# BOARD # 359: ECR-EDU Core Research: (Mis)alignment between ME course content and student career intentions

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## Introduction and Background

Mechanical engineering (ME) follows a similar curriculum across American institutions [1], [2], including topics such as mechanics, thermodynamics, and material science [2]. Design courses and technical electives offer some opportunity for additional topics, such as social, cultural, and environmental aspects of engineering [3]. However, engineering has a technocentric culture, which can limit course content from these more comprehensive aspects [4]. A narrow, technocentric focus in ME education is likely to have significant implications for students who wish to pursue careers that engage with social, cultural, and environmental aspects of engineering, which may be disproportionately prioritized by women and minoritized students already underrepresented in engineering [5]. Researchers surveyed over 1000 senior ME students across nine U.S. universities, finding students desired engineering jobs with comparably less math intensity, but more collaborative, coordinative, and creative work [6], [7]. As careers in ME are broad, including in product development and management, technical consulting, and public health industries [6], [7], [8], there are concerns that a limited education focus does not adequately prepare students for the diverse range of engineering work [9], [10], [11]

Evidence on students' views of course-career alignment, particularly in roles emphasizing social and environmental aspects of engineering as well as other more comprehensive skills, . Two junior ME students in a qualitative study desired social and contextual skills, noting only first-year and senior design courses emphasized technical communication, teamwork, applied ME knowledge [12]. Thus, as part of a multi-methods study, the study reported here focused on interviews with students about their course experiences and career interests. The findings contribute to our understanding of student career pathways in engineering and how to support students' pursuits in careers that apply broader and more comprehensive skillsets.

## Method

This study was guided by the research question: How do ME senior undergraduate students describe the (mis)alignment between engineering course content and their career intentions? The 18 participants in this study were from a midwestern research intensive university, and included seven male students, ten female students, and one student who did not indicate. Among the 18 participants, 11 participants self-identified as White/Caucasian, three as Asian, two as Middle Eastern, one as mixed eastern European and South Korean, and one as Latinx. We elected to focus on senior ME students because they have enriched course experience and are likely better understanding about their career interests and directions both within and beyond the ME field.

Data for this study were from a larger study examining curricular messaging in industrial engineering and ME. We collected data using semi-structured interviews on educational messaging on the nature of engineering, students' values and interests in engineering, and career choices and persistence within the field. For the present study, our analysis focused on interview data related to career thinking and how course content informed students' career plans.

The interviews were transcribed and analyzed for how students related course experiences with their career intentions. In the first cycle coding, summary statements were made by two coders to

describe data of each participant relevant to the following concepts: 1) career intentions, 2) required course experiences relevant to their career intentions, and 3) other experiences, beyond core coursework, relevant to students' career intentions. Direct quotes were recorded along with the summary statements. These summary statements were then copied into NVivo for the second cycle coding, where we searched for themes of career intentions related to 1) course content, 2) course information, and 3) skills/practices, guided by Saldana's recommended approaches [13].

## Findings

Students discussed alignment between their ME course content and career intentions in two ways: 1) how the course content influenced and aligned with their career interests and 2) the extent to which course content supported engineering skills and knowledge development applicable to their future careers. Table 1 summarizes findings of (mis)alignment between course content and students' career interests as well as perceived applicability of skills and knowledge taught in these courses. The upper section of the table demonstrates student perceptions of course content as informing their interests in pursuing particular careers. The lower section of the table names students' perceptions of the type of course content applicable to their career plans. The table also indicates if course content alignment and content applicability related with required or non-required ME courses. While half of the 18 participants described how ME course content drove their career directions, the majority (16) articulated at least some way that the skills and knowledge taught in their ME courses would be relevant to their future work.

**Table 1.** Students' perceptions of applicability of ME course content and its alignment with their career interests

| | **Count of participants (N=18)** | | | | | |
|---|---|---|---|---|---|---|
| | **Courses inform interest in a career that is:** | | | | **Course content Aligned/applicable with:** | |
| | *Aligned with content* | *Aligned with SOME content* | *Misaligned with content* | *Not mentioned* | *Required ME courses* | *Non-required ME courses* |
| **1. Course content/ career plan alignment** | 6 | 2 | 1 | 9 | 2 (of 8) | 8 (of 8) |
| | *Applicable* | *Mixed applicability* | *Not applicable* | *Not mentioned* | *Required ME courses* | *Non-required ME courses* |
| **2. Course content applicability to career plan** | 12 | 4 | | 2 | 14 (of 16) | 6 (of 16) |
| 2a) Foundational knowledge | 8 | 2 | 2 | | 10 (of 10) | 4 (of 10) |
| 2b) Problem solving | 6 | | | | 6 (of 6) | |
| 2c) Teamwork | 5 | | | | 4 (of 5) | 2 (of 5) |
| 2d) Tech communication | 4 | | | | 4 (of 4) | |

*(Mis)alignment between content students learned in ME courses and their career directions*

Of the nine participants who discussed how their ME courses influenced their career direction, six described interests in a particular career that aligned with their ME course content. Another two participants described career interests that were informed by and aligned with some ME course content. The remaining one participant reported that his ME course content was misaligned with his career interests and he decided to leave the ME field. Half of the participants did not articulate any way in which their ME courses drove their career thinking. Among the eight students who described some extent of positive alignment between ME course content and

their career directions, only two named alignment with their required courses as shaping their career thinking while all eight identified alignment with courses outside of required ME courses. Two participants named required courses in shaping their career directions. For example, one participant discovered an interest in design and manufacturing through a required design course.

> *[Designing machines and understanding how things were made] was something that… also got put forward… in my [design course], where we started talking about manufacturing…It was something that I had that realization that, wow, we talk a lot about products, but we don't talk about how they're made. And how things are made is just really cool to me… and it just sparked an interest in me.*

Of the eight students who described non-required courses as shaping their career thinking, six discussed technical electives that inspired them to work in specific subfields of ME. One participant described an elective course that motivated his plans to specialize in electromechanical system design through a graduate degree. He commented:

> *The most meaningful experience that I got in mechatronics and control systems… when I was taking [an elective course]... I wanted to do electromechanical systems design, but then honing in on that, I learned more about how control systems plays a role in that and how the fusion of those fields forms mechatronics, which I'm also interested in. So I learned a lot more about the fields that interested me and I got to focus on certain categories within them.*

Two participants also named non-engineering courses as driving their career directions. One shared: "*My urban planning course has really made it clear to me that I want to get involved in local politics to shape zoning codes."* Another described a business course that enabled her to "*find a direction that I'm interested in going and seeing how I can be a leader..."*

One participant spoke of misalignment between his course content and career interests as shaping his career thinking, explaining he switched from the traditional ME field to data science route because he did not find his ME course content interesting:

> *I kind of realized going through some of the hands-ons, like the [series of design] classes in mechanical engineering that are the traditional design and build, most of my peers really loved those classes… I honestly just didn't feel the same way about it…. I just found that I wasn't super interested in those types of problems, the kind of design and manufacturing types of problems, which covers a lot of mechanical engineering…The thing that maybe excited me the most was…data science, machine learning….*

*Knowledge, skills, and practices students in ME courses applicability to future engineering work*
Sixteen of 18 participants described ME course content as applicable to their future careers, including foundational technical skills and knowledge, problem solving, teamwork, and technical communication skills. Of these 16 students, 14 explicitly discussed how the skills and knowledge emphasized in their required ME courses were applicable to their future careers and six students discussed applicability of non-required course content.

Ten students identified foundational knowledge in core ME courses as applicable to their intended future work. Six of these participants considered the design approaches they learned in required design courses as applicable to real engineering work. Another two participants described the fundamental knowledge of thermodynamics and heat transfer in required ME

courses applicable to the industries they are interested in, such as the food industry and sustainability. Four participants also described learning applicable technical skills and knowledge in elective courses. One participant highlighted the finite element analysis he learned in an elective course was applicable to a design/manufacturing engineer's work.

> *In a mechanical engineering elective course, finite element is basically just like, "Here's how you use finite element analysis to work on parts," which is a key skill I think… You're going to go to industry and how you're actually going to make sure your parts don't break. This is how you do it [using finite element analysis]. And this is one of the industry standard softwares that's used here, get familiar with it and do all these things with it.*

Four participants described feeling that some (2 participants) or all (2 participants) of the technical knowledge in their core courses was not directly applicable to their future careers. These students described lacking an understanding of what a particular engineering job entails even after they took relevant ME required courses. For instance, one participant described:

> *Systems and controls is something that I really enjoy…I've taken two theory classes on it, but I don't really have a great understanding of… what it's actually like, if I go into industry and I'm a systems and control engineer, what am I doing? Am I sitting at a computer doing MATLAB all day…? I feel like there's a missing knowledge gap there that I don't really know what I would end up doing if I… went into industry...*

Participants also named practices taught in their ME courses related to problem solving, teamwork, and technical communication as applicable to their intended future work. Six participants appreciated the problem solving ability they developed through required courses. One participant who intended to become a software engineer recognized the process of problem solving, rather than theoretical knowledge, as essential for MEs after she took a required design course and explained that these thinking and problem solving skills were transferable across fields. Another participant described he learned "breaking down core principles, setting up a free body diagram, and solving problems" in every single one of his required courses which is important to where he is going as a professional ME engineer.

Five participants described teamwork developed from their required ME courses as important and applicable for their career. For instance, one participant described both his understanding of collaboration and ability to collaborate with peers improved progressively through taking ME required courses. In addition, two participants named non-engineering courses that helped them gain teamwork and collaboration skills which are applicable to future careers.

Four participants described communication skills they learned in required ME courses, especially the engineering professional lectures in those courses, as beneficial for their careers. One participant said, "Technical communication is important in whatever field you go into." Another participant added, "Being able to effectively present my ideas… have definitely stood out to me as really helpful [in my future career]."

**Discussion and Conclusion**

Our findings showed most students (16 participants) found knowledge and skills learned in ME courses as applicable to their future careers. Many students (10 participants) named foundational knowledge from required ME courses as applicable to their intended future careers. Students also

named teamwork, problem solving, and technical communication as applicable skills and practices taught in ME courses. Other researchers also reported undergraduate engineering students' interests in learning these applicable skills in engineering programs [6], [7], [11]. While most students cited the applicability of their course content to their future careers, less than half of the participants (8 participants) described their courses as shaping their career directions. For required coursework, only two participants described these courses as driving their career decisions. The research has shown that the limited emphasis of social, cultural, and environmental aspects of engineering in engineering curricula is likely to reduce women and minorities students' participation in engineering [5]. Our findings suggest there is an opportunity to integrate more comprehensive knowledge, skills, and practices in required ME curriculum as a means to connect to and support engineering students' career interests.

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