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From website to work environment: Exploring minority undergraduate engineering students' conceptualizations of engineering careers

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From website to work environment: Exploring minority undergraduate engineering students' conceptualizations of engineering careers at national laboratories

Abstract

Within engineering education, there have been rising calls for more research on the transitional period students face leading up to graduation (e.g., post-graduation planning) and moving into the next phase of their career. This study seeks to complement existing research by exploring the experience of students as they seek to make sense of engineering career pathways and make decisions about engineering positions. To this end, we investigate how minority undergraduate engineering students conceptualize engineering career pathways based on an organization's website content.

We, a team of minority undergraduate engineering students, led a qualitative analysis of the websites of two national labs: Los Alamos National Laboratory (LANL) and Kansas City National Security Campus (KCNSC). The website content was analyzed by extracting excerpts that matched keywords related to engineering careers. Each excerpt was annotated with our impression of the company as a potential employer. In collaboration with other researchers, a codebook was developed based on contemporary career frameworks and was used to assign primary and secondary codes to each of our perceptions. The results illustrated how we viewed both labs as committed to providing employees with a good work-life balance, as well as opportunities for both personal and professional growth.

The insights from our study can provide organizations and higher education institutions with a deeper understanding of how this generation of engineering graduates makes sense of engineering career pathways. These results can also aid engineering programs in helping students navigate post-graduation planning. Future work on students' perception of engineering careers is necessary for furthering potential employers and institutions understanding of their workforce.

Motivation

Over the past thirty years, the number of Black and Latinx students who graduate with an engineering bachelor's degree has increased nearly four-fold (Carnevale, 2021). However, engineering degree attainment does not translate to engineering careers for this underrepresented group of minorities, as only 14% of engineers in the workforce today, aged 25-54, are Black or Latinx (Carnevale, 2021). Given the mass attrition of Black and Latinx engineers as they matriculate from engineering education to the workforce, we focus our investigation on minority students' post-graduation planning, or the liminal period as they shift from engineering student to early-career engineer while negotiating their employment needs and prospects. The transitional period engineers face when moving from academia into employment is one that is not well understood or documented (Cannady, Greenwald, & Harris, 2014; Cross et al., 2017, Metcalf, 2010). This transition is further complicated by the recent global shifts in workforce trends and massive changes to workers' attitudes about work during and immediately after the COVID-19 pandemic (McArdle et al., 2007; Russell & Frachtenberg, 2021). Most scholarship on early-career engineers focus on career choice and perceptions of engineering students, where gender and other demographic groups are compared (Naukkarinen & Bairoh, 2022). Additionally, other

scholars examine misalignment of skills and/or expectations among early-career engineers as they adjust to the shift from academia to industry (Rohde et al., 2019). Although useful, the scholarship on early-career engineers' transition to the workforce is best positioned to answer questions about inputs (e.g., engineering student career choice, goals, perceptions of work) and outputs (e.g., early-career engineers' competency work-fit, job satisfaction, organizational commitment, etc.). The in-between career stages, especially post-graduation planning? is opaque, and much like a black box, provides little insight on the actual transition (e.g., regarding job search, application, interview and hiring process) that all engineering graduates must go through to secure an engineering job.

Given the historical and persistent underrepresentation of minority groups in the engineering workforce, our work presents a timely effort to understand better and include the career attitudes of the emerging engineering workforce. We investigate how the concept of an engineering career is shaped for minority engineering students from a Hispanic-serving institution to further understanding on how career opportunities in government-funded labs are perceived by a group of Black and Latinx engineering student researchers experiencing the job search and post-graduation planning process. For context, our study is a smaller portion of the PRE-CCAP (Partnership for Research and Education Consortium in Ceramics and Polymers) project. The consortium consists of three Minority Serving Institutions (MSIs) and two national labs (Los Alamos National Laboratory and Kansas City National Security Campus). The main goal of PRE-CCAP is to establish a sustainable pipeline of highly trained next-generation workforce for the Department of Energy and the National Nuclear Security Administration's core mission. The PRECCAP project provides opportunities for minority students through research internships, research skills training, and intellectual collaboration between MSI's and DOE laboratories.

Purpose

While many new engineers traverse the ecosystem of private industry, many have experiences that affect their identity within the organization and potentially dissuade them from continuing their engineering career (Brunhaver, et al., 2021). Our work is theoretically grounded by Savickas (2013) career construction theory; briefly, the theory states that a person's career develops through their interpretation of life and career situations. Our rationale for using career construction theory over other prominent career theories, is because it allows us to interrogate how individuals negotiate their jobs and make sense of their professional selves in light of their milieu (Savickas, 2013).

Our work seeks to complement existing research on the school to work transition of engineers by studying engineers in their post-graduation career planning milieu. To that end, the purpose of this work is to understand how the media content (e.g., websites) presented by two national laboratories was perceived by students undergoing post-graduation planning in different engineering disciplines. We, the first three authors who represent a team of minority undergraduate engineering students, led a qualitative analysis of the websites of two national labs: Los Alamos National Laboratory (LANL) and Kansas City National Security Campus (KCNSC). The results of this work can provide insights about the perspectives of engineers

entering the workforce to multiple stakeholders in a student's post-graduation planning process such as companies, individuals working in the industry, as well as students entering the workforce. Overall, to better understand the thought process of individuals who are prospective or future employees of engineering organizations, we sought to address these research questions:

1. What does the content of National Lab websites convey to the engineering students about the nature of an engineering career?
2. What does the content of National Lab websites convey to the engineering students about organizational culture at these engineering organizations?

Methods

This study is a part of a larger project geared towards understanding career concepts of students from historically underrepresented groups in engineering. We mention this because key terms from an on-going systematic literature review informed the selection of data used in this study. For the reader, we briefly provide some context for how the key terms were decided and describe how we selected, sorted, and analyzed the data to best answer our research questions. Given that we have worked closely with the data and to acknowledge that the findings are filtered through our interpretations and biases, we begin by presenting our positionality as researchers to situate ourselves as part of the methodology.

Positionality

The three primary authors who conducted this study were undergraduate researchers at a primarily Hispanic-serving institution in the southeast United States. This positionality section is structured as follows, a third person account of each author's relationship to this project alongside a first-person narrative (in italics) on the prevailing conceptions and pre-dispositions of the student authors to working in engineering industry.

The first author is a Senior in the Biomedical Engineering department who is a member of the African American community. Her role in this study helped provide insight on the experiences of a first-generation Black female engineer navigating the transition from higher education into the workforce.

> *In my engineering career thus far, I have worked in different research labs, as well as had two internships. I plan to go to graduate school to further my knowledge in materials research and then enter industry. In my future career, it is important that I work at a company that respects a work-life balance and prioritizes furthering their employee's knowledge. I want to work at a company whose values align with mine and gives me meaningful work experience.*

The second author is a Junior in the Mechanical Engineering department living in the U.S. under DACA protected status. Her role in this study helped provide insight on post-graduation planning from the standpoint of a first-generation international student seeking employment in the U.S.

> *My motivations for my career lie in creating a better human experience through my work. I want to be sure that the product of my work will provide the person at the end of the line with something durable and dependable. It is important to me that my work is meaningful to me and provides outlets for my creative endeavors. I want to improve people's lives while still allowing*

myself the time to pursue other activities outside of engineering that bring me joy like continuing my education and giving back to my community.

The third author is a Junior in the Mechanical Engineering department. His role in this study provided insight on the post-graduation planning process of a Hispanic male engineering student.

My desires for my future career are to simply learn as much as possible and have an impact on the advancement of technology, however minuscule that may be. Being able to be someone whose presence and work in the engineering field allowed humanity to take that next step to achieve either energy independence from non-renewable energy sources or anything that will improve the quality of life of everyone. Ultimately, I hope to enjoy the process and be proud of the outcome once I reach it, however hard, tedious or stressful it may be.

The three authors worked collaboratively throughout this study in all aspects, and they operated under the guidance of two senior researchers. The former is a mixed-race woman of color from a clinically trained biomedical engineering background. Her research in designing medical solutions for health disparities led her to the field of social sciences to study the root cause(s) of inequities, she is currently a postdoctoral associate at Florida International Univeresity working to broaden participation of underrepresented groups in the broader STEM workforce. The last author is a Latina engineering education faculty member whose educational background is in aerospace and systems engineering. During her own pursuit of an engineering career as an undergraduate, she regularly found herself not fitting into "traditional" position types and having to explain the value of her multidisciplinary background to recruiters. Her current research focuses on examining and transforming the critical structures and transition points within educational systems to create more equitable and inclusive educational experiences for students.

Keyword Development

A Preliminary Literature Review (PLR) was conducted earlier by the researchers to investigate: *"What is an engineering career?"* while paying special attention to whose perspective was represented in the literature (e.g., industry perspectives, students, faculty, practicing engineers). Through this PLR, 86 papers were collected and subsequently used to create a list of keywords and phrases. In particular, the researchers developed a list of keywords and phrases that they felt would be conducive to further analysis of what can be expected of an engineering career both from an organizational standpoint and from the intrinsic motivators that students might have for pursuing a career in this field. In total, 35 keywords and phrases were developed for the PLR. However, the researchers decided that only 10 of the keywords from the PLR encompassed the job search process, so the resulting 10 keywords (see Table 1) were used to focus the data selection for the content analysis.

Table 1. List of curated keywords used to guide content selection

Curated Keywords to Guide Content Selection	
-engineer	- organizational support
-skills	- work culture
-competency	- professional
-satisfaction	- interdisciplinary
-career	- relationship

Content Selection

To more accurately understand the perceptions that students and individuals who view the content of websites may have, the researchers decided to examine the content of organizational websites using the keywords from the PLR. The primary data sources for this study were the websites of LANL and KCNSC. LANL and KCNSC are partners in the PRE-CCAP program to support students' career pathways at Minority-Serving Institutions into national labs. The researchers essentially simulated the process a student might go through while exploring career content and prospects at LANL and KCNSC by focusing on sections of the website that included job listings, company policies, and promotional content geared toward prospective employees. The student authors divided up the keywords amongst each other, allowing each person to focus on a specific aspect of the job search process. Relevant content from the websites that the research teams associated with the curated key terms were placed into a shared document for iterative memoing and sense-making.

Memos & Sense-making

After the website content was selected, each of the student researchers read and reviewed each line of content and left memos to capture their interpretation of the organizational data with the prompt, *what expectations does this content make me have about an engineering career?* The purpose of the memoing of each individual piece of content was for each researcher to formulate their own understanding and perceptions of how the company presented itself or what the company hoped to achieve by expressing itself through this medium. The final count of the number of memos produced from the organization's websites was 41 memos for LANL and 38 for KCNSC across all three researchers. The memos were then coded using a codebook developed from career psychology frameworks, described next.

Codebook

The codes used stem from career psychology work rooted in career construction theory and are based on Hall's (2021) findings while studying the engineering career concepts of minorities in industry. The codes represent common dimensions used to characterize careers and patterns of vocational behavior. The *priori* codes were used to analyze the memos that captured students' sense-making of the website content. Briefly, *a priori* is reasoning or knowledge which proceeds from theoretical deduction rather than from observation or experience (MacQueen, 1998). The codes represent characteristics of both the content and structural dimensions of careers (Briscoe & Hall, 2006; Driver, 1982). The content dimension represents constructs that characterize career choice and motives, while the structural dimension focuses on constructs that characterize how an individual combines content information to factor differentiation (e.g., when a career is chosen), integration (e.g., permanence), and flexibility among parts (e.g., direction of career trajectory) (Briscoe & Hall, 2006; Driver, 1982). A sample of codes and their definitions is shown in Table 2. For a full list of codes, see Appendix.

Table 2. Sample of codes and their definitions

Code	Definition
Advancement/Growth	opportunities to improve and develop in terms of advancing knowledge and career progression
Security/Competence	motivational drivers for career behavior, choices where the concept of success is rooted in financial or long-term job security or fulfillment from demonstrating efficiency and aptitude in one's occupation
Lateral/Rotation of Positions	opportunities to broaden career knowledge; employees "rotate" through different aspects of the organization for temporary positions and responsibilities in different departments

The resulting memos were coded in two phases. In the first phase of coding, each researcher individually coded each memo with up to two codes. The second round of coding was a collaborative effort, where the student authors reviewed all assigned codes for each memo for interrater reliability. Similarities between the code definitions were discussed and edited as needed where some of the code definitions were too closely related and needed further clarification. This prompted discussion about the similarities between two codes (Values and Work/Life Integrity) that had caused confusion among some of the researchers. It was decided, under guidance from the fourth author, that the Values code related more to values that contributed to success in the workplace specifically and Work/Life Integrity was the intersection of personal and career values. The three researchers then utilized the updated definitions to reach a consensus on which two codes were most appropriate and accurate to apply to each memo. The decisions were made unanimously, and the final codes were listed for each memo. Table 3 provides a sample of how keywords were used to organize content, the associated memos, codes, and categories.

Table 3. A sample of content, memos, codes, and categories from each lab based on keywords

Lab	Website Content	Memo	Codes	Category
Sample Keyword: Professional				
LANL	*As we fulfill the Laboratory's mission, we act as stewards of our environment and obey environmental regulations. By setting goals for continuous improvement, we measure and document our progress, and share our results with our workforce, stakeholders, and the public*	*"[need to] understand the legal aspects of the work that they accomplish"*	Interdisciplinary Leadership/ Management	Organizational Expectations
KCNSC	*Honeywell has earned a valued reputation for innovation and cost-effective solutions by applying commercial best standards in managing operations.*	*"They are a company that strives to uphold their standard of work and maintain the image they have procured as a result. "*	Competition Prestige/Values	Organizational Expectations
Sample Keyword: Satisfaction				
LANL	*Work with the best minds on the planet in an inclusive environment that is rich in intellectual vitality and opportunities for growth*	*"Being able to interact with others who will help you improve as a person in your technical skills but also your personal skills, becoming a more rounded person"*	Teamwork Advancement/ Growth	Career Expectations
KCNS	*These college collaborations go beyond textbooks, GPAs, and lecture halls. They give students hands-on experience to ensure they're ready to join us on the frontlines of supporting the national security mission.*	*"Making sure that any experience gain will prove useful to not only the personal growth of the individual but their future as well"*	Advancement/ Growth Work Life Integrity	Career Expectations

Once the final codes for the memos were complete, the memos were further sorted into three expectation categories that emerged from the data: Career Expectations, Organizational Expectations and Both (Career & Organizational). The memos were color-coded blue, green, and yellow, respectively. Table 4 below provides a visual representation of the color-coding process and example codes.

Table 4: Categorization and color coding of expectations

Researcher Comments	Categorization
I would expect to work across interdisciplinary teams as an engineer in this lab	Career Expectation
I would expect to have opportunities to expand my knowledge in the engineering field	Career Expectation
I expect that there will be issues presented that will require dynamic solutions that will build on engineering skills	Career Expectation
I think that the job requires a certain amount of skills in order to be hired	Organizational Expectation
Must showcase skills in order to be considered	Organizational Expectation
There are dynamic jobs that can fit a range of skills. You wouldn't need to have a specific type of skills, but rather your skills will be matched with a position?	Both

Lastly, in addition to this qualitative content analysis, the prevalence of codes within the memos was also quantified. The codebook consisted of 19 different terms (for? codes, see Appendix) that the student researchers used to apply to each of the memos. Each memo was ultimately given two codes which helped define the primary focus or perception of the memo. The frequency of the codes and categories for each lab's website content were counted and compared using bar graphs and pie charts (see Results & Discussion).

Results & Discussion

Through a content analysis of both the Kansas City National Security Campus (KCNSC) and the Los Alamos National Laboratory (LANL) websites, we sought to understand what the website's content conveyed about (1) the nature of an engineering career and (2) the organizational culture at these labs. Our analysis enabled us to collectively make sense of our interpretations of engineering careers and engineering organization culture based on these websites, thus some of our results are presented in first person. Two distinct ideas appeared when looking at the data: 1) how the content of the websites influences student perception(s) of what an engineering career entails – which was quantified through the coding of memos; and 2) there was a distinction made between different student expectations, those derived from the organization, and those expected from the individual's career aspirations.

The Nature of an Engineering Career

Through the content analysis of each of the websites, we perceived expectations that we would have when entering the engineering workforce. These expectations allowed us to create a mental image of an engineering career and a pathway that we could follow once we started this journey. These expectations fell into two categories, *career expectations* which placed an emphasis on an individual's career experience and goals, both within and outside of the company, and included their personal life and values. Some examples which illustrate a career expectation from our memos would be "*I would expect to have opportunities to expand my knowledge in the engineering field*" and "*The different jobs/internships that students can participate in to get a head start in their career and earn hands-on experience*". While

organizational expectations focused on the company's desires or values; what the company expected out of an individual and the requirements necessary for said individual to be considered a viable asset to the company. Memos reflecting organizational expectations were as follows, "*I think that the job requires a certain amount of skills in order to be hired*" and "*I would think that this company takes pride in their product and ensure that their quality control is accurate and efficient*". Now, there was also the occurrence of these two categories of expectations overlapping with one another. For example, "*There is compensation/reward for development of new technology*" and *"I can appreciate that they are aware and willing to accommodate different lifestyles with their scheduling flexibility."* In such cases, the content of the website placed emphasis on an individual's needs or growth within the company itself. Figure 1 highlights how there is a clear difference between the importance that each website places on certain expectations.

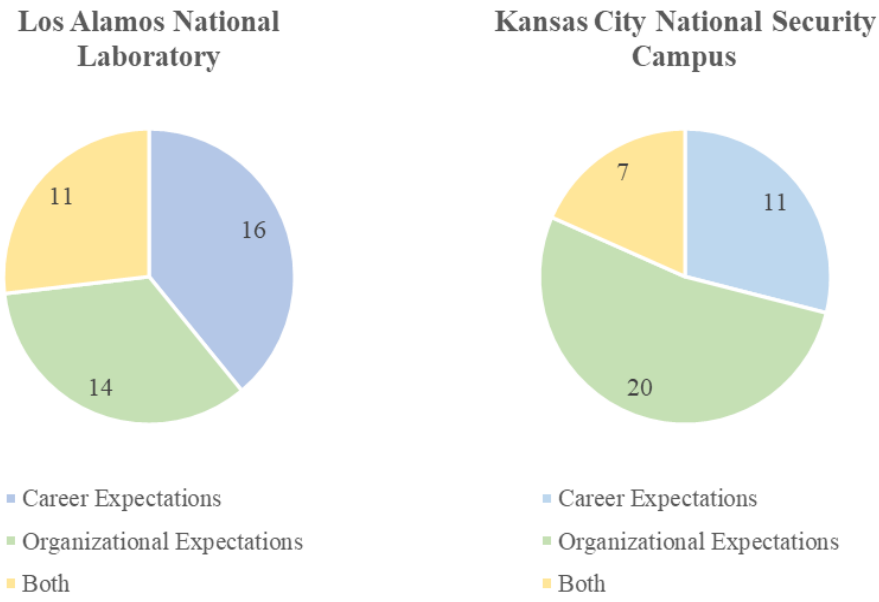

Figure 1: Memo Categorization through Student Expectations

The Los Alamos National Laboratory (LANL) Website had a total of 41 original memos created from the content of the website. Of our memos, 16 fell into Career Expectations (~39% of original memos), 14 into Organizational Expectations (~34.1% of original memos), and the remaining 11 were Both (~26.8% of original memos). The number of memos within each of these categories is relatively close to one another – comparatively speaking to Kansas City National Security Campus Website. The LANL website placed a balance between the expectations that the company expects from you, the expectations an individual who is interested in this company can expect for their own career, and the career growth potential that lies within the company itself. Kansas City National Security Campus (KCNSC) Website had a total of 38 original memos created from the content of the website. Of these memos, 11 fell into Career Expectations (~28.9% of original memos), 20 into Organizational Expectations (~52.6% of

original memos), and the remaining 7 were both (~18.4% of original memos). The KSNSC Website placed a larger emphasis on the organization's expectations and prestige, nearly overshadowing the expectations that an individual may have in relation to their personal growth intentions or their ability to learn and grow within the company – whether that be from a technical aspect or managerial one. Unlike the LANL website, which had a relatively even distribution of memos among the three categories, the KSNSC website has over half of the memos falling into the category of organizational expectations – highlighting a key difference in the presentation that each company appears to achieve through the content of their website.

From our review, the Los Alamos National Laboratory Website had a semblance of balance between what the organization would expect from us and our career goals as well as our ability to accomplish them both in and out of the company. For instance, looking at the following memo, "*it seems they are very proud of who they hire and are always looking for new people who have 'common goals'"*. This gives us the idea that they are not looking to inherently mold prospective employees into what they believe suitable engineers are but rather want to bring individuals into the company who already have a semblance of an engineering identity and who happen to align with the company's beliefs. This perceived equilibrium, as we perceived it from their website, would allow prospective employees, like us, to not feel overwhelmed by a company's expectations. It dissuades the idea of an individual having to set aside their goals and dreams to accommodate to the company's status quo – deterring the fear of having to decide between personal life or maintaining their footing in the company. In doing so, individuals who desire to work with this company may have the understanding that the company's expectations may be difficult or tedious to accomplish, however, not so much so that it forces the individual to forgo their own career expectations. It allows the individual the freedom and flexibility to progress both inside and outside of the company.

The Kansas City National Security Campus Website, as perceived by us, seemed to place more emphasis on its prestige and reputation with working with government contracts and other valuable partners. This emphasis allowed us to identify a potential imbalance in our perceptions of organizational versus career expectations when associating with this organization. By accentuating the prestige and reputation of the organization, KCNSC presented itself in a manner that felt pressuring and gave the impression that individuals who apply to work in their company understand their place in the bigger industry picture (i.e., where KCNSC compares to other labs and organizations). Although there were segments of content – and subsequent content analysis – that encouraged us, or prospective employees, to maintain our individual career expectations and our ability to progress independently, it was overshadowed by the premise of teamwork and the company's ideals and goals. The content as such was presented in a manner that highlighted the ideals of teamwork – a sense of pride and accomplishment in being part of something larger than yourself, creating something that would otherwise be impossible for the individual. However, as idealistic and alluring as that appeared , it could also simultaneously appear to force individuals to consider how much they were willing to prioritize the company's expectations over their own career expectations if they hope to be successful in the company. This presentation had the potential to deter individuals from applying or investing in the company as the organization's expectations could become disruptive to an individual's plans or goals – progressively

encroaching and overwhelming the individual. This phenomenon was especially true if we wished to progress outside of our own expertise and diverge into different categories of an engineering career – either directly related or adjacent to it.

Organizational Culture of Labs

Each website seemed to portray certain ideas more than others – either emphasizing certain aspects of the company, an individual's 'limitless' opportunities, or a combination of both. In doing so, the content illustrated an idea of what working with them (e.g., the organization) would entail – not only as an engineer but as an individual. These insights illustrated what qualities were needed in order to integrate with the organization's culture and their idea of what an engineer should be capable of or the characteristics they should possess.

For every memo there were two corresponding codes that went along with it, for the LANL Website there was a total of 82 codes, and for the KCNSC Website there was a total of 76 codes – see Table 5 for the occurrence of codes within the categorization of memos. The highlighted regions include the 10 codes that were the focus of further analysis. We compared the two websites based on these 10 codes primarily as they defined what each website chose to focus on and emphasize through the content they portrayed and the frequency with which they conveyed similar career constructs through their content.

Table 5: Total number and frequency of codes assigned across websites

	Los Alamos National Laboratory Website	*Kansas City National Security Campus Website*	***Total***
Power/Achievement	1	0	**1**
Security/Competence	5	2	**7**
Variety/Entrepreneurship	5	2	**7**
Mission/Identity	12	9	**21**
Values	10	15	**25**
Advancement/Growth	8	6	**14**
Long-term/Life	0	2	**2**
Intermediate	1	1	**2**
Short-term/Early Career	0	0	**0**
Subject Matter Expert	3	4	**7**
Interdisciplinary	9	5	**14**
Leadership/Management	3	4	**7**
Lateral/Rotation of Positions	4	2	**6**
Upward Promotion	0	0	**0**
Work/Life Integrity	8	3	**11**
Competition/Prestige	2	12	**14**
Teamwork	5	3	**8**
Individual Work/ Autonomy	2	1	3
Designer/Developer/Research	4	5	**9**
Total	**82**	**76**	**155**

Those highlighted in red are codes which were not seen when coding the memos *

Through the content of the website and the coding of the memos, we perceived that while there were similarities in the presentation of an engineering career, there were also distinct differences between the culture which embodied each of these organizations. By looking at Table 5, we inferred that each organization deemed certain qualities in a prospective employee more necessary than others to operate successfully in their organization. Some of these qualities highlighted the strengths of a balanced relationship between the individual and the organization, while other qualities embraced the idea of putting the whole over the individual. In other words, we sensed a disparity in the organizational cultures between each company in how they chose to present their content to ourselves and other students.

Looking at the frequencies in Figure 2, the LANL Website had 5 primary focus codes among the 41 memos. These were Mission/Identity with 12 occurrences, Values with 10 occurrences, Advancement/Growth with 8 occurrences, Interdisciplinary with 9 occurrences, and Work/Life Integrity with 8 occurrences. The other 14 codes had 6 or fewer occurrences when the memos were coded. Out of the total coded memos, over half of the codes (~57.3%) fell into those 5 categories previously mentioned, with the rest of the occurrences falling into the 14 other codes.

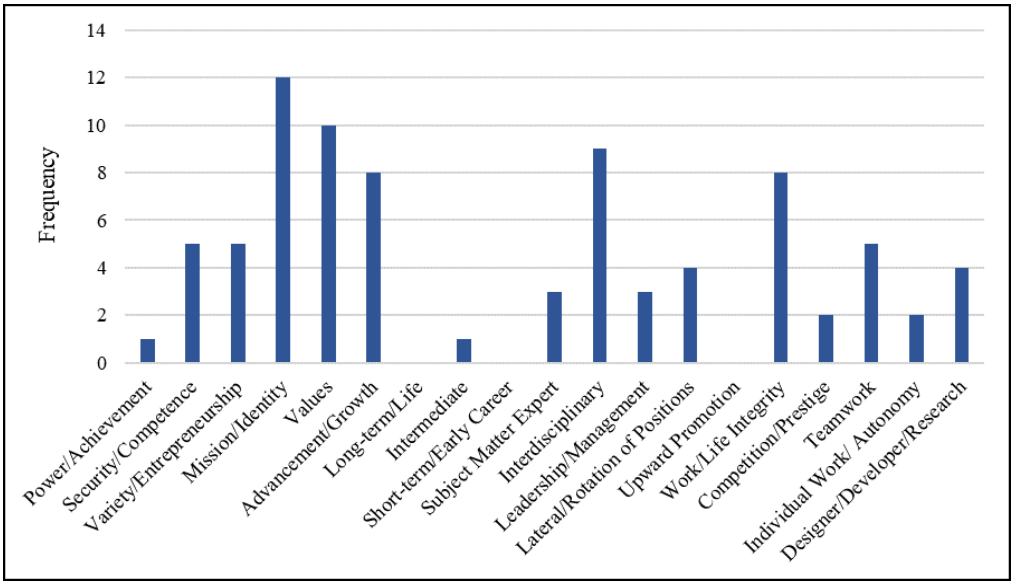

Figure 2: Los Alamos National Laboratory – Code(s) Frequency

Figure 3 shows how the KCNSC Website had 3 primary focus codes among the 38 coded memos, these were Mission/Identity with 9 occurrences, Values with 15 occurrences, and Competition/Prestige with 12 occurrences of the codes. The other 16 codes had 6 or fewer occurrences among the coded memos. Out of the total coded memos, slightly less than half of the codes fell within the three focus codes previously mentioned (~45.6%) while the rest fell into the other 16 coding categories.

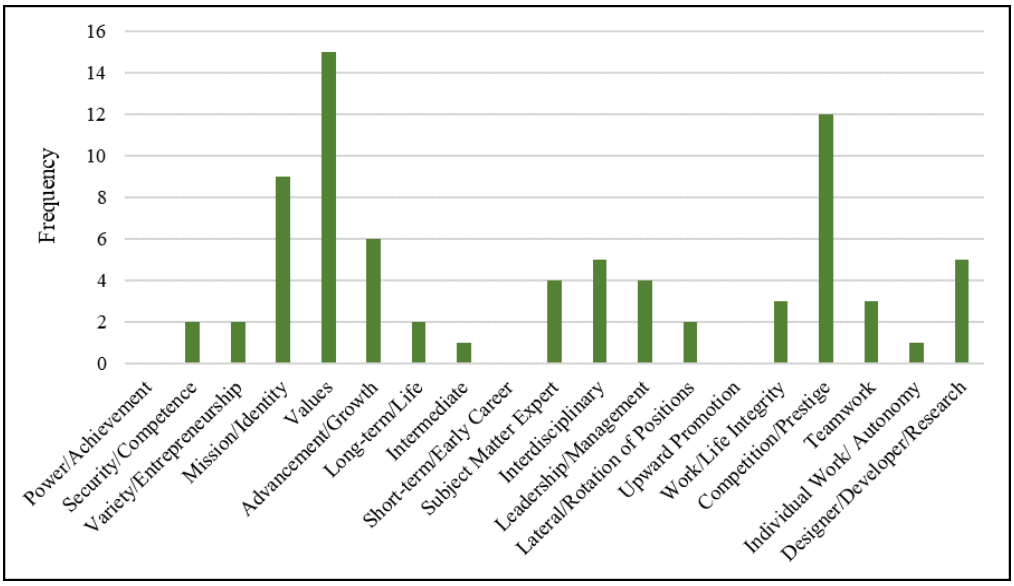

Figure 3: Kansas City National Security Campus Website – Code(s) Frequency

Looking at the 10 selected codes illustrated in Figure 4, we saw major differences between how each organization's culture was structured – made even more evident by the career content each company chose to make their primary focus. When looking at the LANL Website, we perceived the organization's culture to place great emphasis on the company's ability to work alongside the individual to achieve a common goal, often balancing principles of behaviors (Values and Mission/Identity) with the ability to progress and learn (Advancement/Growth and Interdisciplinary). This idea was only further developed with the high frequency of the Work/Life Integrity code, which describes a balance between the different dimensions of an individual's life – both professional and personal. However, while these ideas were highlighted heavily on the LANL website, other important organizational attributes such as Competition/Prestige were emphasized more on the KCNSC Website.

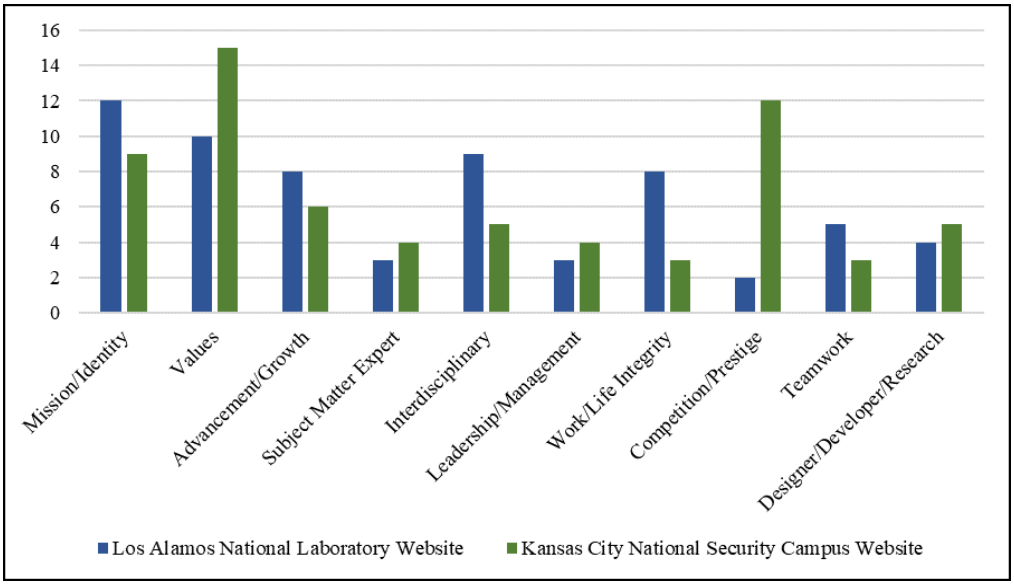

Figure 4: Comparison of Selected Codes

For the KCNSC Website, the bulk of the organization's focus was the guiding principles that define both the individual and the company, and how they are perceived not only by themselves but also by others. The large number of occurrences attributed to the Competition/Prestige code further enhances this idea of the whole – understanding your part in the company and upholding the standards that are expected by the company towards the individual. This heavy focus on the company's worth seemed to present a culture with less emphasis on individual growth, flexibility, and progress as illustrated by the number of occurrences of Variety/Entrepreneurship (2 occurrences), Advancement/Growth (6 occurrences), Interdisciplinary (5 occurrences), Lateral/Rotation of Positions (2 occurrences), and Work/Life Integrity (3 occurrences). Interestingly enough, the overwhelming perception of upholding company expectations and values above your own seemed to have created a lack of focus on the Individual Work/Autonomy and Teamwork codes, with each having only 1 and 3 occurrences respectively.

Implications & Future Works

Although our study represents minority student perspectives of engineering careers from a narrow sample of organizations representing a sub-set of the industry, our findings allude to the broader reality of what prospective engineers are looking for from employers. Taken holistically, it appears that during the "black box" transition to the workforce, minority engineers look for jobs that will bring fulfillment, flexibility, and agency. The focus on the organizational mission and opportunities for personal advancement and growth speaks to the importance of finding work that is both purposeful and fulfilling and is something that prospective engineers are evaluating as they search for jobs. It also appears that flexibility in both the work schedule and type of work are factors that are important when vetting jobs. The attention to the interdisciplinary roles offered for engineering and the focus on prioritizing work life integrity are signals that minority engineers look for in job descriptions and on websites. Lastly, the way organizational values are communicated, or rather the onus that is placed on employees to uphold and embrace those values appeared to be at odds with minority students' tendency to want to embrace their individuality but still be a part of the team.

As we mentioned previously, this work represents a small study that is part of a larger project on how minority engineering students conceptualize an engineering career during the post-graduation planning process. To that end, we are currently collecting survey data and interview data from minority engineers (e.g., graduating seniors and alumni) who have participated in an internship with either LANL or KCNSC. At the culmination of our work, we will have conducted a psychometric assessment of previous LANL/KCNSC lab interns to measure their career attitudes and see (1) how these findings resonate with the employee's experiences and (2) how national labs differ from other internships they may have had. Soon, we plan to evaluate the alignment among minority engineers with different career attitudes, interpretations of career content, and shared internship experiences to influence their post-graduation planning process.

We hope our investigation will yield more detailed insights on whether certain career conceptualizations are attractive to engineering students from minority backgrounds. The

analysis provided in this work resulted in a rich description of the expectations that student researchers (e.g., prospective employees) had for the organizational culture versus for their individual careers should they choose to pursue employment at these labs. In order to further the PRE-CCAP goal of building sustainable talent recruitment programs, the findings will be used to provide feedback to stakeholders on ways to improve the advertising of their engineering career opportunities in a manner that is meaningful and attractive to minority engineers.

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References

Briscoe, J. P., & Hall, D. T. (2006). The interplay of boundaryless and protean careers: Combinations and implications. *Journal of vocational behavior*, *69*(1), 4-18.

Brunhaver, S. R., Jesiek, B. K., Korte, R. F., & Strong, A. C. (2021). The Early Career Years of Engineering: Crossing the Threshold Between Education and Practice. *Engineering Studies*, *13*(2), 79–85. https://doi.org/10.1080/19378629.2021.1961570

Cannady, M. A., Greenwald, E., & Harris, K. N. (2014). Problematizing the STEM pipeline metaphor: Is the STEM pipeline metaphor serving our students and the STEM workforce?. *Science Education*, *98*(3), 443-460.

Carnevale, A. P. (2021). *Mission Not Accomplished: Unequal Opportunities and Outcomes for Black and Latinx Engineers*. 53.

Cross, K. J., Clancy, K. B., Mendenhall, R., Imoukhuede, P., & Amos, J. R. (2017, June). The double bind of race and gender: A look into the experiences of women of color in engineering. In *Proceedings–American Society of Engineering Education Annual Conference & Exposition (ASEE), Columbus, OH. June 24-28, 2017*.

Driver, M. J. (1982). Career concepts: A new approach to career research. *Career issues in human resource management*, *23*, 32.

Hall, J. L. (2021). *Disaggregating the Monolith: A Case Study on Varied Engineering Career Orientations and Strategies of Black Women in Tech* (Doctoral dissertation, Virginia Tech).

MacQueen, K. M., McLellan, E., Kay, K., & Milstein, B. (1998). Codebook development for team-based qualitative analysis. *Cam Journal*, *10*(2), 31-36.

McArdle, S., Waters, L., Briscoe, J. P., & Hall, D. T. T. (2007). Employability during unemployment: Adaptability, career identity and human and social capital. *Journal of vocational behavior*, *71*(2), 247-264.

Metcalf, H. (2010). Stuck in the pipeline: A critical review of STEM workforce literature. *InterActions: UCLA Journal of Education and Information Studies*, *6*(2).

Naukkarinen, J., & Bairoh, S. (2022). Gender differences in professional identities and development of engineering skills among early career engineers in Finland. *European Journal of Engineering Education*, *47*(1), 85–101. https://doi.org/10.1080/03043797.2021.1929851

Savickas, M. L. (2013). Career construction theory and practice. *Career development and counseling: Putting theory and research to work*, *2*, 144-180.

Rohde, J., Musselman, L., Benedict, B., Verdín, D., Godwin, A., Kirn, A., Benson, L., & Potvin, G. (2019). Design Experiences, Engineering Identity, and Belongingness in Early Career Electrical and Computer Engineering Students. *IEEE Transactions on Education*, *62*(3), 165–172. https://doi.org/10.1109/TE.2019.2913356

Russell, A., & Frachtenberg, E. (2021). WorldsApart: Technology, Remote Work, and Equity. In IEEEComputer 54(7), July2021. DOI: 10.1109/MC.2021.3074121

APPENDIX

Code	Definition
Power/Achievement	motivational drivers for career behavior and choices where the concept of success in an occupation aligns with upward promotion and growing responsibility and authority (e.g., roles and title changes)
Security/Competence	motivational drivers for career behavior, choices where the concept of success is rooted in financial or long-term job security or fulfillment from demonstrating efficiency and aptitude in one's occupation
Variety/Entrepreneurship	motivational drivers for career behavior, choices where the concept of success is rooted in achieving breadth of knowledge within a domain or more broadly to combine skills across domains to demonstrate career autonomy; non-traditional patterns of career success
Mission/Identity	motivational drivers for career behavior and choices where the concept of success in career is based on a mentality of career as an extension of an individual's self-concept; someone's life work
Values	represents principles or standards of behavior, of what is important for work
Advancement/Growth	represents opportunities to improve and develop in terms of advancing knowledge and career progression
Long-term/Life	content implies career longevity, this organization offers tenured career opportunities, permanent or sustainable career tracks
Intermediate	content implies careers here are flexible you can get a great start here; but you can also plan to retire with this organization
Short-term/Early Career	occupations and jobs are described in a temporary, or experiential manner
Subject Matter Expert	content implies they are seeking or that employment here will lead to the development of engineers who possess a deep understanding of a particular subject
Interdisciplinary	content implies that they are seeking engineers who can/will use more than one branch of knowledge and possess the ability to use skills to solve problems comprehensively
Leadership/Management	the process of dealing with things/people a company or organization; opportunities for professional development and leadership
Lateral/Rotation of Positions	opportunities to broaden career knowledge; employees “rotate” through different aspects of the lab for specific periods of time. They allow new or existing employees to get experience in a variety of engineering tasks by holding real, temporary positions and responsibilities in different departments
Upward Promotion	opportunity of moving into a higher pay bracket and or status, vertical movement of an employee within an organization
Work/Life Integrity	interaction between values across dimensions of life; having and living your life by defined values in personal life, family (relationships) and career.
Competition/Prestige	marked by exhibiting a competitive environment or culture of prestige
Teamwork	the cooperative effort of a group of people seeking common end

Individual Work/ Autonomy	completing tasks independently and or, exercising complete control over the direction and process of how you work
Designer/Developer/Research	work focused on the engineering design process in any part of the product or system that involves prototyping, production and or adapting. Engineers responsible for the design of new products/technology