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Undergraduate Engineers and Teachers: Can Students Be Both?

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Abstract

Today's college-aged students are graduating into a world that relies on multidisciplinary talents to succeed. Engineering college majors are more likely to find jobs after college that are outside of STEM (science, technology, engineering, and mathematics) fields, including jobs in healthcare, management, and social services. A survey of engineering undergraduate students at the University of Colorado Boulder in November 2012 indicated a desire by students to simultaneously pursue secondary teacher licensure alongside their engineering degrees: 25 percent "agreed" or "strongly agreed" that they "would be interested in earning grades 7–12 science or math teaching licenses while [they] earn [their] engineering degrees. As colleges of engineering education, how can we support the success of our students in these multidisciplinary fields post-graduation, including teaching?

The University of Colorado Boulder's College of Engineering and Applied Science in partnership with the School of Education, has developed an innovative program that results in graduates attaining a secondary school STEM teacher license concurrently with an engineering BS degree. This streamlined pathway through engineering educates and prepares a workforce of secondary teachers capable of high-level teaching in multiple STEM subjects—either engineering coupled with science (biology, chemistry, and physics), or engineering coupled with mathematics. These engineers are motivated and inspired to pursue two career routes because they find value and passion for both professions. One study showed that successful mathematics and science teachers "would have liked to be engineers". Teachers expressed that being comfortable and understanding engineering phenomena is a barrier to why they initially did not pursue an engineering career. We are fostering students that develop both an engineering mindset alongside a commitment to giving back through secondary teaching in this program.

This research aims to discover if and how students in the engineering + teaching program identify themselves as both an engineering student and as a teaching student. We are exploring why students decided to pursue engineering and teaching and how they plan to use engineering, teaching, or both in their futures. It is important to also understand how we attract students to this program. Given the diverse student experience inherent in this degree program built around passion and desire to combine engineering and teaching, the paper addresses the questions, "How do engineering knowledge and teaching knowledge intersect for undergraduate engineering students?" and "What challenges exist to navigating an engineering major with a teaching license pathway?"

Initial survey and focus group data collected this past academic year indicates that students in this degree program identify as both an engineer and a teacher. Using mixed-methods analysis informed by current education research—including quantitative and qualitative survey questions and small focus groups—we explore the ways in which students discovered this program and how they plan to incorporate the two disciplines in their future. We are interested in how engineering students will incorporate the knowledge that they learned in engineering classes into the lesson plans they design for secondary classroom students.

Keywords: P-12 engineering, engineering undergraduates, pre-service teaching, engineering education

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Introduction

Today's college students graduate into a world that relies on multidisciplinary talents to succeed. Engineering majors are likely to find post-college jobs outside of STEM (science, technology, engineering, and mathematics) fields, including jobs in healthcare, management, and social services (US Census Bureau, 2014). In order to prepare these graduates for success, engineering colleges must create opportunities for students to obtain skillsets external to engineering. The students agree; a survey of engineering undergraduate students at the University of Colorado Boulder in November 2012 indicated a desire to simultaneously pursue additional experience or certification alongside their engineering degrees, in disciplines such as business, management and foreign language. At the top of this list of other interests, secondary teacher licensure was a popular concurrent program choice: 25 percent "agreed" or "strongly agreed" that they "would be interested in earning grades 7–12 science or math teaching licenses while [they] earn [their] engineering degrees." Colleges of engineering thus may be interested in finding ways to support the success of their graduates in these multidisciplinary fields, including STEM teaching.

The University of Colorado Boulder's College of Engineering and Applied Science, in partnership with its School of Education, has developed an innovative program that produces graduates prepared to attain a secondary school STEM teacher license concurrently with earning their engineering BS degrees. The streamlined pathway through engineering prepares a workforce of secondary teachers capable of high-level teaching in multiple STEM subjects—either engineering coupled with science (biology, chemistry, or physics), or engineering coupled with mathematics. These engineers are motivated and inspired to pursue two career routes because they find value in, and passion for, both professions. The teacher licensure pathway through engineering fosters students that develop engineering mindsets alongside their commitments to give back through secondary teaching.

The research reported in this paper investigates if and how students in the *engineering plus* (e+) teaching pathway, CU Teach Engineering, identify themselves as both engineering and teaching students, and what benefits and challenges they perceive to negotiating this "dual" identity. Analysis of initial survey and focus group data indicates that students in this degree program *do* identify as both engineers and teachers. Using a mixed-methods approach informed by current education research—including quantitative and qualitative survey questions and small focus group analysis—we explore the ways in which students discovered the e+ teaching program and how they envision integrating the two disciplines into careers. We are also interested in how engineering students incorporate what they learn in their engineering studies into the lesson plans they design for secondary classroom students.

Background

Research on bringing engineering into the K-12 arena suggests that exposure to engineering education at the K-12 level increases students' motivation to not only enroll, but to succeed, in math- and science-related courses in middle and high school, as well as pursue engineering and other STEM careers (McGrath, McKay, & Schultz, 2008; National Academy of Engineering and National Research Council, 2009). This maps well to a nationwide push for increased STEM learning at all levels from preschool through college. Although the idea of bringing integrated STEM content, specifically engineering, into K-12 curriculum is appealing to teachers, many lack the formal training and knowledge of fundamental STEM principles (Fontenot & Chandler, 2005; Hill, 2011; Klein-Gardner & Chukwurah, 2013). K-12 engineering research suggests that many successful mathematics and science teachers "would have liked to be engineers"; however, they also express that not being comfortable with, and understanding, engineering skills are barriers to why they initially did not pursue engineering careers (Lottero-Perdue, 2013). Consequently, many teachers may be reluctant to use engineering as a means of connecting other STEM subjects across their curriculum. Yet K-12 teachers with prior engineering experience are able to increase their students' awareness of engineering, and ultimately, interest in pursuing engineering careers (National Academy of Engineering and National Research Council, 2009).

Engineering students who enter college with prior teaching and mentoring experience have often searched for ways to get back to teaching, including paid and volunteer positions in formal and informal settings. K-12 engineering programs are often partnered with local engineering colleges, industry partners, or individual practicing engineers with interests in education. Popular afterschool elementary and middle school engineering programs such as TEAMS (Tomorrow's Engineers… creAte, iMagine. Succeed) at the University of Colorado Boulder, give undergraduate engineering students the opportunity to employ hands-on engineering activities to help youngsters learn first-hand that engineering is a creative and helping profession (Yowell, Zarske, Knight, & Sullivan, 2013). Integrating real-world problems and applications is what engineers do on a daily basis; these engineering undergraduates bring their expertise and perspective into local K-12 classrooms, engaging thousands of students in problem-solving and technologies that leverage their knowledge and passion for giving back to others.

Engineering education has traditionally been introduced at the college level, but an increasing nationwide interest exists towards making engineering part of pre-college education (Etheredge, Ellis, Gralinski, Grasso, & Andam, 2004; National Academy of Engineering and National Research Council, 2009). Asking current undergraduate engineering students, "How might engineering education improve learning in science, math, and other disciplines?" we gain insight into the benefits engineers can bring into the classroom (Neujahr, Seignoret, Benenson, & Goldman, 1997). A pilot program at City College of New York, the ECSEL Engineering Coalition and the New York City Collaborative for Excellence in Teacher Preparation (NYCETP), is aimed at encouraging engineering students to consider teaching as a career (Etheredge et al., 2004). Students in this new program are holding teaching assistant positions at a local high school, working in physics, math, and mechanical engineering classes—with great success. Additionally, Neujahr et al. report that, after the engineering students participated in the program, "nearly all of them now expressed interest in becoming educators at some point in their careers" (1997). It is encouraging to see engineers acquire an interest in potentially pursuing K-12 teaching as a future career path.

Research Questions

This research explores how students integrate an ardent interest in pursuing two seemingly dissimilar careers—in engineering and teaching—and how they envision using engineering, teaching, or both, in their futures. Given the diverse student experience inherent in this degree program built around the passion to become "more than an engineer," this paper addresses two primary research questions:

1. How do engineering knowledge and teaching knowledge intersect for undergraduate engineering students?
2. What challenges exist to navigating an engineering major with a teaching license pathway?

Methods

Research Setting

In fall 2013, the University of Colorado Boulder's College of Engineering and Applied Science (CEAS) initiated a new Bachelor of Science "Engineering Plus" (or e+) degree program (Forbes, Bielefeldt, & Sullivan, 2015; Zarske, Cunitz, Forbes, & Sullivan, 2015). The multifaceted e+ degree program provides students with a flexible, yet technical, career pathway that includes completion of (1) a design-rich engineering core, (2) a disciplinary emphasis in aerospace, mechanical, architectural, civil, electrical or environmental engineering, and (3) a purposeful sequence of customizable electives either within or external to engineering (hence the "+").

One of the original—and intentional—pathways in the "+" sequence includes an engineering emphasis coupled with secondary science or math teacher licensure. The e+ CU Teach Engineering pathway is designed to prepare undergraduate students to earn secondary (grades 7–12) science or math teacher licensure as well as to work in the engineering field. A flexible and multifaceted professional pathway, the BS CU Teach Engineering degree program aims to integrate a design-focused engineering curriculum, extensive science or math content, education pedagogy courses, and student teaching into a single degree program.

Participants and Instrument Design

In fall 2015, 14 students entered the CU Teach Engineering pathway—a cohort of students ranging from incoming first-year students to seniors close to graduation. Their e+ engineering emphases represent a variety of disciplines, including civil ($n = 5$), mechanical ($n = 4$), electrical ($n = 1$), environmental ($n = 1$), and undecided ($n = 3$), with the majority of the students ($n = 10$) interested in coupling their engineering preparation with secondary math teacher licensure.

In September, 71 percent ($n = 10$) of the current CU Teach Engineering students who had taken at least the *Introduction to Teaching* course (in the sequence of education courses required for licensure) completed a survey that aimed to understand student perceptions of the e+ teaching pathway. The respondents were 30 percent female ($n = 3$) and 70 percent male ($n = 7$), representing a spectrum of academic standing: two seniors, three juniors, four sophomores, and one first-year student.

Administered via Qualtrics® Research Suite online survey software, the full survey consisted of 14 items, including multiple choice (e.g., yes/no) and text entry (see all 14 questions in Appendix A). Three survey questions queried strengths of the CU Teach Engineering program and career plans, while five questions probed perceived differences between engineering and education programs and barriers to simultaneously navigating both disciplines. Other questions asked students to briefly describe the use of engineering skills in education courses, as well as the use of teaching skills from education courses in undergraduate engineering courses.

To supplement the quantitative findings with a qualitative perspective, students who completed the online survey were invited to participate in a focus group. Two hour-long focus groups were held with CU Teach Engineering students during December 2015, with pizza served as an incentive. Eight of 10 survey respondents participated in the focus groups. The first focus group comprised four e+ students, including two second-year students, one junior and one senior. The second focus group included four e+ students and consisted of one first-year, one second-year, one junior, and one senior. Both focus groups had two female e+ students in attendance. All first-year and second-year students in the focus groups matriculated into the university as e+ students, whereas the upper-level students transferred into e+ from another engineering degree program at the university. Focus group participants' engineering *emphases* in the e+ degree program included mechanical, civil, and environmental engineering. During both focus groups, five main questions were asked of the students around the topics of "impact of engineers that become teachers," "how teaching contributes in your design and engineering classes," and "scheduling conflicts" (see Appendix B for focus group questions), as well as clarifying and follow-up questions.

Surveys and focus groups for all participating students were conducted under CU Boulder's Institutional Review Board (IRB) approval, reviewed annually by external and internal evaluators. Student responses were pseudonymized to protect participant identity.

Analysis Methods

Survey results included both quantitative and qualitative responses for analysis. Focus group analyses are also described below.

Quantitative

The survey data were analyzed for missing values and data entry errors; missing values were examined for patterns of skipped responses. No student skipped more than one item in the survey, and no substantial relationships were found between skipped items. Demographic data, including gender and academic standing, were retrieved from the university database.

For yes/no multiple-choice questions, data were aggregated and analyzed for comparison purposes. Additionally, students were asked to choose engineering/teacher/both to describe their post-graduation career plans. Percentages and respondent counts indicate student agreement with perceived differences between campus pathways through engineering and education programs.

Additionally, the survey included several open-ended text questions in attempt to clarify respondents' yes/no answers and descriptively query strengths of the CU Teach Engineering program, differences between CU Teach Engineering students and other CU Teach students on campus, barriers to navigating a dual engineering and teaching student pathway, how engineering influences the way the respondent teaches, the impact of engineers that become teachers, and the respondents' future career plans. The text responses were analyzed for repeated terms and ideas and reported in the findings below.

Qualitative

Focus group analysis followed a simple systematic method for analyzing narratives described previously in the literature (Gorden, 1992). The focus group scripts were transcribed independently by one of the authors, and then two authors determined 11 thematic categories that were mentioned repeatedly throughout each of the two focus groups.

Next, the authors agreed on simplified statements (codes) to represent each category, as well as a concise definition of each (see Table 1). Colors were then assigned to each code as a category symbol and for ease of coding transcript copies. Thus, each general theme in the text was given a

Table 1.
Codes and definitions for analysis of focus group transcripts.

Code (11 thematic categories)	Definition
Teaching influences (red)	Participant mentions people that have influenced/are influencing his/her decision to teach
Teaching experiences (orange)	Participant mentions times when s/he is teaching someone else, such as tutoring, teaching peers, practicum experiences
Specific content courses (yellow)	Participant discusses value of or experience in a specific education or engineering course
Barriers—practicum (lt. green)	Barriers to a teaching license, e.g., scheduling practicum time, overlap with engineering office hours/ courses
Barriers—scheduling (dk. green)	Barriers to a teaching license, e.g., scheduling engineering, teaching, and additional math/science classes necessary for teaching at same time
Teaching skills transfer (lt. blue)	Participant discusses how s/he use teaching skills outside of K-12 classroom
Engineering skills transfer (dk. blue)	How engineering helps K-12 teaching, e.g., understanding concepts, real-world examples, connecting math/science with engineering
CU Teach Engineering program pride (purple)	Praise or justifications for CU Teach Engineering
e+ and CU Teach Engineering community (magenta)	What exists now? What do students want it to be?
Future plans (dk. red)	Students' personal hopes, dreams, and fears about the future
Program suggestions (brown)	Marketing and suggestions for program improvement

code and definition, as well as a color to symbolize each code.

Three coders (independent of the authors) read and color-coded the transcripts according to the 11 themes listed in Table 1. Related text was classified by giving each fragment of color-coded transcript a unique identification number, and entered into spreadsheet columns and rows for indexing and to facilitate comparison of each coder's responses. The inter-rater reliability was determined through visual comparison of lines of coded text from each coder. Findings reported in this paper reflect only the text with unanimous thematic agreement by all three readers.

Findings

Survey and focus group analysis showed that CU Teach Engineering students are enthusiastic to explore their interests in both engineering and teaching. They view engineers and teachers as different, but find value in both professions and how the professions can be combined to benefit many facets of society. The survey results were analyzed prior to the focus groups to obtain themes for further exploration of this group of pioneering CU Teach Engineering students.

Survey Results

In previous research, we found that e+ students have a lot of pride in their major choice (Zarske et al., 2015). Realizing that the CU Teach Engineering concentration students participate most often in e+ community-building events, the authors began the fall 2015 survey by querying the strengths of that pathway to teacher licensure. Students described the CU Teach Engineering pathway as multidisciplinary and flexible, with advisors and professors who are personable, passionate, well qualified, and care about the students. They also listed many strengths that demonstrated their emerging visions of the interconnectedness between engineering and education, including preparing them to excel in teaching, become experts in the design process, teach for creativity and multiple ways of thinking, develop real-life problem solvers and well-rounded students, and apply the analytical approach of engineering to lesson design.

Because we were curious to learn more about what differentiates e+ students from other engineering majors, we asked them several survey questions about the distinction between their program and others (if any). Eighty percent of the students ($n = 8$) affirmed that they perceived differences between the fields of engineering and education in general, while 60 percent ($n = 6$) perceive differences between engineering majors and education majors on our campus. Subsequent survey question asked them to further explain those differences. Some examples of student responses:

- Engineering courses are more "rigorous," "analytical," and engineering students as more "confident" and have a "higher workload."
- Engineering students in teaching are more committed to teaching than math or science students in the same education classes.
- The types of math and science classes that are required by engineering majors versus their counterparts are harder, and we have classmates that "couldn't handle it" and left engineering.
- "Engineers build things and teachers teach how to build things."

These descriptions extend the previous fall 2014 focus group discussion by e+ students (not necessarily + teaching), adding that they feel themselves to be "different" from their non-e+ engineering peers and possess a shared experience of the difficulty of self-identifying as part of a new, unconventional engineering degree program (Zarske et al., 2015). The CU Teach Engineering students not only navigate the new Engineering Plus degree pathway, but also negotiate both the engineering and education environments during their undergraduate years—campus entities that are physically and culturally different from each other.

Continuing to delve into the minds of engineering majors who are concurrently seeking STEM teacher licensure, the survey asked, "Do you find it hard to be both an engineering student and a teaching student?" Fifty percent of the students ($n = 5$) affirmed that they perceive navigating the CU Teach Engineering pathway to be difficult; almost all these (4 of 5) mentioned scheduling and course conflicts between the two disparate campus entities as a source of stress. Engineering again is described as "hard," "time consuming," and "a different way of thinking." One student added, "People don't really understand why I am doing both engineering and education."

The survey also included questions around the benefits of pursuing both a teaching license and an engineering degree, as well as future career plans. Students were asked if their engineering backgrounds influence the way they teach in student-teaching practicum experiences. Ninety percent of the students ($n = 9$) responded that engineering *did* impact their teaching methods, including the ability to analyze and break down content into manageable portions for their students (similar to breaking down complex problems in engineering design), having a creative and open mind on how to approach content and student learning, as well as the ability to extend classroom learning to real-world, technical examples and applications.

Students were asked to briefly describe, "What is the impact of engineers that become teachers?" Several themes emerged, such as the ability to interest/inspire students, the use of real-world examples, the creation of interactive learning environments, the fostering of purposeful and productive classrooms, and having the drive to help the world become a better place. The CU Teach Engineering students see the blending of engineering and K-12 education as a wellspring of possibilities, and opportunities to make a difference. One student wrote that engineers who

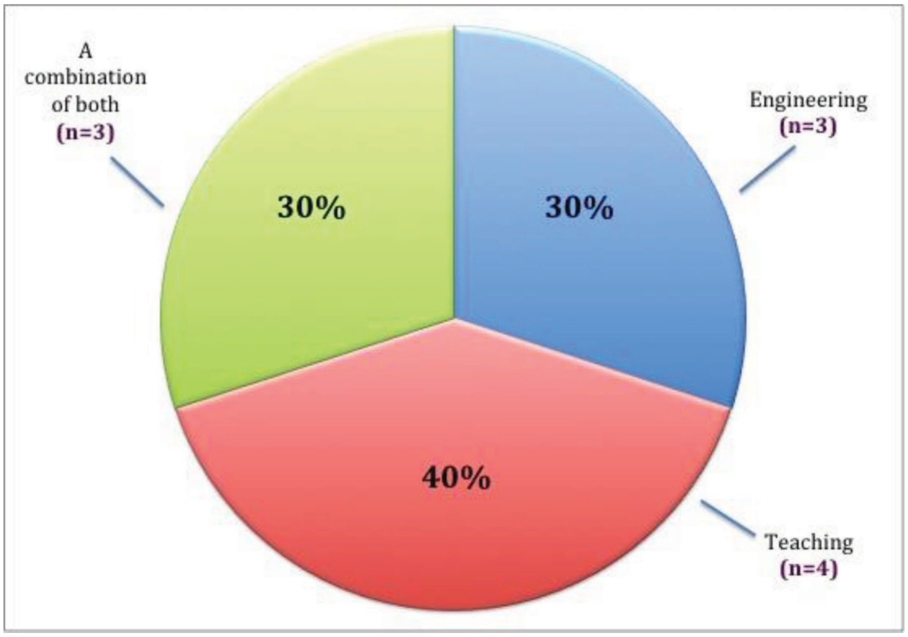

Figure 1. Future career plans for survey respondents ($n = 10$).

Table 2.
Survey respondents' descriptions of their career plans ($n = 10$).

Engineering ($n = 3$)	**Teaching ($n = 4$)**	**Combination of teaching and engineering ($n = 3$)**
Engineering right out of college, then retire as a K-12 teacher	Teaching K-12 math	Peace Corps for 2 years, then teaching MS/HS math
Engineering first (10–20 years) then have a family and teach	Teach K-12 in California	Teach engineering in K-12 first, then masters in engineering / engineering firm
Start a business in engineering internationally	Middle school or high school teacher ($n = 2$)	Counselor for companies to educate their employees, and start own business in environmental or sustainability engineering

become teachers "have the potential to create one or more new engineers out of students. And if a teacher can encourage just two students to become engineers—that is already twice the potential engineering accomplishment that existed before."

Lastly, students were asked to share their career plans, choosing from the multiple-choice responses of "teaching," "engineering," or "a combination of both teaching and engineering." Student responses were fairly evenly distributed across the choices, as shown in Figure 1.

The students were invited to elucidate their choices; their responses are shown in Table 2. Only two of the 10 respondents envisioned using the skills gained for a teaching license in non-K-12 settings. One student described working, "as a counselor for companies, to educate people or simply work on the sustainability part of the company," and another describes a plan to "start my own business in engineering internationally with a long-term focus, teaching users how to maintain and even update what we have built."

Focus Group Results

Conducting the two focus groups helped us gain insight into the real experiences e+ students are having as program participants. The discussions started with personal stories about how students became interested in pursuing both engineering and teaching, including their motivations. Then the discussions delved into describing the impact of engineers that are teachers, how teaching incorporates engineering, how engineering is integrated into teaching practices, the struggles that e+ students experience, and overall program suggestions for improvement. Of the 11 themes that emerged from the two focus groups (Table 1), two emerged as significant in both groups and relevant to our research questions: teaching skills transfer and the barriers of scheduling.

Teaching Skills Transfer. As detailed in Table 1, the teaching skills transfer was explained as how students use their teaching skills outside of K-12 classrooms. All three raters agreed on discussion of this theme in both focus groups, with the second focus group spending more time around dialogue about teaching skills transfer than the first focus group.

Some of the discussion about teaching skills transfer for both groups related to students' work within engineering team projects. The e+ students are required to take a team-based design project-focused course every year for a total of four projects courses—more than any other engineering major in the college. Students discussed the experience of applying what they learned in their education and teaching courses to their communication with others in these projects classes. A sophomore in the first focus group said, "When working in group projects, I am able to say things a certain way so they know what I am saying."

Several students in the second focus group also shared their experiences with incorporating teaching into their engineering design courses. A first-year student described a time in the past semester when he applied the knowledge gained from his teaching course to effectively communicate his product to his audience. This student stated, "I just went through an engineering projects class and we made a product that we had to sell and I made a commercial/promotion video." Another second-year student described her experience as, "The teaching qualities that I have brought into my engineering classes are more based on learning patience in projects groups. This came from going back if someone did not understand something the first time and having to be patient when describing it a new way to get them to understand the point."

This transfer of the teaching skills learned in education classes extends to explaining engineering to clients and non-technical audiences as well. One student explained how he used lesson planning approaches to help him make things in engineering more fun to learn and engaging by using teaching practices. He said, "How do you make others want to learn about your project? If you have the knowledge of how a teacher works and thinks about engagement then you can get people interested in your product." Another junior mentioned, "I feel what I have learned in my education classes has been useful information about being a leader."

Still another student reflected on his past experiences in the classroom and described how teaching has contributed to the way he now explains concepts to others outside of engineering. This senior stated, "The way you word a question is based on who your audience is and it needs to basically tailor to that specific person to get them to understand what you actually said. The teaching aspect has helped me out a lot." The students also discussed how teaching and engineering "build off each other." A junior in civil engineering described it this way: "From taking the teaching classes, you learn new ways of conveying information. It is easier to talk to people in the engineering world."

The focus group discussions around teaching skills transfer revealed that engineering students who have taken education classes are integrating their teaching expertise into other academic settings and perceive gains in their understanding of ways to better convey and communicate information to others. They are able to apply effective explaining strategies to help friends, peers, and other students with homework and projects. They use their teaching experiences in everyday life as well, including being community leaders.

Specifically, CU Teach Engineering students recognized that their teaching skills are helpful in developing more patience and success when working in groups. Being able to make real-world connections with material being taught and explain concepts to others are valuable skills that some of these students have developed as a result of their teaching experiences in classes and practicums.

Barriers—Scheduling. A second theme that emerged as important to the CU Teach Engineering students was around obstacles to navigating the e+ teacher pathway. As detailed in Table 1, this topic was aimed at exploring the barriers to scheduling engineering, teaching, and additional math/science classes for the e + teaching degree pathway participants. Again, raters came to agreement around the discussion of scheduling conflicts, with more discussion occurring in the first focus group than the second.

While these barriers were spoken about later on in both focus group discussions, the CU Teach Engineering student participants had a high amount of agreement about the issue since they are required to take core engineering courses, courses within the area of emphasis (civil engineering, mechanical engineering, environmental engineering, etc.), education courses, and content courses for licensure through math or science. In the first focus group, one second-year student described the hurdle in this way: "Trying to fit the practicum hours during the middle of the day when you could be doing other things is difficult. It makes it harder because then you lose that chunk of your time and you have to do stuff later after you are already exhausted from being up all day trying to get everything done." A senior year student in the same focus group added. "The other thing that conflicts with a lot of things is the education classes being so late in the day, from 4:30 p.m.–7:00 p.m. That time with the engineering classes can get hard, especially when you are in a design class and when your team wants to meet."

Students in the second focus group had similar responses about the e+ teaching degree scheduling challenges inherent in meeting the course requirements from three different campus entities. About his experience trying to schedule the math content courses needed for secondary teacher licensure, another senior student said:

> The only real issue I have had with scheduling is not necessarily with the education courses, but the ones that come with the math [requirements]. Since I am [in] the math emphasis, I have to take classes like geometry, discrete math and history of math. First of all, not all of them are offered every semester, which causes major issues. From my experience, the education courses are extremely flexible. If you have to leave five minutes early or move something around, they will do that. These math courses, and science, will not. That is where the issue comes in with those classes not being coherent with the engineering courses.

Descriptions of these students' scheduling conflicts included setting aside practicum hours; attending meetings with projects groups; scheduling engineering, education, and content (either math or science) classes; and making time for other extracurricular activities and obligations. They also expressed a concern with the lateness of the education courses and how that affects their ability to take advantage of office hours.

The focus group findings that explain the barriers and juggling students face in the CU Teach Engineering pathway are important for administrators to learn about for purposes of program improvement; we hear clearly that this is a challenging pathway to negotiate. CU Teach Engineering students are taking courses from at least three campus entities that do not historically communicate with each other about scheduling specific classes. Compounded by the great amount of time necessitated for engineering design projects and homework, study groups and team meetings, these students do not have time for much else.

Study Limitations

The findings of these quantitative and qualitative analyses should be considered within the limitations of the study. The testimony presented in this study is self-reported, and therefore inherently subject to researcher bias. Each author is in some way involved in the e+ degree program; no impartial researchers took part in the study.

Agreement between the focus group coders was mixed. For each of the 11 themes that emerged from the two focus groups, the coders' results showed majority agreement on the basic themes but they "found" the themes expressed in different text. While this is common for this task, it should be considered when interpreting results.

A total of eight students participated in the two focus groups, representing 57 percent of CU Teach Engineering's inaugural student population, while the 10 survey respondents represented 71 percent of the teaching pathway's students. We acknowledge that these are small sample sizes. As such, the findings in this paper provide a snapshot of a limited number of themes in the program's early stages with some of its pioneer students.

Key Findings and Discussion

Our findings indicate that the CU Teach Engineering students are a passionate group that continue to want to make the program better. They maintain the sense of pride in being pioneers in uncharted waters that was revealed in earlier research and openly discuss advantages and struggles to making their CU Teach Engineering dreams a reality. From their surveys and focus groups, several primary ideas emerged.

From analyzing the students' survey responses, we learned that teaching skills have a big impact across multiple situations, including their incorporation into engineering design and engineering courses, being in a leadership role, explaining things to others, and in-classroom teaching. The students recognize the benefits to practicing *habits of mind* from engineering and teaching. They use skillsets from both fields of study to enhance their coursework and communication across disciplines and environments.

Incorporating teaching practices when working in design groups was a popular student response when asked how they have used their teaching experience in their engineering courses. The multiple mandatory design courses taken by Engineering Plus students provide opportunities for them to continually improve and build off of their preceding design course experiences, as well as practice their developing teaching skills.

From the focus group data, we uncovered how students incorporate their teaching experiences in engineering contexts and how they utilize their engineering experiences to spark secondary students' learning in schools. These pioneering students' motivation to overcome obstacles and pursue secondary teaching licenses in tandem with engineering majors derives in part from the support of their peers in the CU Teach Engineering pathway—hearing from other CU Teach Engineering students about their hopes and desires to teach. They also feel encouraged and supported by the CU Teach Engineering faculty, staff and advisor. The students express admiration and appreciation for the small community they have in the CU Teach Engineering degree program. They are fascinated with what they are doing in their engineering classes and are excited to bring those activities and real-world applications into secondary math and science classrooms. CU Teach Engineering students are fluidly making connections between engineering and teaching, and have the desire to share and teach others. Learning about the experiences of current CU Teach Engineering students gives the program decision makers insight on some of the barriers and struggles in the CU Teach Engineering degree program including practicum and course scheduling across three campus entities.

We found the future career plans of these students enlightening. The program designers originally anticipated that the teaching pathway would mostly feed directly to secondary math and science classrooms, so it is wonderful to see that the students have myriad different plans. While some want to make a traditional move from a teacher licensure program to teaching in K-12 settings, others envision pathways such as practicing engineering first and then teaching later, and alternative industry roles that capitalize on teaching skills. The combined passion for engineering and teaching has the potential to manifest in a great diversity of future endeavors.

We recognize the existence of obstacles to overcome in order to make this dual pathway attractive to more students. CU Teach Engineering students "feel different" from other students on campus: they must navigate two separate identities—engineers and teachers—that transcend the insular environment of academia. They often find that others outside the program do not understand why they would go through the trouble of extra course work and hard-to-schedule semesters. They report that they even embody a "different" way of thinking between engineering and education, experiencing them as distinct disciplines. While they identify ample benefits to what they are doing, they have shared with us that they also face pervasive struggles during each semester of study.

The CU Teach Engineering pioneer students are passionate, though. They feel strongly about the pathway they have chosen and are committed to make it work. It is our responsibility to help them through this journey. The opportunities for undergraduate engineers who are concurrently licensed and experienced in K-12 education are bountiful; we anticipate that these individuals will make many impacts and inspire future generations of learners and leaders to think critically and systematically about STEM issues and challenges.

Recommendations for Future Work

The results from the analyses in this paper will inform future evolution of the CU Teach Engineering pathway and potentially provide guidance to faculty and administrators at other universities aiming to create pathways for undergraduate engineering students who simultaneously desire K-12 teaching licensure.

One program improvement suggestion that emerged from the focus groups was a desire for more community events that mingle CU Teach Engineering students and faculty. The CU Teach Engineering students want more opportunities to socialize with their peers, perhaps at networking events or hosted retreats. Students desire to know all of their CU Teach Engineering program peers and make personal connections through classes, extracurricular activities, and interests. We are considering piloting an Engineering Plus mentoring program to help students academically and to build community among the students.

Another suggestion for improvement is to implement a more streamlined and fluid scheduling process for the three different types of courses necessary to obtain the secondary teaching license. We have some work to do in this arena.

Future research plans include continuing to collect formal and informal qualitative and quantitative data, ultimately enabling a longitudinal look at student migration to and through this engineering + teaching degree pathway. We also intend to further explore questions around students' identity development as both engineers and educators, seeking to understand how these "dual" identities complement and/or conflict with one another.

An investigation of the different cultures surrounding the College of Engineering and School of Education is also warranted, as these pioneering students have suggested salient differences in the status and stereotypes of engineers versus teachers—both on-campus and at large. With a deeper understanding of the distinct disciplinary cultures that the CU Teach Engineering students travel between as well as an expanded awareness of the unique culture of the CU Teach Engineering pathway itself, we will be able to better support the students who embark on the promising pathway to combined engineering and educating.

Looking ahead, as the program grows we anticipate facing challenges related to scaling our course offerings and resolving students' individual scheduling difficulties. Always on our radar is a focus on continuous improvement in how we recruit engineering students to pursue teaching and how we can optimally support the students to persist through the engineering and teaching degrees they seek.

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Appendix A: CU Teach Engineering Survey

1. Which emphasis are you most interested in pursuing within your Engineering Plus degree?
   - ☐ Aerospace engineering
   - ☐ Architectural engineering
   - ☐ Civil engineering
   - ☐ Electrical engineering
   - ☐ Environmental engineering
   - ☐ Mechanical engineering
   - ☐ Undecided
2. Which concentration are you most interested in pursuing within your Engineering Plus degree?
   - ☐ CU Teach Engineering Math (math teacher licensure)
   - ☐ CU Teach Engineering Science (science teacher licensure)
   - ☐ Undecided
   - ☐ Other ____________________
3. How did you become aware of the CU Teach Engineering Program? (Please select all that apply.)
   - ☐ Engineering Plus website (College of Engineering)
   - ☐ CU Teach Engineering website (School of Education)
   - ☐ Posted flyer/bulletin board on campus
   - ☐ Advisor from my major department/school
   - ☐ Professor
   - ☐ Another CU Teach Engineering student
   - ☐ Friend
   - ☐ Information table in Engineering lobby
   - ☐ Information table in UMC
   - ☐ Advertisement on Buff Bus
   - ☐ New-Admitted Student Day Information Fair
   - ☐ Freshmen Orientation during summer
   - ☐ Parent
   - ☐ High school counselor/teacher
   - ☐ Facebook/Twitter
   - ☐ LA Program
   - ☐ Other (please specify) ____________________
4. What are the strengths that you identify in the CU Teach Engineering concentration (in 150 characters)?
5. Is there a difference between engineering and teaching in general?
   - ☐ Yes
   - ☐ No
6. Do you think there are any differences between engineering and other CU Teach students on campus?
   - ☐ Yes
   - ☐ No
7. If yes, please list up to three differences.
8. Do you find it hard to be both an engineering student and a teaching student?
   - ☐ Yes
   - ☐ No
9. If yes, please explain:
10. After graduation, do you plan to find work in teaching, engineering, or something that combines both simultaneously?
    - ☐ Teaching
    - ☐ Engineering
    - ☐ A combination of both teaching and engineering
11. Briefly describe your career plan after you graduate college with an engineering degree and a secondary teaching license.
12. Do you think your engineering background influences the way you teach?
    - ☐ Yes
    - ☐ No
13. If yes, please explain:
14. What is the impact of engineers that become teachers? (Please give examples, if you have any.)

Appendix B: CU Teach Engineering Focus Group Questions

1. Why did you choose to pursue engineering and teaching?
   a. What are your goals and passions that inspire you to be a teacher and an engineer?
   b. Is it hard to study both engineering and teaching?
2. What is the impact of engineers that become teachers?
   a. Describe any teachers in high school that influenced your decision to study engineering.

   b. Do you think that teachers who studied engineering can inspire their students to study engineering?
   c. Is this something that you see yourself doing as a teacher? Explain your intentions.

3. Describe how teaching contributes in your design and engineering emphasis classes.
   a. On the flip side, how can you develop a teaching mindset while studying engineering?
   b. How have you used your engineering experience while teaching in practicums?
   c. What concepts, theory, and applications have you taught to students?

4. Do scheduling conflicts between the two majors impact your desire to want to teach?
   a. What are some ways that the scheduling aspect can be improved for e+ students?

5. What are our "selling points?"
   a. How can we advertise the CU Teach Engineering program to gain more interest from engineering students at the university?
   b. What are your suggestions for improvement in the program?