Exploring the Early Career Pathways of Degree Holders from Biomedical, Environmental, and Interdisciplinary/Multidisciplinary Engineering

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Exploring the Early Career Pathways of Degree Holders from Biomedical, Environmental, and Interdisciplinary/Multidisciplinary Engineering

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This research paper describes a mixed methods exploration into the early career pathways of individuals who majored in biomedical engineering, environmental engineering, and interdisciplinary/multidisciplinary engineering. There are a number of studies that investigate students' pathways post-graduation; however, most of these studies focus solely on engineering industry pathways or track the first placement after graduation. This study explores a wider perspective of pathways that engineering graduates may take through a retrospective study at a single institute. First, we examined how 273 alumni retrospectively described the first four positions in their career pathways (e.g., working in a particular job, attending graduate school, etc.). We used descriptive statistics to understand patterns in graduate programs, job titles, and industry sectors. We found that even when positions did not include "engineer" in the job title, many alumni remained in engineering-related sectors or reported that their positions were related to engineering. We also leveraged Sankey diagrams to represent the "flow" of individuals across different positions. These diagrams revealed the breadth of career pathways, with alumni moving into and out of engineering positions. Second, we performed a content analysis on write-in responses in which alumni expanded upon their survey answers. Within the interpretive limits of the data, we observed two general ways in which alumni framed their careers. In "positive" presentations, alumni discussed the value of their engineering degree, especially the development of problem-solving skills. In "negative" presentations, alumni expressed a lack of control over their careers and expressed doubts over their relationship with engineering. Additionally, several alumni commented about being unconventional in their careers, which is notable given the general heterogeneity of early career pathways. These findings have implications for continued conversations about degree programs that ostensibly prepare students to work as engineers, but which also prepare them to seek out other fulfilling career opportunities. Future work based on this preliminary analysis will explore the career pathways of other engineering majors.

Introduction

Research shows that an engineering degree prepares students for a range of careers. However, engineering undergraduate training has often focused on equipping students with the knowledge, abilities, and attitudes that will make them successful as engineers in industry rather than the broad possibilities that an engineering degree offers. Reflecting this focus, a common topic in engineering education literature discusses ways to bridge the gap between industry and undergraduate training [1]. However, the qualities students develop—such as critical thinking, problem solving, and teamwork—are also valued by employers in general. Additionally, research studies in engineering education on students' post-graduation pathways often frame students who do not enter engineering industry or academic positions or who leave these positions after a few years as "lost." In this work, we posit that the skills gathered during an engineering undergraduate degree can have significant positive impact on the workforce, even if graduates do not directly work in engineering careers. Understanding the different career pathways that engineering undergraduate degree holders embark upon may enable educators to better prepare students to pursue their interests and use their engineering skills in a variety of contexts, not just engineering industry.

There have been documented differences between different engineering disciplines, especially regarding career outcomes [2]. These nuances are important to capture so that career preparation efforts can be contextualized with program norms and expectations. While all engineering majors prepare students for a breadth of career opportunities, the career outcomes of BME, EnvE, and IDE/MDE may be particularly revealing for several reasons. The relative recency of these programs may mean that alumni's career pathways are broader and are less entrenched as disciplinary norms. At the same time, these programs may equip students with interdisciplinary skills and mindsets that are valuable in many work contexts. Further, prior work in the career outcomes of these majors (i.e., BME, EnvE, and IDE/MDE) often compares them to other more established engineering majors, rather than focusing on them in their own right [3]. These programs provide a currently understudied perspective into the extent to which alumni capitalize on their engineering degrees.

Background and Context
Relevant Literature
Currently, there is limited literature that examines the progression of engineering degree holders' career pathways. Prior work has predominantly focused on students' career intentions and alumni's current positions. Although studies have documented that many engineering students intend on becoming practicing engineers [4]—[5], Lichtenstein and coauthors found that many students' career intentions are uncertain, even in their final semester of their undergraduate degree [6]. Gilmartin and coauthors also found that engineering students had both engineering and non-engineering career intentions [2].

The alumni perspective, on the other hand, is frequently captured by asking individuals to describe their current job or by identifying a specific instance of "leaving" engineering. For instance, Frehill found that the majority of engineering degree holders not currently working in engineering attributed this decision to having more interesting options elsewhere [7]. Fouad and coauthors asked women to classify themselves as currently working in engineering, having left engineering within the past five years, having left engineering more than five years ago, and having never entered engineering after graduation [8]. This measurement was used to separate engineering persisters from non-persisters to understand differences in their current job attitudes. A recent report from the National Academy of Engineering used two distributions of a national survey that asked about current employment status to understand the movement of individuals across two time points five years apart [9]. The report found that while many individuals remained working as engineers, a considerable portion moved into engineering from another occupation over the time frame. This finding complicates prior focus on the unidirectional departure of individuals from the engineering workforce.

Notably, the Academic Pathways study, Engineering Pathways Study, and the Professional Engineering Pathways Study examined both sides of the college-to-career transition to understand how career intentions lead to career outcomes. In one analysis, Carrico, Winters, Brunhaver, and Matusovich compared 36 alumni's initial career plans with their employment outcomes four years later [10]. These alumni moved between working and graduate programs, and half of the alumni reported that they were not doing what they expected for their career. Similar to the present study, another analysis explored the write-in responses at the end of a survey in which junior and senior

undergraduate engineering student participants could elaborate on their career plans [11]. Together, this body of work has led to insights about the very early careers of engineering alumni (i.e., within the first five years) and overall trends in the movement of engineering alumni within the labor force. However, there remains a need to understand the movement of individuals across several positions after receiving their engineering degree.

This study contributes to this body of work by utilizing retrospective accounts of the early career pathways (i.e., the first four positions held after graduation). This perspective allowed us to follow on average the first fifteen years of alumni's careers. Because retrospective characterizations are subject to recollection biases, we focused our measurements on factual information (e.g., job titles) that are likely less subject to distortion over time. When appropriate, we also couch our interpretations to acknowledge the layers of experiences that may influence participants' responses at the time of taking the survey. We focus our analysis of these retrospective accounts on whether alumni work as engineers (or not), whether they work within engineering-related industries (or not), and whether they explicitly rate their careers as to related to engineering (or not). The qualitative portion of this study adds nuance and identifies multiple ways of talking about one's career pathway.

Disciplinary Contexts in BME, EnvE, and MDE/IDE
Below, we summarize some of the existing norms and conversations within BME, EnvE, and IDE/MDE about career outcomes. These summaries are given from the perspective of prior scholarly work, and they reflect the contexts in which the alumni were educated.

Biomedical engineering (BME) is a relatively recent field with a unique connection to the medical industry [12]. This connection has led to a broad range of career pathways for BME graduates [2], [13]. Our prior work found that students interested in BME were less certain about pursuing engineering industry careers [14]. A common phrase in biomedical engineering is to be a "jack of all trades, master of none" [15]. BME students are equipped with skills from a variety of engineering disciplines (e.g., mechanical engineering, materials science and engineering, and electrical and computer engineering) to develop expertise about applications of these disciplines to medicine. However, this broad base of knowledge may prove challenging for some students as they specialize and develop a particular skill set.

The practice of environmental engineering (EnvE) dates back to the 1800s in the form of hydraulic and sanitary engineering used to support urban development and the industrial revolution [16]. However, it was not until the mid-20th century that the discipline solidified in response to concerns about air and water quality and general environmental degradation. As a result, EnvE is closely associated not only with other engineering disciplines (e.g., civil engineering, biological engineering, chemical engineering, and materials engineering), but also with bodies that regulate engineering work. EnvE training equips individuals with skills that are not only valued in engineers, but also in government organizations and consulting firms.

Both biomedical engineering and environmental engineering are inherently interdisciplinary in nature. However, they differ from the curricular structure of interdisciplinary engineering programs. Interdisciplinary engineering (IDE) programs are designed to support the integration of engineering with other disciplines such as liberal arts or programs that align more closely with the

desired attributes of the 2020 engineer, which extend beyond the traditional focus of technical training [3]. More importantly, these programs appeal to students who are attracted to the ability to construct a personalized plan of study based on their diverse interests in engineering and non-engineering disciplines when solving complex problems [17]. Masi and Hosoi found that interdisciplinary engineering students are intrinsically motivated and reported higher self-efficacy of engaging in interdisciplinary practices in comparison to their mechanical engineering peers [3]. Their study also reported how both mechanical and interdisciplinary engineering alumni rated cross-disciplinary practices as important in their current roles. Yet, interdisciplinary engineering alumni were more likely to select a non-engineering career pathway after graduation, such as careers in the medical field, law, or business [3].

Purpose of Study
The purpose of this analysis was to explore the career pathways of alumni from BME, EnvE, and IDE/MDE programs and to understand how these alumni perceived their careers to be related to engineering. This preliminary analysis comes from a larger research project surveying the early career pathways of all engineering majors at a single university [18]. We selected three majors which are generally considered newer and interdisciplinary and for which we had large enough sample sizes to conduct analyses. We examined survey data from a total of 273 alumni from BME ($n = 125$), EnvE ($n = 79$), and IDE/MDE ($n = 69$). The survey collected retrospective descriptions of alumni's first four career positions (both job title and career field) and their perceptions of these positions' relatedness to engineering. We used descriptive statistics and visualization tools to explore trends in responses. The data also included a write-in section where participants could elaborate on their pathways and experiences, which we used to supplement and add richness to our quantitative findings. The research questions that we address in this paper are:
1. What job titles and industry sectors do BME, EnvE, and IDE/MDE alumni use to describe their first four positions after graduation?
2. What career pathways are formed by these different positions?
3. How do alumni retrospectively rate the relatedness of their positions to engineering?
4. What else do alumni describe about their career and educational experiences?

Methods
Data for this paper are derived from a survey of 3,807 alumni of engineering undergraduate degree programs as a single institution. The data were collected over July to September of 2019. Alumni were recruited via emails from the alumni association and their respective degree programs to take an electronic survey. As previously mentioned, we achieved 273 valid survey responses from our three majors of interest.

Survey Measurements
The survey included a section in which participants were asked to retrospectively characterize up to the first four positions along their career pathway. We defined for the participants that a "position" entailed any significant (i.e., longer than three months) life stage along an individual's pathway, including working full time in a particular job, looking for work, being a stay-at-home partner, or attending graduate school. By examining the first four positions, we were able to capture a significant portion of alumni's pathways, while balancing concerns for survey fatigue. For each position, we asked them to characterize the type of position (e.g., employed full time, attending graduate school) and approximate its duration. As applicable, we also asked them to write-in the

field of the graduate degree program, write-in a job title, and identify the closest industry sector from a given list. We used write-in responses when possible to allow participants to be as accurate as possible in their own words. For the industry sectors, we developed a list of 18 common industry sectors by compiling identified sectors of the U.S. Bureau of Labor Statistics with common descriptions used by various engineering professional organizations. The broad industry sectors are listed in Table 1. From these 18 sectors, we identified five that were most closely related to the work typically done by engineers; these sectors are highlighted in bold text. Although necessary for our analytic strategy, we later discuss the limitations of this measurement. Finally, we also asked alumni to rate their agreement from 1-6 to the statement, "This position is/was related to engineering." This item is not intended to be an objective measure of relatedness, but instead as a reflection of alumni's current feelings about a particular position.

Table 1. List of broad industry sectors used in survey. Sectors in bold text are considered mostly closely related to engineering.

Academia / Higher Education	Education (excluding Higher Education)	Public Administration and Policy
Architectural Services	Financial Services	Publishing and Communications
Armed Forces	Healthcare	**Research and Development**
Codes, Standards, Certifications, and Regulations	Information Technology	Retail, Hospitality, Entertainment, Recreation, or Food
Construction	Legal Services	**Transportation, Warehousing, and Utilities**
Design	**Manufacturing**	Other

Analysis
From these data, we report the distribution of graduate programs, job titles, industry sectors, and perceptions of relatedness. We examined whether graduate programs and job titles contained the word "engineer" (or close approximations like "eng"). We also explored patterns in common terms within job titles, such as "sales," "research," "manager," and "executive." Using industry sector data, we investigated whether alumni reported working in one of the five sectors (Manufacturing, Codes, Design, Research, or Transportation and Warehousing) we identified as closely related to engineering. Finally, we used the explicit measurement of relatedness to understand how participant perceptions of their work changed over time and in different types of positions.

We used Sankey diagrams to show how alumni move from one position to the next along their career pathways. Using the results of the previous analysis, we assigned each position a label of "engineering," "engineering-related," "non-engineering," "student," and "other." We used the "student" label to identify any graduate degree position. We labeled a position "engineering" if their job title included the term "engineer." We labeled a position "engineering-related" if participants did not have "engineer" in the job title but did locate the position within one of the engineering-related sectors. We used "non-engineering" to classify all other working positions that did not fit within the prior two categories. The "other" label captures all other positions, including those who reported being unemployed or retired.

The end of the survey included an open-ended write-in box, which prompted participants to add anything else they felt was relevant to their career pathways. We used a general content analysis to find general patterns in responses, noting the limited interpretive power of these data (i.e., being unable to clarify or ask follow-up questions). We engaged in deductive coding based in part on the quantitative findings, documented when alumni noted working as an engineer or feeling like an engineer. We then followed with inductive coding to capture other patterns in the data. This inductive step resulted in codes marking different ways that alumni presented their careers (i.e., positively or negatively). The results of this qualitative analysis should not be taken as overarching themes, but as prevalent ways that these alumni chose to talk about their careers.

Results and Discussion
Participant Demographics
Women made up 39% of BME alumni, 43% of EnvE alumni, and 26% of IDE/MDE alumni, which are similar proportions to national program averages [19]. Our participants were over 80% White across each degree program. For BME and EnvE alumni, the majority of survey participants (79% and 87%, respectively) graduated between 2010 and 2019. Alumni of the IDE/MDE program had a more even distribution of participants from 1970 to 2019. The demographic information of survey participants is informed by disciplinary trends (women typically have above average representation in BME and EnvE, compared to other engineering disciplines), institutional characteristics (the institution in this study is a Predominantly White Institution [PWI]), and program histories (BME and EnvE undergraduate degree programs are relatively recent compared to IDE/MDE, which was founded several decades prior). These influences may limit the transferability of findings to other contexts.

Quantitative Findings
From the 273 alumni survey participants, we collected retrospective descriptions of 741 positions. Figure 1 represents the count data and average duration for each position. As some of the graduates are relatively early in their career, not all alumni have worked in four positions.

Position 1	Position 2	Position 3	Position 4
2.48 years	3.20 years	4.49 years	4.85 years
$n = 273$	$n = 211$	$n = 156$	$n = 101$

Figure 1. Distribution of position durations and counts.

What job titles and industry sectors do BME, EnvE, and IDE/MDE alumni use to describe their first four positions after graduation? In this section, we discuss the different positions that engineering alumni hold in terms of graduate school programs, job titles, and industry sectors. We note the ways in which the positions may be linked to engineering, either through pursuing graduate degrees in engineering disciplines, working as engineers, or being employed within engineering-related industry sectors.

Of the 741 positions described by alumni in this survey, 99 were positions in which the engineering undergraduate degree holders classified themselves as a student in a graduate program (57 from BME, 32 from EnvE, and 10 from IDE/MDE alumni). The majority ($n = 63$) of graduate positions

were the first position in an alumnus' pathway. Additionally, a majority of the programs ($n = 63$) contained the word "engineering" in the title. The most common graduate degree program for BME and EnvE alumni were master's and Ph.D. programs in their undergraduate discipline. Other relatively popular graduate programs for BME alumni included medical school ($n = 9$) and mechanical engineering programs ($n = 7$). All but seven of the EnvE alumni described attending a graduate program in civil engineering, environmental engineering, or sustainability. For IDE/MDE students, on the other hand, there was no trend in the reported graduate programs, which included law school, finance, and industrial engineering.

There were 622 positions in which the alumni described working full- or part-time. As expected, when compiling alumni from three different degree programs, there was a high degree of heterogeneity of job titles. In alumni's first position, 44% of the titles contained the words like "engineer" or "engineering." However, that number decreased to 39% in the second position, 35% in the third position, and 31% in the fourth position. Terms that reflect alumni's moves to middle and upper management (e.g., manager, executive, president) were also prevalent, making up 19% and 31% of third and fourth positions, respectively.

We asked alumni to identify the most accurate industry sector from a list of 18 choices (see Table 1). Within these 18, we identified five (Manufacturing, Codes, Design, Research, and Transportation and Warehousing) that were most related to engineering. As with the decreasing number of positions with "engineering" in the job title, the proportion of employed positions within engineering-related industries decreased from 53% in first position to 40% in the fourth.

However, the data also revealed limitations in our classification system for industry sectors that are closely related to engineering. Other popular industries included Healthcare ($n = 74$), Information Technology ($n = 58$), and Other ($n = 56$). Especially given the representation of biomedical engineering alumni, it is difficult to say how a degree holder might categorize a position where they are involved in the manufacturing of medical devices. Additionally, for those alumni who selected Other, we gave them the opportunity to write in their response. Interestingly, alumni wrote in sectors that may be generally considered to be related to engineering, including "oil and gas" and "consulting," but which were not specifically named in our broad list of industry sectors. Having a more generous definition of engineering-related industry sectors would result in a significantly higher proportion of positions that we would connect to engineering. Our future work may recategorize some of these write-in responses.

By combining our findings regarding graduate programs, job titles, and industry sectors, we can approximate the number of positions that are connected to the field of engineering. The 63 engineering graduate programs, the 283 engineering job titles, and the 108 engineering industries (not otherwise counted as an engineering job title) lead to a majority (61%) of positions being connected to the field of engineering. However, this calculation also revealed many engineering alumni work in positions that we classified as not related to engineering.

What career pathways are formed by these different positions? We operationalized Sankey diagrams to visualize the flow along career pathways, which can be seen in Figure 2. We used the previously described categories of "engineering" (red), "engineering-related" (orange), "non-engineering" (green), "student" (blue), and "other" (purple). Due to space constraints, the diagrams

are simplified and we only report the counts of "engineering" positions (i.e., those with "engineering" in the job title). The overall takeaway, however, should be the high degree of flow between positions. The visualizations showed some disciplinary differences. The pathways of both BME and EnvE alumni exhibited significant flow into and out of engineering over the course of the four positions, although the proportion of engineering positions decreased over time. IDE/MDE alumni entered and maintained working in non-engineering positions in greater frequency than BME and EnvE alumni. Additionally, compared to the other programs, the first positions of EnvE alumni were more frequently categorized as engineering.

How do alumni rate the relatedness of these pathways to engineering? Finally, for each position we asked survey participants to rate their agreement to the statement, "This position is/was related to engineering" on a 1-6 anchored numeric scale. This item was not used to determine the categories used in the Sankey diagrams, but instead provides an additional perspective. While scores did decrease over time, the average score on this item remained about a 4, indicating that, on average, alumni agreed that their position was related to engineering. When broken down by the categories used in the Sankey diagram, there were some observed differences. Those with "engineering" in their job title had an average response of 5.4, while those classified as students had an average response of 4.8. Alumni classified as "engineering-related" and "non-engineering" had average scores of 4.2 and 3.1, respectively. Thus, on average alumni reported some feelings of relatedness to engineering, even when they did not work as engineers.

Qualitative Findings
To complement the quantitative findings, we engaged in a qualitative analysis to draw attention to the participants' experiences in their own words. We used a general content analysis to identify patterns that were relevant to the research questions. Below, we highlight four related patterns: (1) positive and negative presentation of one's career pathway, (2) valued engineering skills, (3) tensions about one's identity as an engineer, and (4) perceptions of unconventionality. Responses have been deidentified.

We recognized two general approaches to how engineering alumni described their careers. First, 23 alumni discussed their career path in a linear, controlled manner, often praising their education. Positive presentations focused on the leveraging of opportunity, developing passion, and the sensation of feeling lucky. For example, one participant wrote,

> The exposure to soil science and ecology through my Environmental and Ecological Engineering degree, as well as my minor in Natural Resources and Environmental Science, inspired me to pursue my graduate degree (concentrating in Ecology and Conservation) and led me to now working in ecological consulting.

However, others used the write-in box as an opportunity to express negative experiences in their careers. The 21 negative presentations often focused on external forces and unexpected setbacks. Alumni with these responses expressed a lack of control, and some wondered about how their pathways would be different if they had made other choices. Two alumni with negative presentations wrote,
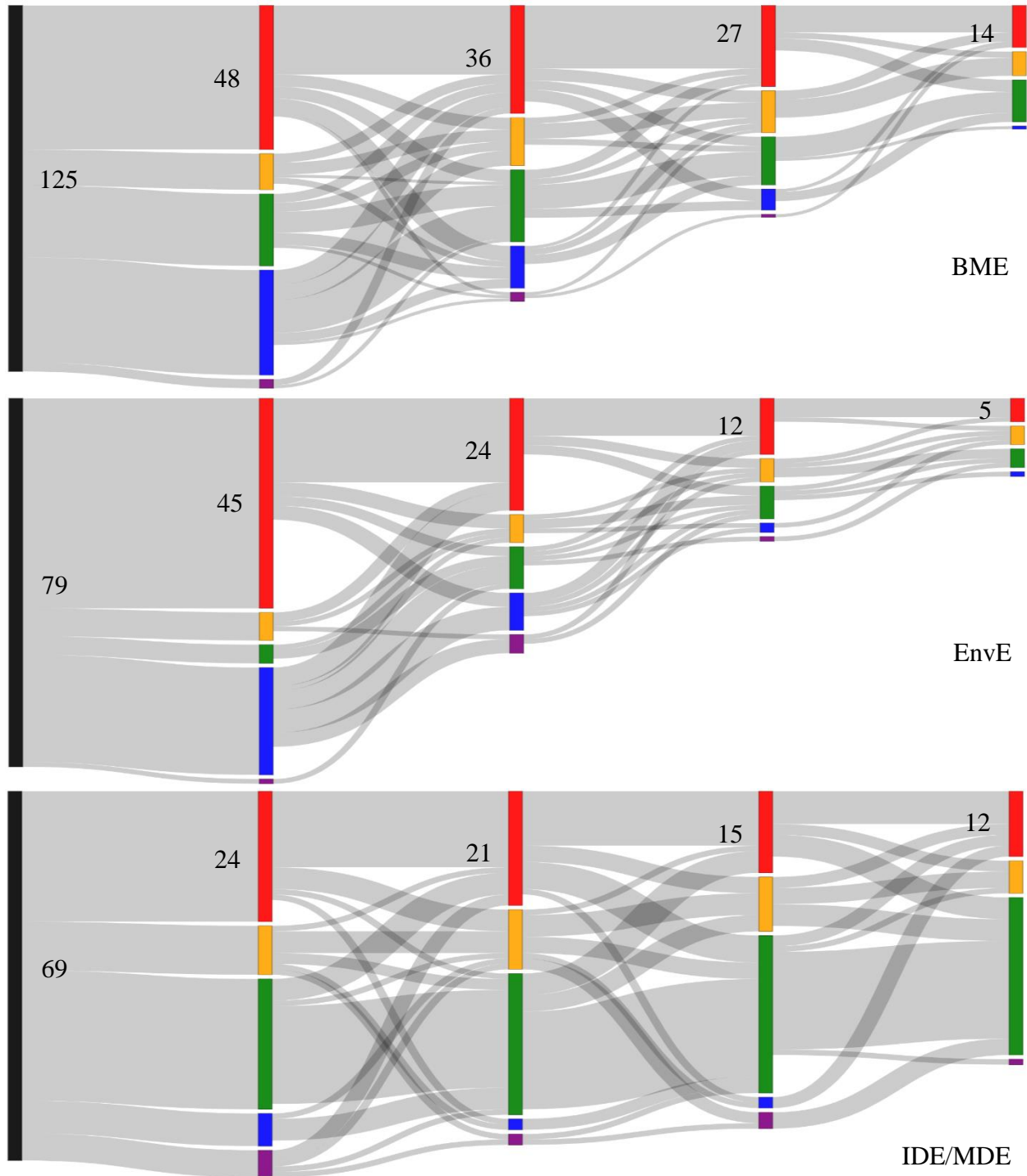
Figure 2. Sankey Diagrams of the career pathways of BME, EnvE, and IDE/MDE alumni. Note that Red = engineering job title, Orange = engineering-related industry (but not job title), Green = non-Engineering, Blue = student, and Purple = other. We report counts of total alumni and positions classified as an engineering job title.

Due to industry consolidations, my career was faced with multiple layoffs. Each one altered my career pathway and put me in new positions that I did not anticipate. While each new position provided new learning opportunities, I am not satisfied with the overall path of my career.

I felt like I took the first job offer I had because it was getting close to the end of the year, finals were over, and I hadn't gotten an offer. So when I was offered something a week after commencement, I accepted. I wonder how things would have been differently if I had waited and found a job in an industry that I was actually passionate about.

These different ways of presenting career pathways informed the ways in which alumni discussed their relationship to engineering, as we explore below.

Some of the most positive portrayals of engineering in alumni's careers happened when alumni discussed the skills developed through their engineering training. In 19 cases, alumni commented on utilizing the skills that came with their engineering degree. The most commonly cited engineering skill was problem-solving, which alumni applied to their various jobs.

While I may not have applied electrical or biomedical engineering techniques, I have always applied the engineering problem solving paradigm that was a thread in all of the engineering courses.

I never anticipated that I'd need engineering as a track coach, but I regularly engineer solutions involving track equipment. I don't use any advanced engineering technology, but I apply basic physics and math to transport pole vault poles, construct track equipment, make equipment safer, or position equipment efficiently. "Engineer" has only been part of my title in one of my many positions, but I have used the principles of engineering to find solutions in nearly all of them.

This portrayal treats problem-solving as central to engineering. Additionally, these quotes suggest a reason why some individuals maintained that positions classified as non-engineering in terms of title and industry sector were nevertheless directly rated to engineering.

Other alumni ($n = 5$) expressed a strained relationship with engineering, where they struggled to feel like engineers or felt like they were not using their engineering training in their careers.

I went to graduate school because I did not feel like an "engineer." I did not feel like an engineer even as I got my PhD in bioengineering using cellular biomechanics in my research. It wasn't until I was a postdoc doing engineering design that I truly felt like an engineer.

Ninety percent of my responsibilities at my current job, while being an engineering consulting firm, have been filling out paperwork, maybe this is just how it is for an environmental engineer [...] but I did not realize this would be the majority of my future workload. And I feel I like most of my job could easily be done by someone without any engineering experience or degree.

Both respondents explicitly characterized themselves as engineers, either in "truly" feeling like one or calling themselves an environmental engineer. However, the respondents also wrote

about not feeling like an engineer in an engineering degree program and not feeling like they were doing engineering work.

Finally, six alumni expressed a general sense of unconventionality or being non-traditional, due to working outside of engineering, pursuing a career in an engineering field outside of their home discipline, or by developing skills that set them apart from engineering professionals.

> Atypical career choice for an engineer - I became a physician. But I make use of engineering skills in terms of problem-solving.

> My career path was somewhat unconventional, but very rewarding and totally enabled by my engineering education. My degree was biomedical engineering (followed by an MBA) but I worked primarily in IT, everything from software product development, product management, and organizational management.

> As a biomedical engineer I took the path less traveled to ensure I had a differentiated value proposition as a job candidate -- namely to hone my soft skills and business acumen in concert with the highly advanced technical skills I acquired... This combination proved invaluable toward taking the step from engineer, to engineering sales, to growing and selling a start-up, to ultimately starting my own venture capital firm.

Claiming to be unconventional or nontraditional positions these alumni as differing from the norms in engineering. However, the quantitative data showing the prevalence of various career pathways suggest that these norms may be more of a shared expectation than based in reality.

Discussion and Conclusions
In this paper, we explored several ways of understanding how BME, EnvE, and IDE/MDE described their career pathways, with special attention to how these pathways overlapped with the field of engineering. Our findings align with prior work that identified that one-third of engineering undergraduate degree holders work as engineers [10], [20]. Alumni's pathways also demonstrated the flexibility of career pathways, with very few alumni only working as engineers across their first four positions. Through Sankey diagrams, we were also able to visualize and concur with the conclusions of prior work, which highlighted that alumni move into and out of engineering [10]. Finally, we also identified that career pathways had distinctive characteristics within disciplines. For instance, many IDE/MDE alumni maintained careers that were classified as "non-engineering," while EnvE alumni more frequently worked as engineers.

Results from this analysis highlight the need to expand definitions what "counts" as an engineering career. Despite common narratives that emphasize engineering undergraduate degree holders working as engineers within sectors like manufacturing (e.g., [21]), relatively few positions fit this classification. A more comprehensive distribution was identified when we separated out the job roles that alumni take on and the organizations that employ them. Further, we found that on average alumni rated their positions as moderately related to engineering, even when they worked in positions that we classified as "non-engineering." While the aforementioned limitations of our survey items limit the utility of these items, results from our study do highlight the benefit of adding nuance to items measuring engineering careers.

Finally, our qualitative analysis suggests the value of future inquiries into how engineering alumni describe the connection between their careers and their undergraduate training. The "positive" descriptions in our data focused on the utility and value of an engineering degree, even in non-engineering pursuits. The negative descriptions, on the other hand, discussed a lack of agency and included difficulties aligning engineering with their work activities. While we use the term "negative" here to describe our interpretation of the tone of the responses, we do not wish to suggest that these are the "wrong" career experiences. Career pursuits entail a number of unknown variables that may result in undesirable outcomes, and recognizing discontent may be a first step to finding career interests that are more enriching.

Future work from this project will include expanding the analysis to other engineering major. We also plan to interview faculty members and students to understand their perceptions of career preparation and potential career pathways leading from an engineering degree.

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