Student Perspectives on Navigating Engineering Pathways

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Like many of the National Academy of Engineering's consensus studies, the 2018 *Pathways* report [1] tells us what we maybe already knew, but nevertheless needed to hear: students enter engineering education from diverse points of origin and continue through to careers that are as likely beyond engineering as within it. However, a close reading of the report also reveals two voices. On the one hand, there was the voice of educators and administrators eager to celebrate the fact that engineering can serve as rigorous preparation for a variety of future occupations. On the other hand, there was a smaller number of educators, including NAE staff members who, through their engagement with the literature on women and minorities in engineering education sought to make the point that many students enter engineering with diverse backgrounds and preparation in ways that impact their educational experiences, and shapes the choices and the career pathways that they take. It is also clear from this literature, some of which is cited below, that those choices are not always entirely of their own choosing.

In this paper, we wish to present some preliminary results from a pilot study on student perspectives about engineering education, and how students navigate through their own educational transformation. What we provide in the paper is an early analysis of interview data gained from student interviews, where undergraduate URP/REU students interviewed other students about their educational experiences. Our initial analysis suggests that student pathways are determined in largely *interactionist* terms, namely through their encounters with other students, instructors, advisors, and other individuals. How students come to experience and manifest well-known phenomena such as imposter's syndrome [2], racial and gender dynamics in group work [3]; the influence of family and felt obligations among Hispanic and Latinx, first-generation, and non-traditional students [4]; and their culturally conditioned willingness or lack thereof to engage with support services (e.g. see Palmer and Gasman [5]) all influence how they view their own progress and shape the choices they make about their degree program. Consistent with the findings of the *Pathways* study, many of the consequential decisions that students make are less about whether or not to stay in engineering—the old argument under our outdated "pipeline" model—but instead more formative decisions about how to navigate through their educational experience, and what course they themselves chart for their futures. It is our goal to describe what occurs inside the black box as students from diverse backgrounds come to define their pathways through an engineering program.

This paper will also feature student voices. All seven of the undergraduate researchers who worked with us will eventually present their own interpretations of how their interviewees entered engineering; what encounters shaped their pathway through an engineering degree program; and what aspirations their interviewees came to develop, going forward. (In this paper we present selected results, but may rotate who speaks during the online presentation of our paper). The non-undergraduate members of the research team will offer an analytic framework and describe the basic methods employed prior to the student presentation of their analyses, offer some reinterpretation of their findings (with opportunity for comment), and conclude with preliminary observations about general patterns that our early data point towards. The paper as a whole will also suggest how we can extend existing symbolic interactionist studies of student

experience and occupational identification in ways that are aligned with current conversations about student pathways in engineering. We also give the final word to the students, who report on their own findings from the project.

Analytic Framework & State of the Art

Our analysis builds on some early symbolic interactionist studies, and specifically the notion of a student's development of an identification with an occupation [6]. A classic study in this genre is Becker, Geer, Hughes, and Strauss' *Boys in White* [7], where significant homogeneity within the entering cohort of medical students at Kansas State resulted in a more-or-less uniform pathway to the profession—a case where the pipeline model might make sense. However, the much more diverse backgrounds, value commitments, and preparation of engineering students (even within a single institution) predispose engineering students to enter their program with diverse mindsets that produce, in turn, more diverse encounters and outcomes. While medical education itself has grown more diverse since the 1950s [8], it's important to note that the structure of medical education continues to guarantee that all medical students have successfully navigated a pre-med curriculum heavy in science and math content, and that they have been selected into schools based on their academic performance and abilities. By contrast, even the most highly ranked engineering schools in the United States have sought to bring in more diverse student cohorts. Although the reasons for doing so differ [9], almost universally these institutions cite differences in preparation as a current institutional challenge, thus expanding the challenge of managing educational pathways. We have found this to be especially true at public institutions driven to expand access while improving retention rates, based on performance metrics set by the state.

Retention studies have been conducted for nearly every sub-population including women and many racial and ethnic groups. Some of the work has shifted to *intersectional* analyses—for example, Archer's exploration of black male students' resistance to "geeky" identities [10], or Johnson *et al.*'s study which highlights some Native American and Latina women's preference to work as scientists within their ethnic communities as a method of balancing ethnic and engineering identities [11]. However, less work has been done on the *interactions* that occur across different student cohorts. Indeed, scholars have argued that due to the growing complexity of intra-group dynamics—which Vertovec calls "super-diversity"—along the lines of race, gender, ethnicity, language, religion, regional identities, kinship, clan, tribe, political parties, political movements, and immigration status, more research is needed to understand the complex intragroup dynamics that produce particular outcomes [12-14]. In engineering, the most extensive work done with an interactional focus has been in the domain of women in engineering—so for example, gender based conversational dynamics and role assignments that occur with group work, or the more adverse interactions women students sometimes experience when interacting with male and especially older male faculty during office hours. However, such studies have been built largely around the experiences of a specific cohort, and not the interactions that occur simultaneously across the multiple and increasingly diverse cohorts found in today's engineering programs.

One important exception is Karen Tonso's ethnographic study of engineering students enrolled at a public engineering school, *On the Outskirts of Engineering* [15]. By embedding herself with the students themselves as they worked their way through an engineering design curriculum, Tonso was able to gain access to the highly varied student subcultures that exist within

engineering, and the interactions that occur across different student cohorts. The groups she identifies and describes were not merely constructing differences based on gender and ethnicity; rather, students built cohort groups around a more fluid set of ascribed identities such as nerdboy, dormie, frat brother, sorority woman, and overachiever, each based on perceptions about the conduct of another group. Tonso's work is also interesting in that it does not take a student's field of study or academic efforts as necessarily central to undergraduate student identities. Identity formation was considered as much a result of a student's extracurricular activities and indeed, their various interests in life, which nonetheless shaped their attitudes towards each other and their studies.

This said, beyond the survey she conducted to capture student perceptions of one another, Tonso's work is built around an ethnographic study of design studio environments—engineering students in first, second, and fourth year design studios. This limits significantly the educational arenas under study, including, as pointed out by one of the student authors of this paper, the math-science courses where a great deal of differentiation occurs. Moreover, despite looking at students across the years, by not focusing on the longitudinal experiences of any single student as they navigated their way through college, student pathways have to be inferred rather than directly observed. This paper focuses on individual student experiences in order to document how student interactions with students and faculty in an academic environment brings them to chart different pathways through engineering. Put a little differently, our study is built around speaking with individual students about the history of their encounters while attending college, with a focus on distinct (memorable) moments in their college experience. We then trace how this produces a unique set of educational pathways.

Method

This paper is based on an NSF REU supplement secured on top of a larger qualitative study of faculty and academic administrator perspectives on engineering education reform (NSF-SES-1656125, SES-1655750, SES-1656117, collaborative). Eager to ascertain whether the faculty perspectives on student experience that we gained in our data were consistent with actual student experiences, we secured an REU supplement to conduct a pilot study for this purpose. Based on this additional support, we were able to assemble a group of seven current or former undergraduate students who agreed to interview engineering students about their backgrounds and their experiences in college while enrolled in an engineering degree program.

These student-researchers were themselves of diverse backgrounds, and rather than having them interview students at our own institution, we asked them to rely on their personal networks (e.g. friends of high school friends; student leadership from national organizations they belonged to) in an attempt to match the institutional demographics of our larger study. Although we did not insist on a one-to-one mapping, public and private institutions; general universities, engineering schools, and liberal arts colleges; and primarily white and Hispanic serving institutions are also included in the student data set. A subject selection matrix was employed to also maintain some degree of balance within our sample with regards to gender, race/ethnicity, and socioeconomic background, with the project PIs helping to secure additional interviews to round out demographic variation. We currently have N=29 interviews completed, and their mapping to the larger project and the basic demographics of our sample are described in Table 1 & 2, respectively.

Table 1: Institutional Profile of Faculty/Admin vs. Student Data

			Faculty/Admin Data	Student Data
Overall Sample			**N=**	**N=**
	Colleges & universities (4-year institutions) with full participation in our study (4+ interviews)		**26**	**19**
	Community colleges (2-year institutions) - Note: includes transfer students for student data		**5**	**2**
Institutional Demographics of Colleges & Universities Four-year institutions only (N=26)				
By Tier (US News & World Report, undergraduate engineering rankings)				
	Doctorate granting	#1-#10	**6**	**2**
	Non-doctorate granting	#1-#10	**5**	**1**
	Either category	#11-#30	**8**	**4**
	Either, #75+ doctorate, #40+ non-doctorate		**7**	**5**
Geographic location				
	East coast		**7**	**13**
	South		**6**	**2**
	West		**6**	**2**
	Midwest		**7**	**2**
Institutional type				
	Public universities		**11**	**6**
	Private universities		**2**	**3**
	Public engineering schools		**3**	**5**
	Private engineering schools		**6**	**4**
	Liberal arts colleges (with embedded programs)		**4**	**1**
	Minority serving institutions (MSI; would also be one of the above types)		**5**	**1**

Table 2: Interview Subject Demographics

Demographics of individual interview subjects	**N=**
Gender	
Female	**12**
Male	**15**
Not identified	**2**
Race/Ethnicity	
Hispanic	**3**
Black/African-American	**5**
Asian	**8**
White	**10**
Other/Not identified	**3**

There is also a somewhat novel methodological move embedded within our research design. Because engineering education researchers are also educators, the asymmetric relationship between teacher and student can impact the quality of the interview data. For instance, there is

something potentially problematic about having faculty members interview students about the difficulty they have speaking with faculty. While there may be other methods for facilitating access, having students interview other students enabled us to tap more directly into student experiences.[1] We also realized, through the course of this pilot study, that we were inviting our student researchers to engage in a practice that was contiguous with a mode of interaction familiar to students—talking to friends about the challenges they were facing and using that to develop an awareness of, and effective strategies for navigating their way through college. Moreover, because of shared experiences, shared interests, being introduced by a friend, rapport came easily in many instances. The quality of the interviews were not always uniform: gender dynamics, early anxieties about conducting an interview, and other factors occasionally disrupted the flow of the conversation. In particular, our student researchers' ability to come up with meaningful follow-on questions were more variable at the outset, although they all tended to improve and become more effective over time. Despite these limitations, there is little doubt, from our reading the transcripts, that there was a level of rapport in a large majority of the interviews that would have otherwise been difficult to obtain.

All interviews were set up as semi-structured interviews, with a fixed list of questions and an opportunity to ask follow-on questions. The students we chose to do the interviews were not necessarily engineering students (see Table 3, for undergraduate researcher demographics); we instead chose students who had some exposure to the lead PI's home discipline of science and technology studies, with the thought that these students would have had greater exposure to social science methods, and hence more easily brought up to speed on interview techniques. The initial student members of our research team were first brought into the project to help transcribe and edit faculty interviews from our main project. This meant that this initial cohort was already familiar with oral interviews, as well as the overall structure of our research project. They were already knowledgeable about how U.S. faculty viewed engineering education. This initial cohort of three students, two of whom continued on to do our student interviews, helped with the initial project design and indeed, for drafting the REU proposal. They also contributed directly to the development of the interview questions and protocol, beginning with an initial brainstorming session to identify topics of interest to engineering students. After the PIs compiled their suggestions into a list of possible interview questions, the students helped "translate" those questions into their own language. This was done in two rounds to ensure proper alignment of the interview questions with the analytic framework described above.

[1] Active debate regarding the difficulty and ethics of conducting interviews across power differentials, including race, gender and class, continues in scholarly discussions of interview methodologies [16-19]. O'Brien [17] argues that race-matching alone is insufficient in accounting for the multiple layers of difference and power differentials that exist between researcher and interviewee. Instead, she contends that the most important objective for the researcher is instead to "activate" race by addressing it specifically, indicating to interviewees that it is acceptable to discuss race openly (p. 79). In the context of our student interviewers, we find that students are better able to "activate" student issues, giving interviewees permission to express critique of faculty and the institutions that they inhabit.

Table 3: REU Student Researcher (Interviewer) Demographics

Name	Race/Ethnicity/Gender (as self-identified & disclosed)	Year	Major(s)
Joerene Aviles	Southeast Asian/Non-binary	Post-baccalaureate	Biomedical Engineering
Eva Dibong	Black/African/Female	Junior	Mechanical Engineering & Design, Innovation, and Society
Beatrice Mendiola	Asian/Female	Junior	Mechanical Engineering & Design, Innovation, and Society
Michelle Murray	Caucasian/Female	Junior	Mechanical Engineering & Design, Innovation, and Society
Melissa Shuey	Caucasian/Female	Junior	Mechanical Engineering
Marta Tsyndra	Caucasian/Female	Senior	Mechanical Engineering & Design, Innovation, and Society
Makayla Wahaus	Asian-American/Female	Senior	Applied Physics & Sustainability Studies

Training, although not entirely uniform, was built into the project design so that all new students who joined the project were interviewed by, and in turn interviewed one of the students familiar with the faculty interview data, or else they were asked to review multiple transcripts already generated by other students and to participate in a mock interview. During the early part of the project, while the students honed their interview skills, we held biweekly meetings to discuss both the substance of the interviews (e.g. “what did you find most interesting?”) as well as questions of method (“what did you find most challenging about your latest interviews?”; “what follow-on questions did you ask?”), this as a means of attuning them to the topic as well as refining their interview techniques and skills.

Recounting Student Experiences

In assembling this paper, we asked the students to revisit their interview transcripts, choose their favorite one, and to frame their interpretation of their interviewee’s experience by answering the following questions:

1. How did this student come to choose engineering? Who or what influenced them to make this choice?

2. What difficulty did they encounter, if any?

3. How did they navigate their way through college? In particular, what people, event, experience, or program enabled them to overcome their challenges?

4. What are their aspirations today? What do they hope to do after graduation?

After the project PIs commented on these statements based on the analytic framework pertaining to occupational identification and intersubjective encounters that was established for this study, the student researchers were again invited to offer a response based on the following prompt:

> Do you agree with what we've said about this student? If not, how was our description off? What else might you add, based on your review, once again, of the transcript?

Student A

Interviewer: Joerene Aviles
Subject: Johnny[2] (M), MechE[3], Junior (Community college transfer student), Southeast Asian[4]
Public University (PhD granting), West Coast

The first interview addresses a low-SES student from an ethnic background (Southeast Asian), who experiences difficulty socially integrating into a large, primarily white state university:

> 1. How did this student come to choose engineering? Who or what influenced them to make this choice?
>
> Johnny chose to study engineering from a variety of factors. On one hand, his family pushed him to pursue higher education as a way out of poverty, so he wants to please his family in a career that pays well. On the other, he had an interest in building and creating things from a young age, playing with LEGOs, Connex, and similar toys. He then went on to a STEM high school where he was exposed to engineering careers.
>
> 2. What difficulty did they encounter, if any?

[2] Pseudonyms are used for our subjects throughout this paper. "American" first names have been replaced with other names common to other white, US born individuals. Ethnically and racially identifiable first names have been replaced with other names common to that ethnicity and/or race.

[3] Disciplinary/departmental names are given in generic groupings to reduce the identifiability of the institution and subject. Mechanical might include aeronautical engineering. Biomedical engineering is used to designate significant variants such as biological engineering. Civil and environmental engineering will be listed separately, due to the significant difference in gender composition as well as the students' normative orientation in these fields.

[4] Race and ethnicity are listed using commonly known groupings. Those with mixed race and/or ethnicity are listed according to self-reported identities.

Johnny primarily struggled with homesickness, mental health, and making the transition from high school level courses to college level courses. In high school, Johnny excelled in his STEM courses with rarely any studying, and felt his "college-prep" and community college courses were similarly easy. Coming from a diverse neighborhood, Johnny was surrounded by his culture and many others growing up. The move to the eastern part of [a western state] was difficult for Johnny, where the university has predominantly white students, where he was often one of the only Asian students in a class of 30. He felt secluded and depressed due to not having close connections with those in his courses. He began going through the motions, but has kept in contact with friends and family in [his home town].

3. How did they navigate their way through college? In particular, what people, event, experience, or program enabled them to overcome their challenges?

Johnny was an active participant in the student government at his community college. After transferring to his university, he didn't continue with this extracurricular but he continued to work two part-time jobs, one as a math tutor for K-12 students at an off campus tutoring center and another as a mentor in a high school program. He chooses to navigate the larger state school independently, despite his anxiety, depression, and stress that comes from this.

4. What are their aspirations today? What do they hope to do after graduation?

While Johnny doesn't have a clear goal for what engineering career he'd like to get into after graduation, he aspires to work in engineering industry and work up in those corporations. He has an interest in manufacturing and will most likely aim towards a mechanical engineering career in that pathway.

Speaking as the project PIs, what stands out to us is Johnny's social isolation, one likely reinforced by his socioeconomic status, obligations to his family, and need to work while in college. This social isolation and exclusion has left Johnny without the social network necessary to more easily navigate through college—having study groups, getting information about what courses to take and not to take, etc… This has also left him depressed, which either he or the interviewer interprets to be about mental health. While this affects his engagement with academic work, Johnny's male identity, and possibly more specifically his identity as a low-SES Asian male presses him towards a behavioral strategy of self-reliance, forcing him to "navigate the larger state school independently." As such, and despite having attended a STEM-oriented high school, Johnny's identification with, and knowledge about engineering remains limited and generic; he "doesn't have a clear goal," and despite being a junior, can offer little specificity with regards to what firm and engineering industry he wants to work for. He also has no specific strategy for how to ascend through the ranks of a corporation. Still, as a male, Asian engineering student, Johnny persists in engineering as his chosen degree, perhaps because of a sense of obligation to his family and their expectations for his success.

Commentary by Aviles:

I agree with a majority of the points made by the PIs, though I'd like to add that Johnny's isolation from other students was also due in part to the age difference and his transfer status, and not solely due to his low-SES Asian male demographic. Although he was not a non-traditional student, he felt that he was "old" as he needed to live in the freshman dorms due to school policy as a new student. While dorms are usually sources of friends, and thus formation of support groups, this age difference made connecting with his dorm-mates difficult. As a transfer with junior standing, many students at the four year institution also would have developed their own cliques by then; thus Johnny was further isolated as he had a difficult time joining established friend groups.

Student B

Interviewer: Marta Tsyndra
Subject: Abby (F), ChemE, Senior, South Asian
Private Engineering School (PhD granting); East Coast

Abby is a student with a good educational background and supportive middle-class parents. She entered college with a good deal of confidence, perhaps too much confidence. Like many others who experienced little difficulty in high school, she found herself struggling with college.

1. How did this student come to choose engineering? Who or what influenced them to make this choice?

In high school Abby really liked math. However, she had a dream to go to medical school one day, and engineering seemed like a perfect way to combine these two passions.

As someone who was pre-med, Abby thought chemical engineering would provide insight into the solutions that doctors end up prescribing to their patients, and that it would give her opportunities outside medicine if she ever changed her mind. Abby also had a cousin who got her bachelor's degree in biomedical engineering and then went off to become a doctor. Abby always thought that it was fascinating that someone could have both backgrounds. She was inspired by her cousin to pursue both engineering and med school.

2. What difficulty did they encounter, if any?

Abby experienced a steep learning curve at first. Even though she was used to hard science courses, the application of physics to her subject proved to be difficult. She was always a top performer in high school, graduating 4th in her class. However, it was different in college and she had to get used to the thought that she was not "the best" anymore. Moreover, she had to learn how to study again and manage her time better because she realized that everything required twice as much time and effort as before. Abby also thought that the college

grading system was unpredictable and, at times, unfair. Combination of stress, self-loathing and family issues greatly affected her mental health and motivation. It was really difficult for her to maintain proper health (both mental and physical) while keeping up with difficult and demanding engineering courses.

3. How did they navigate their way through college? In particular, what people, event, experience, or program enabled them to overcome their challenges?

For Abby having a strong support system of friends was essential in college. She found a great group of friends and was able to share all of the difficulties she faced with them. It was easier to go through difficult classes and other hurdles together and it helped that she always had someone to socialize with in a place like Tech, where social life is not as developed as at other larger schools. She realized that she wanted to use counseling services to be able to better manage and understand her mental health. When school work was more than she could handle on her own, she went to TAs for help and it was very useful for her. A combination of all of these things really made a big difference for Abby and made her engineering experience more bearable.

4. What are their aspirations today? What do they hope to do after graduation?

Despite the fact that Abby does not want to pursue medical school anymore, she still wants to work in a medical field and help people in a different way. Abby hopes to pursue a career in biotech or pharmaceuticals and be in a role where she feels like she is making a difference in someone's life and where she can meaningfully contribute to society. She also wants to pursue a non-engineering, part-time master's in data science to diversify her skillset.

As PIs, what we find most striking in this account are the little bits of narrative detail that has been thoughtfully left out of this story. Abby didn't like her cousin very much, and her decision to use engineering as a pathway into medicine was an attempt to show her family, if not relatives, that she was as good as her. Seeking to differentiate herself from her cousin, she chose chemical engineering rather than biomedical engineering. The challenge of pursuing a difficult path that involved mastering both engineering and medicine was something she felt she was up to.

Like many other students who got straight As in high school, the difficulty and intensity of studying engineering at a competitive school made getting good grades a challenge. Having most likely received a good deal of praise while in high school, her lower grades, though not necessarily lower than the other students she competed with (nor did it necessarily impact how much she learned), deeply impacted her sense of self-efficacy, pushing her towards depression.

For Abby, who quickly identified with the other students attending Tech, finding friends was not difficult. This provided her with the study groups and support network necessary to make it through her classes, even as it provided her with a social outlet. Still, the experience left her bitter, as she could no longer fulfill her life ambition. Sadly, Abby understands, or at least

believes that she can't attend medical school with her grades. She feels that choosing biology, or some other pre-med major including biomedical engineering might have made it easier for her to stay on her preferred path.

Also interesting in the context of Becker et al.'s *Boys in White,* Abby is headed towards graduation with the same naïve sense of idealism with regards to the purpose of her profession as she had when she entered. To some extent, counseling and having friends enabled Abby to come to terms with her past choices, although the seeming arbitrariness of college and engineering degree programs remains a frustration for her. Still, by the end of the narrative, Abby has recovered some of her sense of self-efficacy, and holds on to the vision of medicine as a discipline that helps people. She has partially accepted the fact that she will now have to do so through a career in biotech or pharmaceuticals that builds on her training in chemical engineering.

Commentary by Tsyndra:

I think that the analysis done by the PIs is fascinating and accurately infers the smallest details of Abby's experience in engineering. I would like to add that after Abby completed her second year as a chemical engineering student she found herself unhappy with her path. However, she felt like it was too late to switch her degree. Desire to live up to her family's expectations and job security pressured her to further pursue engineering. Despite her struggles with mental health, family, grades, and general dissatisfaction with her degree, she was able to find a great sense of comfort in her friends, relationships and counseling. This support network is what kept her "sane" in a school like Tech.

Student C

Interviewer: Eva Dibong
Subject: Amaya (F), Junior, Industrial Eng., African American
Public Engineering School (PhD granting), South

1. How did this student come to choose engineering? Who or what influenced them to make this choice?

Growing up, Amaya was "very by the book." Coming from an immigrant family, she felt pressured to go into STEM. She decided to pursue engineering due to this pressure but also because of the prestige and salary associated with it. Since she did not have any professional engineers in her immediate circle, she resorted to Google to learn more about the field and to gain a better understanding of what it entailed. Through her research, she fell in love with the things/innovations produced from engineering and decided to major in Industrial and Systems Engineering at Southern Engineering School.

2. What difficulty did they encounter, if any?

She mentioned that her biggest issue was not getting into engineering but staying

in engineering. Although her older siblings had gone to college, none of them majored in STEM. They all had different experiences and could not always help her. Amaya also mentioned the difficulty of transitioning into college from high school and being far from home. Overall, it seemed like her biggest challenge was her expectation of not being able to succeed. She mentions, "when I think about engineering I do not think about people like me." Most engineers do not come from a cultural background similar to hers. Most of them are not women and even fewer of them are black women. Coming into the field, Amaya doubted herself and struggled academically. Despite this doubt, she had high expectations for herself.

3. How did they navigate their way through college? In particular, what people, event, experience, or program enabled them to overcome their challenges?

Several programs have helped her navigate her way through engineering and college, the first one being NSBE (National Society of Black Engineers) who has for its mission to increase the number of culturally responsible Black Engineers who excel academically, succeed professionally, and positively impact the community. In addition, Amaya mentioned receiving support from a program at Southern Engineering School that focuses on women and underrepresented minorities. She spoke highly of other retention programs such as STEP (Science, Technology, Engineering, and Mathematics Talent Expansion Program) and the "Help Me Help You" talks.

With the help of these programs, and opportunities for leadership roles within them, she was able to navigate engineering education (i.e. succeed academically) and get over her timidity and self-doubt. In her own words, "it is not my life if it does not have 100 roadblocks." Amaya believes in working hard to overcome challenges. She makes an effort to ask people what they do in order to do well, and applies this knowledge to herself.

4. What are their aspirations today? What do they hope to do after graduation?

Amaya now wishes to be the "first African American female CEO of a Fortune 500 company" and start a non-profit NSBE chapter in Addis Ababa, Ethiopia. Amaya aspires to do good with the money she earns and hopes not to be driven by money. She realizes how much NSBE has done for her and she wishes to give a platform to kids in Ethiopia who have a passion for STEM. She also believes it is our responsibility to give back and mentor people who can benefit from our experiences.

Amaya's interview is probably one of the ones that touched us the most. Perhaps even more than what comes through in Eva's account, Amaya struggled with the start of college and her self-confidence. While it's not clear to us whether Amaya's grades were any lower than her cohort, the cultural shock of moving to a less diverse institution, and her sudden inability to get an A in all her classes affected her deeply.

Like other women and underrepresented minorities, Amaya seriously considered the possibility of leaving engineering. However, upon finding NSBE, meeting similar students, hearing their stories, and "learning what they do in order to do well," she regained her confidence. Her current aspirations, and the moral purpose that she's gained from NSBE, speak for themselves.

Commentary by Dibong:

I mostly agree with this interpretation of Amaya's experience. I would like to add that it is not clear whether or not she considered dropping engineering. I think Amaya encountered several challenges that made it difficult for her to stay in engineering. However, during her interview, she did say that "it is not [her] life if it does not have 100 roadblocks." This statement led me to the conclusion that she is not one to back out from challenges nor is she very likely to quit when the academics get tough. On another note, it seems like she walked into engineering, a field known for imposter syndrome due to the lack of representation of people who look like her in engineering. I think this is one of the main reasons why she initially struggled with self-confidence.

Conclusion

This paper is built around highly subjective individual stories, and as such, there will remain certain things that we will never know with any certainty. Yet, at the same time, these stories, both individually and collectively, support our key argument that intersubjective encounters between different student cohorts, between students and faculty, or students and their advisors, and the more "intertextual" encounters between backgrounds, interests, engineering curricula, and problem sets chart a multitude of different pathways through which students experience and navigate their way through engineering degree programs.

While as a pilot project our data set does not fully exhaust either the breadth or depth of the field, stories like those given above begin to map out some recognizable pathways through which students navigate their way through college. Among those that are evident even in the limited number of stories we examined for this paper are as follows:

- Students entering college with different degrees of preparation experience engineering programs quite differently.

- College, and engineering in particular remains a challenge for many. Many students do find engineering degree programs to be much more difficult than what they experienced in high school, and differences in background and preparation can exacerbate those challenges.

- Access to peer groups, and secondarily, to support programs that they find accessible seem most important to student success. Faculty, while occasionally mentioned as a resource are, in the context of our interview questions, more often perceived as being inaccessible, and spoken of as a challenge to be overcome.

- Conversely, social isolation seems to be the greatest risk for students with diverse backgrounds. Isolation is multiply damaging in that it prevents a student from having peer groups for studying, guidance, and emotional support. It can also contribute directly to issues of mental health.

- From the standpoint of the National Academy's *Pathways* report, it's clear that the basic model of students entering college from different starting points, and winding up with different career paths is fully supported by our data. However, the way in which students experience and in many cases carve out these pathways are highly personal experiences that they may hold to be positive or negative.

- In our interviews so far, a sense of self-efficacy emerges as the single most important indicator of whether a student perceives themselves as having charted a positive pathway through engineering.

We believe these findings point to various policy recommendations about diversity initiatives, admissions policies, support services, peer networks, wellness, and engineering curricula. For example, schools should ensure that their diversity initiatives enable women, first-gen, and minority students to find supportive cohorts, and for there to be accessible and destigmatized student support services for any student who requires a safety net. Faculty should continue to ask whether their current science-based engineering curricula serves the interests of all students, and whether more differentiated academic programs are needed even within specific institutions and degree programs. We hope to explore such policy recommendations through a follow-on study to our pilot project, based on a larger, more representative data set. That said, we believe that the interviews we've collected to date do much to "open the black box" of how students actually navigate their way through an engineering degree program and the challenges that they present.

Closing Comments by Student Researchers

Throughout the process of pulling together the stories of the students represented in this paper, we recognized several recurring factors throughout the interviews. Socioeconomic status is the strongest environmental factor that influences how the individual motives, goals, and identities of engineering students are shaped. Especially for low-SES students, socioeconomic status becomes a goal in and of itself: students make choices and adjust what they do in college and in engineering in particular to maximize their career prospects and their potential for monetary gain. This can be seen in the many stories about students seeking to build generational wealth or obtaining jobs with higher salaries. By contrast, students who grew up in a household with a higher socioeconomic status, who may have parents already working in a STEM career or who have had access to schools with a rigorous pre-engineering curriculum, are found engaging with various extracurricular opportunities because they do not feel pressured to help support their family financially.

While social and cultural background does matter in determining the pathway through engineering that students choose, having a good support system can also help determine whether they continue on that path or change paths and their level of success. Finding a support group is hard enough for most students entering college, but minority students navigating their first

semester can easily become lost within a system that has been designed to exclude them. Some of our interviewees said they had found decent support systems at their respective schools, which helped, and they believe this will continue to help them succeed in both their academic and personal lives. Others have faced serious struggles academically, economically, and emotionally because it seems that they have not found the assistance that they need to accomplish their personal and professional goals.

This project has helped to highlight a diversity in the experience of engineering students that is not always known. We are proud to have helped feature voices that may not have been heard before. It's essential for all engineering students to hear these stories and know that they are not alone in their engineering paths. If this pilot project is able to fully take off, there is the potential to get even more student voices out there to represent the hidden diversity of an engineer's background and their experiences in college.

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