Underrepresented Minority Engineering Students' Professional Experiences with Cooperative Education: Perceived Benefits, Drawbacks, and Pathways to Participation

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Abstract

This study examines underrepresented minority students' perceptions of cooperative education programs (co-ops), and how these perceptions (and other influences) are related to students' decisions about whether to participate in co-ops. This study also examines current co-op students' experiences, including identified benefits and drawbacks of co-op participation. Eight African American, Latinx, and Pacific Islander engineering students (three co-op, one applicant, and four non-co-op) were interviewed about their co-op perceptions and experiences. Both co-op and non-co-op students highlighted depth of experience as a strong benefit of co-ops. Students differed in their decisions about whether to pursue co-ops based on how they ranked the relative significance of the characteristics of co-ops and internships. Students described how minority engineering organizations provided them with information about co-ops and influenced their expectations and decisions.

Research findings could help inform institutions, offices of professional practice, and student advisors on how to describe the benefits of co-op participation and address potential student concerns. The findings suggest that minority organizations play a key role in providing information and influencing students' decisions. University programs and advisors can help students make informed decisions about undergraduate work experiences by understanding the sources and types of information that students seek and value. This work also contributes to broader understanding in engineering around the potential role of co-ops in efforts to broaden participation and increase retention of underrepresented minority students in the engineering profession.

Introduction

Despite numerous calls to increase diversity and inclusion in the Science, Technology, Engineering, and Mathematics (STEM) workforce, African American, Latinx, Native American, and Pacific Islander engineering graduates remain significantly underrepresented in engineering [1]. Progress in increasing the retention and persistence of underrepresented populations in engineering degree programs and the engineering workforce has been slow [2]. Furthermore, even less progress has been made in diversifying the engineering workforce, with marginal change in the proportion of underrepresented minority engineers in the workforce in recent decades [3], [4]. To address problems of diversification and retention in the STEM workforce, we must explore potential mechanisms to support these aims.

The transition from college to the workforce is a critical period for retaining a diverse STEM workforce. Early retention in STEM careers is strongly influenced by employees' early career experiences and socialization [5]. Students can obtain early career work experiences and socialization through pre-graduation undergraduate work experiences. These pre-graduation work experiences expose students to the engineering workforce prior to full-time employment

and can help these students to formulate career plans and prepare for their transition to the workforce. By providing early socialization to the engineering profession, these pre-graduation work experiences may ease individuals' transitions from student to professional [6]. Thus, encouraging pre-graduation work experience for students may help contribute to higher retention in the STEM workforce.

One form of pre-graduation work experience, cooperative education (co-op), has demonstrated academic and employment benefits for student participants [7]–[9]. Co-op participants alternate school semesters and work sessions with the same employer. Through multiple work sessions, they can build their professional networks and clarify their career preferences. Students who complete co-ops are more likely to obtain an engineering job post-graduation and receive relatively higher starting salaries than students who do not participate in co-ops [10]. These positive career outcomes suggest a promising pathway to broaden participation and diversity in the engineering profession. However, underrepresented minority students are less likely to participate in co-ops than white students, even when controlling for other demographic and academic motivating factors [10]. Low participation rates keep some underrepresented students from potentially benefitting from co-ops for professional mentorship opportunities and socialization, which are also linked to increased retention in engineering. Thus, it is important to understand how underrepresented minority students navigate educational decisions about whether to pursue co-ops, including what influences their decision-making processes, to best serve these students and prepare them for STEM employment.

Literature review

Outcomes of co-op participation

Co-op participants gain both academic and employment benefits from the practical knowledge and work experience provided by co-op participation. Co-op students have, on average, higher GPAs and are more likely to graduate in engineering than students who do not participate in co-ops [8], [11]. Furthermore, co-op students experience positive gains in employment outcomes, including positive mentoring relationships, socialization into the engineering profession, and higher post-graduation starting salaries than students who do not participate in co-ops [7], [8], [12], [13]. Studies measuring outcomes related to co-op participation consistently affirm the value of this experience.

Qualitative studies of students' perceived co-op experiences also confirm the positive effects of co-ops. One study of underrepresented minority engineering students who completed either co-ops or internships found that these students reported positive learning gains from their "actual work in the field," which students further described positively as "authentic" [14]. These workplace experiences helped students connect their coursework with engineering practice [13], [15]. These connections in turn can promote engineering persistence and clarify students' career intentions. Students indicated that their primary reason for pursuing co-ops or internships is future employment, describing these experiences as providing "real world" experience and also increasing their employability [16]. Like students, early career engineers felt that their co-op experience prepared them for full-time employment and eased the transition from student to professional [6]. These positively described experiences suggest that co-ops could provide a

pathway to broaden participation and diversity in the engineering profession. Yet, underrepresented student populations are less likely than majority peers to participate in co-ops [10]. Additional research is needed to understand these differences in participation rates and how co-ops might contribute to broadening participation of underrepresented populations in engineering.

Students' decisions about whether to participate in co-ops

In previous studies, students have provided several reasons for not participating in co-ops. Students primarily cited extended time to graduation as a reason for not pursuing co-ops [9], [15]. Some students also indicated not wanting to miss opportunities on campus or a preference for internships over co-ops [9]. Internships are an alternative work experience that many students consider in their decision about whether to pursue co-ops. Internships are typically single-term work experiences completed during the summer term. They are often shorter than a co-op term since they are often completed during the summer term (10-12 weeks) as opposed to a fall or spring term (16 weeks). Internships also do not guarantee multiple rotations of work experience. Previous research has largely considered co-op and internship experiences independently (without comparison) or in aggregate (i.e., combining students who have participated in co-ops and/or internships in their analysis). Such approaches do not compare students' preferences for internships or for co-ops, or their reasons for choosing between them. We address this distinction in our study to provide further understanding about how students conceptualize their choices about pre-graduation work experience.

When making decisions about education and pre-professional development, such as whether to participate in a co-op, some underrepresented minority students may seek information or guidance from minority engineering programs. Universities have established these programs to improve the recruitment and retention of historically underrepresented students in engineering. Lee and Matusovich [17] conceptualized the role of minority engineering programs as Engineering Student Support Centers (ESSCs) that provide assistance to underrepresented engineering students. They provided a model of these programs and interventions that illustrates the role of the programs in supporting minority engineering students, including providing faculty/staff and peer group interaction and professional development. They found that ESSCs can influence students' professional development by disseminating information about career opportunities, including internships, co-ops, and full-time jobs. Students perceived these support centers as sources of help, positioning, connections, and development [18]. In the context of decisions about pursuing co-ops, these centers can support students' decisions by providing helpful information and guidance through programs and networks.

Our study extends the literature by examining what underrepresented minority students consider when deciding whether to participate in a co-op and who influences their decisions. We explore the benefits and disadvantages students identify when deciding between different potential pre-graduation work experiences (internship or co-op). This comparison between co-ops and internships adds depth to our understanding of how students perceive pre-graduate work experiences and of how they decide which experiences to pursue for professional development.

Research questions

The following research questions guided our exploration of underrepresented minority engineering students' experiences and perceptions of co-ops:

> RQ1: How do underrepresented minority engineering students perceive the benefits and drawbacks of co-op participation?
>
> RQ2: What reasons do these students give for choosing to not pursue co-op participation?
>
> RQ3: Who/what influences their decision about whether to pursue co-op participation?

Methods

Data collection

We conducted this study as part of a larger study in which we interviewed students about their perceptions of co-ops and experiences in co-ops. Our research team comprised two graduate students and one faculty member. We conducted interviews at a large Midwestern research university with a voluntary co-op program that offers three-session and five-session options. The program serves over 1,100 students with more than 300 active employers from industry and government agencies. The institutional review board at this institution approved our study. We interviewed eight underrepresented minority engineering students about their perceptions of co-ops and experiences in co-ops (see Table 1). Students ranged from first year to fourth/fifth year at the time of the interviews, including students from a variety of engineering majors. One student was in the process of applying for co-op positions at the time of interview with us and is labeled as Applicant in Table 1.

We recruited students through a survey emailed to undergraduate engineering students who had completed the second course of the foundational engineering sequence. The survey gathered information to identify students in the following categories: current co-op participants; students interested in co-ops but not participating; and students not interested in co-ops. Survey participants responded to closed- and open-ended response questions about their perceptions of co-ops, experiences in the process of pursuing co-op placement, and demographic information. Upon completion of the survey, participants were invited to express interest in a follow-up interview to discuss their decisions about co-ops and experiences with co-ops. We followed up with all students who responded positively to this invitation to schedule an interview. We also recruited additional students to interview through snowball sampling.

We conducted a semi-structured interview with each student. Each interview lasted 30-60 minutes. To ensure quality in the interview process, we followed an interview protocol, which the research team had developed and piloted with 10 students. The interviews were guided by questions about the students' perceptions of co-ops and experiences in co-ops. Specific questions asked when students first learned about the co-op program, what they had heard about co-ops from others, what influence this information had on their decision, what other factors influenced their decision to pursue co-op participation, and what they perceived to be the benefits and

drawbacks of co-ops. We developed the interview questions based on preliminary findings from the students' survey responses and quantitative analysis we conducted as part of the broader study. We also used probing questions to encourage students to elaborate on their responses. We had the interviews transcribed and then checked the transcriptions for accuracy.

Data analysis

We analyzed the interview transcripts using a thematic analysis approach, following Braun and Clark [18]. We first read the interview transcripts for familiarity, recording memos with summaries, notes, and relevant quotations for each student. We generated a list of questions to guide the coding process (e.g., what did the student mention about family/friends/finances; why was the student interested in co-op; why was the student not interested in co-op; what barriers, difficulties, or challenges did the student mention associated with the co-op application process or participation in co-op; what benefits of co-op did the student mention). These questions were guided by literature examining students' perceptions of co-ops [9]. We then read each transcript and created matrices of relevant quotations in response to each question. We reviewed these matrices iteratively, memoing notes on emerging themes. These themes included how students compared co-ops and internships, and the role of peers, family, and minority student organizations in their decisions about whether to pursue co-op participation. We coded each transcript according to the emerging themes. We further refined the themes through iterative writing, reviewing transcripts and quotations, and discussing emerging findings with other researchers to ensure trustworthiness of the data and results. We met frequently to debrief and discuss the analysis and emerging findings and maintained ongoing engagement with the data. We relied on the participants' own words in describing themes to retain the participants' meaning.

Results

In analyzing our participants' descriptions of co-ops and their process of deciding whether to pursue co-op participation, we explored their experiences and sources of influence in considering educational decisions. We found that, notably, both co-op students and non-co-op students described similarly the characteristics of co-ops and emphasized the importance of supplementing their coursework with some form of engineering-related work experience. Students often expressed their decisions about co-op participation as a comparison of co-op and internship opportunities.

RQ1: How do students perceive the benefits and drawbacks of co-op participation?

A. Both co-op and non-co-op students positively perceive co-op participation as providing in-depth experience.

Both co-op and non-co-op students described the depth of experience gained through co-op participation as one of its primary benefits. The students attributed this depth of experience both to the length of the co-op terms and to the multiple rotations with the same company. They described how this structure of co-op terms allowed students to become "immersed" in the co-op company and to learn more from in-depth projects. For example, Chris, a first-year engineering

student, wanted to "get more of an in-depth experience" and thus chose to pursue a co-op rather than an internship. He said, "I feel like a more in-depth knowledge of what the company does, and then being able to integrate into that company is more beneficial than working for three companies in internships." He emphasized the benefit of multiple experiences with the same company.

Table 1. Study Participants

	Pseudonym	**Description**	**Reasons interested in co-op**	**Reasons not interested**
Co-op Student	Mariana	Latina Female Mechanical	Pay during co-op Long-term career benefits Commitment to company	
	Elizabeth	Latina Female Electrical	Co-op to fulfill requirement of international study program Stability	Extending graduation Missing out on campus
	Matt	Other Male Chemical	Easier to obtain co-op than internship as sophomore	Extending graduation Missing out on campus
Applicant	Chris	Pacific Islander/White Male First Year	Easier integration into company post-graduation Depth of experience	
Non-co-op Student	Emma	Latina Female Mechanical		Preference for internships Commitment (not sure where she wants to work) Extending graduation Missing out on campus
	Kayla	African American Female First Year	Easier integration into company post-graduation Depth of experience	Preference for internships Extending graduation Difficulty of co-op schedule as student athlete
	Brandon	African American Male Civil		Preference for internships Commitment (not sure where he wants to work)
	Daniel	Latino Male Material Science		Preference for internships or research Missing out on campus Length of co-op term

Emma, a Latina mechanical engineering student, shared a similar perspective of co-ops and the benefits that a co-op would provide over internships, even though she chose to pursue internships rather than a co-op. She described how a student can get "immersed into a company" through a co-op: "Co-ops would be really good for getting immersed into a company and learning different positions, learning the actual culture of a company, where you couldn't get that in a two- or three-month internship." Her response echoed those of other students who described co-ops as providing opportunities for greater immersion into a company and a greater depth of project experience. Emma also said, "You get more actual experience [in co-ops] and might actually have projects that you finish throughout the time you were there." Students strongly valued pre-graduation work experience and found these attributes of deeper experience attractive.

Both co-op and non-co-op students viewed pre-graduation work experience as necessary preparation for their future careers. Students said that this work experience made them more employable and prepared them to transition into their first job post-graduation. Kayla, an African American first-year engineering student, viewed pre-graduation work experience as preparation for future work. She said that mentors in her high school "[encouraged] us to do co-ops to get company experience and exposure to the job." She felt that only taking courses as a student without supplementing them with work experience "doesn't really equip you for being in the engineering atmosphere in industry." She said, "It's good to have pre-exposure before you get your degree and you don't know what to do [as a newly hired engineer]." She appreciated how co-ops provided this pre-exposure to engineering work. Brandon, an African American civil engineering student, also attributed his initial interest in the co-op program to the benefits of the work experience it provided: "I felt like it would really prepare me for after graduation – having the best education that I could have gotten along with some work experience. So it would have made me more marketable to other employers." Brandon continued to affirm this value of the co-op experience, even though he chose to pursue internships rather than a co-op. Students agreed that the greatest benefit of a co-op was the greater level of work experience that it provided in comparison to internships.

Co-op students further described how getting more pre-graduation work experience through co-op participation contributed to their future career goals by developing them into "better," more-experienced engineers. Matt, a chemical engineering student, linked the value of his co-op experience to his future career plans and employability: "The benefits [of a co-op] are that you get a lot more time in industry as opposed to an internship or not getting any industry experience. I'd say employers are much more likely to hire another co-op student." He said that having more experience as a co-op student would allow him to "walk in as a full-time hire and really know what I'm doing and advance quickly." He chose to participate in a co-op to support his career goals and emphasized the career benefits of participating in a co-op.

Mariana, a Latina mechanical engineering student, described further the benefits of her experiences as a co-op student: "It makes me a better engineer because I don't have to retrain myself in the systems, in the culture…once you're a co-op and you're starting your third rotation you're like, 'I definitely got this. I know how to do this.'" She described how her co-op experiences helped her better navigate her education to prepare for future work by "seeing which role could I take next, where can I grow, how can I tailor my classes to suit what I want to pursue." She said, "So definitely having that exposure makes me pursue those courses that make

me more employable, a more valuable employee, and also give me the tools that once I'm in the job that I know what to do." Similar to other co-op students, Mariana valued the professional and technical skills she gained through her in-depth experiences as a co-op student. Students linked co-op's depth of experience to the commitment of multiple co-op rotations, which are also longer than internships. Students varied in perceiving this commitment as either a benefit or a drawback of co-ops. Their perceptions of the commitment of a co-op is explored in the following theme.

B. Co-op and non-co-op students describe similarly the characteristics and distinctions of co-ops and internships – co-ops are associated with "commitment," and internships are described as "flexible."

Several students' decisions about whether to pursue a co-op rested on their preference between the perceived commitment of co-ops and the perceived flexibility of internships. Students perceived internships to be more flexible in time, position, and the potential to pursue different career options. The commitment of co-ops was described by students who were interested in them as "having a stronger relationship [with the company]," "building a history with that company," "building company loyalty," and "security in long-term commitment." Chris said,

> I prefer co-op instead of internship because you get to work with one company several different times. So you build a history with that company, and then after graduation you get to integrate into that company, whereas [in an] internship you get more companies to work with, so you get a broader scope, but you don't have those long-term connections with a company.

Chris felt that the commitment of a co-op provided benefits both as a path to a job post-graduation and, subsequently, easier transition and integration into that job because of prior experience.

Similarly, Mariana described "the benefits of adding up your time with a company." She listed job security as her top perceived benefit of a co-op:

> I also wanted the security of being able to go back to a company without having to go through the process of interviews…. I wanted to have the long-term commitment… the co-op program was [a better fit] of what I wanted to do and how I saw myself in terms of growing with a company…putting in the time to get to know a company, that company putting in time to get to know you. That's huge. I feel it makes you a better engineer, it makes you a better employee because you build that company loyalty for a long period of time.

Mariana felt that committing to multiple experiences with the same company helped her "grow" with that company and become a better employee. Elizabeth, a Latina electrical engineering student, also viewed the commitment of a co-op as a benefit and said that it gave her the freedom to devote her energy to professional development: "It gives you so much freedom. I haven't gone to IR in maybe two or maybe one rounds just because right now I already have it all lined up…. While everyone else was trying to find jobs, I'm getting experience…I already have an offer basically every semester and then I can just work on other soft skills while I'm working…. So

that sounds like a win-win to me." Non-co-op students also associated a co-op with commitment, but they described this commitment in different terms from co-op students, as the following section explores.

RQ2: What reasons do students give for not pursuing co-op participation?

A. While non-co-op students list characteristics of co-ops and internships in similar ways as co-op students, non-co-op students rank differently the desirability of these characteristics.

In contrast to their co-op peers who viewed the commitment of a co-op as a strong benefit, students who preferred internships often associated the commitment of a co-op with the potential of being "stuck" in a role or company they would not like. They preferred internships and the perceived benefit of being able to "explore" their potential interests through internships. Brandon was initially interested in co-ops but decided to pursue internships instead because he feared getting matched with a co-op that he would end up not liking: "I feel like a co-op would kind of leave me trapped in something that if I didn't end up liking it, it's like, 'Aw, I'm kind of trapped'…with internships you want to get more exposure – like two different companies – just to see where you stand in terms of what you want to do." In contrast to how other students ascribed benefits to the commitment of a co-op, Brandon feared potential drawbacks of this commitment if he did not like the work.

Emma also preferred internships because of their flexibility in letting her explore various interests: "I like the internships because I was able to go to different internships at different companies and decide which one I like better… That helped me decide for my career, whereas [in a co-op] you just get immersed into one specific company and you don't really know what else is out there." She perceived the co-op program to be a fixed path, while internships gave her more choice in her future career: "[With an internship] you basically decide where you want to go – what kind of internship you want and then what kind of career you want." Students who felt unsure about their future career directions emphasized the perceived flexibility of internships as a significant consideration in their decision between co-op and internship opportunities.

Students expanded on this distinction between co-op commitment and internship flexibility, noting a perceived certainty of co-op students, who "knew what they wanted" in terms of future jobs from the beginning of their time in college. Emma said,

> [Co-op is] a lot more commitment to that company… I feel like [co-op students] want to do that job forever. I don't know if it's forever, but that's what they want to get a full-time job from…I feel like they're a lot more focused from the beginning – from freshman year.

She contrasted herself to these students by describing her relative uncertainty about future career plans as a freshman. She said that her uncertainty contributed to her choice not to pursue a co-op "because I didn't really know what I wanted." Sharing Emma's uncertainty around career plans, Brandon also viewed himself as "more of an internship-type person": "after looking into [the co-

op program] a little bit more I feel like I'm more of an internship-type person because I don't exactly know what I want to do…. I feel like my biggest [reason not to pursue a co-op] is I didn't know exactly what I wanted to do coming into college." He explained, "Figuring out which [engineering discipline] I wanted to stick with was one of the first things I had to do before I started even looking into what I wanted to do in terms of co-ops or internships." Since he did not enter college with this decision certain, he felt that a co-op was not an option for him.

B. Both co-op and non-co-op students expressed a desire to graduate in four years, often financially motivated, which created a barrier to co-op participation.

Many students said they felt a "need" to graduate in four years. Some were motivated by finances, while others perceived a time expectation from others in their family or at the university. These students talked about getting over the "stigma" of lengthening time to graduation in order to pursue a co-op. Daniel, a Latino material science engineering student, said, "I thought [a co-op] sounded interesting, but I am more interested in internships because I really like the idea of staying on the four-year track…. I might have been misguided but I just liked that idea…. I'd say that was the most major [reason not to pursue a co-op] for sure." Kayla said that she felt pressure to finish college in four years from advisors on campus. She was currently pursuing internships but was starting to consider a co-op.

> I think a co-op would probably be really good for me because now that I've gotten over the stigma of "You have to get out in four years"…. [On orientation day] all of the advisors were like, "Get out in four years. You shouldn't do a co-op because it lengthens [time to graduation]…." But everyone is on their own journey so you've kind of just got to listen to them but not let it really get to you.

She connected the advisors' advice to financial considerations, saying, "I think they were just trying to scare us with loans." Other students described similar experiences of being strongly persuaded to graduate in four years because of the cost of college. However, few non-co-op students mentioned the financial benefits of co-op participation.

Even co-op students described initial perceptions of co-ops having financial drawbacks with respect to lengthening time to graduation. However, they also described later changes in perspective, recognizing the financial benefits of being paid during co-op rotations. Matt's father discouraged him from considering a co-op because co-op participation lengthened time to graduation. Matt said, "My dad's main argument against it was, 'Why don't you just graduate a year early and earn a salary?" However, Matt later said that a benefit of a co-op was getting paid while in school. Elizabeth felt the pressure of loans and did not want to participate in a co-op initially because she wanted to graduate as soon as possible:

> When I first got to school, everyone was like, "You're going to graduate in four years." That's what you have to do…. Overall, I ended up extending one semester [because of co-op participation] which is not bad, but at that moment to me it just sounded like you're going to have to pay more and you're going to never get that degree, you're spending so much time before you even start being able to pay those loans.

Elizabeth received her co-op offer after an interview that she thought was for an internship. She described how she initially did not want to accept the offer because of financial concerns related to extending her time to graduation: "I went to my advisor and talked to her and was like, 'I just really don't want to be a co-op student. I don't want to have to extend extra semesters. I just want to graduate in [four years] and be done. I want to have my work experience, but I don't want to have to move my graduation date, especially because…at the time I didn't realize that it's not that you're paying for more semesters." Elizabeth eventually came to appreciate the pay from the co-op when she realized that she could use that money to start paying off her loans before graduation; however, she did not originally perceive co-ops in this way. These quotations raise questions about the sources of information that influence students' knowledge and perceptions of co-ops.

RQ3: Who/what influence students' decisions about whether to pursue co-op participation?

A. Students primarily viewed families as supportive, but not influential, in their educational decisions.

Students described families as being "supportive," though not influential, in their decisions about whether to pursue co-op participation. Emma said that she had to make decisions herself because her family was not familiar with choices related to higher education and her future career. She emphasized her first-generation college student status when describing how she navigated various educational decisions, including co-op participation. She said,

> I'm a first-generation American I guess, so my parents never went to college. It was always what I wanted to do. My parents never pushed me into doing it or anything… everything I did was for myself, I guess. So when I decided I wanted to go to college, that was my own choice…even internships –my parents don't know what that is. I decided I wanted to look for one myself and I wanted to get that experience myself because it wasn't like my family was pressuring me into getting a job or anything.

Emma said that the decision between co-ops and internships was "my own choice." Accordingly, she sought sources of information outside her family when considering whether to pursue a co-op. She viewed internships as a pathway to "help me decide [a direction] for my career" and used this opportunity independently to help "figure out" a career path.

In contrast to Emma, Elizabeth described her family as more knowledgeable about college and engineering; however, she also emphasized that their role was primarily supportive rather than influential in her choices. Elizabeth's father, an engineer, introduced her to engineering. She said,

> He showed me that he loves his job…. I grew up seeing him talking to me about projects that he was in and him telling me about what it was like being in a plant or what it was like with the circuitry problems that he was having…. I grew up knowing how much voltage comes out of your wall, that was a basic in my household.

However, she emphasized that her father did not overtly influence her decisions and that he supported what she chose. Her father was not familiar with co-ops, and Elizabeth described telling him about the program:

> [W]hen I told him I was like, "Hey, I'm kind of considering joining a program where instead of me just running a marathon of just studying for four years and then graduate and then seeking jobs, I can kind of start putting in some job rotations in that marathon, extend it a little bit and then graduate with already at the very least one job offer"…. I pitched it to him and my dad is just like, "Sure! That sounds like a great idea!" And he's super supportive of it or whatnot and so it was really nice that he gave me the freedom for me to realize that that's what I really wanted.

Other students described the support of their family in similar ways. Like Elizabeth, Daniel said his family supported his educational decisions. His mother was a professor in a non-engineering discipline. When asked about her influence on his decisions in college, Daniel said, "She was very open to me just doing what I wanted to do because she knew that I would do something that was productive." Matt's family was more involved in asking him about his decision to participate in a co-op; though, Matt said that they did not influence his decision. Yet, Matt also said that he called his family after accepting his offer because he was anxious about the decision. He said, "I was kind of nervous [about preparing for the co-op] so I did talk with my parents about my decision. I informed them why I chose it and why I thought it was a good idea." Matt's father initially questioned the value of co-op participation because it lengthened Matt's time to graduation, but he eventually became supportive. Matt said that his father told him, "I don't know much about this program or this field, but if you think that's what's best for your career, go ahead." Matt reiterated that his decision to participate in the co-op was his own, and concluded, "I'd say whether my parents were supportive or not of my decision didn't really play too much of a factor, because ultimately I knew what was best for me." These quotations illustrate that, while families are described as having different levels of involvement in students' educational experiences, students largely do not view them as influential sources of information in their educational decision making.

B. Students viewed minority engineering organizations and programs as useful sources of information, providing access to knowledgeable networks of relatable upperclassmen.

Minority engineering organizations and programs provided students both information and informal networks of staff and peers who shaped their perceptions. Several students listed these organizations and programs as authoritative sources of information on co-ops. For example, Chris said that "MEP [the Minority Engineering Program] was the one that brought my eyes to [co-ops]…the MEP program helped to guide me in my research, and [the students in this program] had a lot of knowledge because a lot of them have done co-ops." He further described the value of the information he received from MEP: "I had more of a direct guidance of where to look and research the difference between [co-op and internship], and I think that helped to formulate an idea of what co-ops are and that they were better for me." Other students also said that they had learned about the co-op program through MEP or one of its programs.

Additionally, these programs provided networks for students to gain information from relatable upperclassmen. Mariana chose a co-op because of a conversation she had had with an older student through one of these organizations:

> Seeing how [the older student] talked and how she was so very well structured not only as a person but also as an engineer was a seller for me to just get engaged in the co-op program. Seeing her as the outcome after five years – I want to be there after five years. I can see myself. I want to be that person.

Mariana and other students looked to upperclassmen as role models for their educational and pre-professional development decisions.

Kayla also looked to upperclassmen as sources of information about possible college experiences. She said that she learned about co-ops through an MEP program. When asked who influenced her decision not to pursue a co-op, Kayla replied, "Mainly upperclassmen. So most of the people who have been here for a little bit, so they know how the game goes. I tend to listen to them." She received varied advice from these students, including both encouragement to pursue a co-op because it provided "really good work experience" and suggestions to "just stick to internships" because co-op participation lengthens time to graduation. After describing this advice, Kayla said, "Everyone is on a different journey…. Some people are just here to get out in four years and that's it. Other people, maybe they didn't do well in a couple classes and want to retake them so they can know the material better and be more equipped for their job." Kayla considered these older students' perspectives and decided which path she felt best fit her needs. She had obtained an internship for the coming summer but remained open to potentially pursuing a co-op in the future. Brandon also asked older students in MEP about co-ops. He was particularly influenced by one student's negative experience: "Talking to people in the Minority Engineering Program that have gone through co-ops, they say it's really hard when you're in a co-op and then, 'Oh gosh,' and you don't like it any more…. I have a friend…[who] realized after the first rotation that he didn't like [his co-op] and he was stuck…. And that's just something that I don't want to get to." Each of the students' expectations was strongly influenced by their perceptions of older students' co-op experiences.

Classmates also shaped students' understanding of and perceptions about the co-op program. Students looked to various peers who had had experiences in co-ops or internships to provide authentic perspectives. Matt was initially uninterested in the program but said that he began to consider the program when "towards the end of my freshmen year, I had some friends who were co-oping. They really enjoyed it and spoke very highly of it." He ultimately chose the co-op after hearing about a classmate's experience in the program: "My lab partner was a co-op student. He told me all about his experiences. I'd say that's when I decided I was going to co-op." Matt said,

> [Other students] played a very big role in all my decisions. I think it's a lot easier to take advice from students, because you know students don't really have a motive. They just want to share their experiences. They're not trying to convince you of anything. I'd definitely say that other students…had a very large role in pushing me to [pursue the co-op].

Students sought out peers to inform expectations about their options. In describing his process to learn more about the co-op experience, Chris said that he "talked to co-op and internship students who explained why they did a co-op versus why they did an internship, and basically their thought process on which one they liked better." Students relied on peers as perceived trustworthy sources of information on potential options.

Discussion

Our study examined how underrepresented minority engineering students perceive co-ops and what influences their decisions about whether to participate in a co-op. We investigated the sources of influence on these students' decisions and what they consider in their decision about whether to participate in a co-op. Our emphasis on the experiences of underrepresented minority engineering students extends previous research on co-ops, by providing a preliminary examination of unique characteristics of these students' experiences. These findings help identify how university programs and advisors can better serve underrepresented minority students in navigating decisions about pre-graduation work experience.

Both co-op students and non-co-op students emphasized the importance of work experience prior to graduation and described how they decided whether a co-op would fit their specific needs. The perceived benefits and drawbacks of co-ops were largely consistent with those identified in previous work on students from majority backgrounds [9]. Consistent with previous studies, students in our study perceived work experience to be the greatest benefit of co-op participation, including associated increases in perceived employability. Additionally, students perceived a drawback in extending time to graduation, and non-co-op students described a preference for internships rather than a co-op. This study extends previous findings by exploring how students describe the benefit of work experience in a co-op (e.g., in-depth project experience, immersion in company culture, exposure to engineering in industry). Additionally, we explore how students distinguish between the benefits of co-ops and those of internships.

When students were asked how they decided between co-op and internship opportunities, their responses suggest that some students perceive co-op participation to require a level of career certainty. Non-co-op students described themselves "internship-type people" since they wanted to explore different career options. Our findings also differ from previous studies in how students describe (and in some cases, do not mention) financial aspects of co-op participation. Previous studies have found that co-op students perceive money earned during co-op participation to be one of its top benefits, following the value of work experience [9]. Yet, in our interviews, most students did not mention money in describing their considerations about whether to pursue a co-op. Rather, students primarily mentioned finances only in the context of concerns about extending time to graduation. Future work could further explore students' perceptions of the financial aspect of decisions about co-ops, including whether these differences stem from differences in how co-op students and non-co-op students perceive co-ops and what information students receive that inform their financial considerations about co-op participation.

Our findings suggest that minority organizations serve a unique role in providing students information about co-ops. For example, co-op students emphasized the influence of upperclassmen and other peers whom they met through these programs. They also said that

information received through these programs informed and influenced their decisions to pursue a co-op. These findings are consistent with previous studies on minority engineering programs as valued sources of information and guidance [17]. Future work in this area could explore how these programs provide pathways to co-op participation, including additional detail about what kinds of programs students find most helpful in informing educational decisions and how students connect with upperclassmen.

Limitations

In investigating why underrepresented students might participate in co-ops at lower rates than their majority peers, we cannot directly compare the perceptions of minority and majority students since this study examined minority students' perceptions of co-ops specifically. We will analyze our interviews with students from racial majority backgrounds in future work for comparative analysis.

Conclusions and implications

Students face complex decisions in choosing how to navigate pre-professional development opportunities, including co-op participation. This study highlights various considerations that factor into underrepresented minority engineering students' decisions about co-op participation, providing insight into how these students distinguish between pre-graduation work experiences (co-ops and internships) and what information influences their decisions. Our results highlight how minority organizations play a key role in providing information and influencing students' decisions.

Our findings could help inform institutions, offices of professional practice, and student advisors in how to convey the benefits of co-op participation and help students navigate these decisions. University programs and advisors can help students make informed decisions about undergraduate work experiences by understanding the sources and types of information students seek and value. By recognizing how students consider educational and pre-professional development decisions, educators can better inform and serve a diversifying engineering student body to grow and achieve career goals. Informed decisions and involvement in pre-professional work experiences could support students in early career socialization and in developing career plans. Thus, efforts to support students in pursuing these experiences could further contribute to diversifying the engineering workforce through greater retention of underrepresented minority engineers.

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