering.

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