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Abstract

A cooperative education program (co-op) in engineering is a partnership between an academic institution and an employer designed to engage students in practical engineering experience through rotations of full-time employment and course study. Co-op employment provides students with multiple benefits, including discipline-relevant professional experience, financial support, and early entry into the engineering labor force while serving as a recruitment tool for co-op companies. Using a mixed-methods approach, this study identifies factors that are associated with student participation in co-ops. The data comprising over 52,000 students from six institutions across 23 years were analyzed using logit regression. While women are as likely to participate in co-ops as men, Asian and Black engineering students are 22% less likely to participate than their peers. The qualitative inquiry entailed 10 student interviews focusing on the reasons why the students decided not to complete the co-op application process, despite their initial interest. The primary reasons were interest in other extracurricular activities and the seemingly lengthy time commitment associated with co-ops (3-5 semesters). Research findings have the potential to be applied toward the development of strategies to further enhance co-op recruitment and engagement of engineering students from a broader range of backgrounds, interests, and experiences as a pathway to potentially increase the overall diversity of the professional engineering labor force.

Introduction and Background

Cooperative education programs (co-ops) in engineering are designed to provide students with professional experience relevant to their academic discipline in alternating cycles between paid full-time employment and traditional full-time classroom education. Co-ops are work opportunities for undergraduate students organized in partnership with industry based organizations,[1] which can also be referred to as Work-Integrated Learning (WIL).[2-3] There are several associated benefits to students who participate in co-ops, including higher academic grades and higher graduation probabilities, as well as discipline-relevant professional experience, financial support, and early entry into the engineering labor force.[4-10] Therefore, co-op participation may be an effective method for improving the academic and employment outcomes of engineering students.

While the literature on the potential benefits of co-op participation is robust, few researchers have examined what factors influence co-op participation and why some students decide not to participate. Understanding the factors that influence student co-op participation is therefore important because relative increases in college persistence and greater engagement in the engineering labor market can help toward meeting the nation's growing demand for a larger engineering labor force and to maintain the nation's competitiveness in technological and scientific areas. Thus, we conducted a mixed-methods study to (1) identify student characteristics that are associated with participation in co-ops disaggregated by engineering discipline, and (2) examine why some students choose not to participate in co-ops and whether they perceive barriers to participation.

Our findings have the potential to help students, co-op administrators, and employers further assess the conditions that encourage student participation in co-ops. Since we also focus on differences in participation by gender and race/ethnicity, our findings can also be applied to developing strategies to further enhance co-op recruitment and engagement of engineering students from a broader range of backgrounds, interests, and experiences as a pathway to potentially increase the overall diversity of the professional engineering labor force.

Data and Methods: A Mixed-Methods Approach

To identify factors associated with students' probability of participating in co-ops, we analyzed comprehensive, longitudinal academic student records from six institutions that comprise the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). MIDFIELD includes 23 years of student demographic and transcript data from 1987 through 2009. Our sample is limited to institutions offering voluntary co-ops, and to engineering majors that are offered across multiple institutions: Aerospace, Chemical, Civil, Computer, Electrical, Industrial and Systems, and Mechanical engineering. To account for the variation in eligibility and program requirements across academic institutions, only students who meet the minimum co-op eligibility requirements at their respective institution, who were enrolled in an engineering major at the end of second semester, and who were not transfer students were included in the sample. The resulting dataset includes 52,070 students, of whom 15,771 participated in co-ops. Table 1 summarizes the characteristics of the sample.

We applied logistic regression models to estimate the probability of whether or not engineering students will participate in their institution's co-op program. The full statistical model (equation 1) includes institution, start year, race/ethnicity, cumulative grade point average (GPA) at the end of the second semester, peer economic status, high school GPA, gender, and declared major.

$$\begin{aligned} log(co-op) = {} & \beta_0 + \beta_1 * (institution) + \beta_2 (startyear) + \beta_3 * (ethnicity) + \\ & \beta_4 (gender) + \beta_5 (ethnicity) \times (gender) + \\ & \beta_6 * (semester2GPA) + \\ & \beta_7 * (PES) + \beta_8 \times (HSGPA) + \\ & \beta_9 (semester2major) \end{aligned} \quad (1)$$

TABLE I. PERCENT COMPOSITION OF CO-OP PARTICIPANTS AND NON-PARTICIPANTS BY RACE AND GENDER.

Ethnicity/Gender	**Co-op participant**	**Non-participant**
White	84.4%	77.2%
Asian	7.2%	8.9%
Black	3.3%	5.0%
International	2.2%	3.2%
Hispanic	2.1%	4.1%
Other	0.7%	1.4%
Native American	0.2%	0.3%
Male	78.8%	81.7%
Female	21.2%	18.3%
Number of observations	15,771	36,299

We followed our quantitative analysis with semi-structured interviews of engineering students who decided not to pursue the co-op application process despite demonstrating an initial interest, measured by their attendance at a recruiting event or information session. The interview participants were recruited from one of the MIDFIELD institutions based on administrative records provided by the office overseeing the co-op program. We interviewed a total of 10 students (7 male; 3 female) who attended a co-op information event and began the application process, but did not submit a completed application.

Although we used a structured interview protocol to focus on factors that influenced students' decisions regarding co-op participation, we allowed room for probing questions to pursue emerging themes. The interview protocol included questions pertaining to how the students became interested in co-ops, the types of benefits they associated with co-op participation, the types of companies and work they hope to pursue, their experiences and perspectives related to the co-op information session or application process, and why they chose not to continue with the application process. We used thematic coding to analyze the resulting transcripts. Each interview transcript was analyzed by at least two researchers to increase the reliability of the findings.

Findings

Table II summarizes the results from the logistic regression on the MIDFIELD student data. We found that Asian, Black, and International students are less likely to participate in co-op programs compared to their peers. There is no statistically significant difference in the participation rates between Hispanic, Native American, and White engineering students. Although there are fewer female engineering students overall, female engineering students participate in co-ops at the same rate as male engineering students. There are differences in the rates of participation by engineering major compared to Mechanical Engineering (the omitted category). This variation is likely due to employer preferences, but may also be associated with historical and social traditions regarding student co-op participation.

We explored further the reasons for the different rates of participation using individual student interview. From our thematic coding, we identified four categories explaining non-participation: 1) interest in other extracurricular activities and internship options, 2) concerns regarding the perceived lengthy time commitment, 3) uncertainty or not well-developed plans regarding major and employment goals, and 4) minimum eligibility requirements not met. Of these categories, interest in other extracurricular activities, often in conjunction with concerns regarding the time commitment involved with co-ops, are primary reasons that students decided not to continue with the application process.

The students, in general, framed their decision-making process as a function of time—they talked about the experiences and competencies that they wanted to accomplish before graduation. They regarded co-op participation as a program that could be interchanged with many other similarly valuable experiences. To illustrate, Sam indicated:

"My biggest thing was that I wasn't guaranteed to be home for the summer probably. And I actually, over winter break, was offered an internship for the summer, so that's pretty much why I altered it."

TABLE II. LOGISTIC REGRESSION ON ODDS RATIOS OF PARTICIPATING IN CO-OP

Parameter	Odds Ratio Estimate	Standard Error
Asian	**0.786***	**0.0544**
Black	**0.769***	**0.0762**
Hispanic	0.990	0.1003
Native American	0.687	0.3220
International	**0.589***	**0.2178**
Other	**0.510***	**0.2098**
Semester 2 GPA	**2.720***	**0.0342**
PES	**0.997***	**0.0015**
Aerospace	**0.588***	**0.0782**
Agricultural/Biological	**0.152***	**0.1807**
Chemical	**0.615***	**0.0705**
Computer	**0.829***	**0.0655**
Civil	**0.672***	**0.0774**
General	**0.500***	**0.0649**
Electrical	**0.725***	**0.0685**
Environmental	**0.268***	**0.1769**
Science & Mechanics	**0.393***	**0.2762**
First-Year	0.792	0.1538
Industrial & Systems	1.020	0.0765
Materials	**0.528***	**0.1624**
Nuclear	**0.329***	**0.1884**
Textile	**0.404***	**0.1375**

R-Square	0.169	**Max-rescaled R-Square**	0.259

* $p < 0.05$ Note: institution and start year are included in the model, but not shown in the table. Among the discipline variables, Mechanical Engineering is the baseline category.

The ability to be able to stay near home during the summer and still obtain industry experience through an internship was a better option for Sam than committing to a multiple semester co-op. Like Sam, Robert considered the time commitment and weighed co-op participation against other potential activities:

> *"And one of the things that made me second guess co-op was because I'd miss an entire semester of my [service learning program] and like I could completely miss delivering the projects with not being here."*

While many of the students discussed the possibility of internships as a deterring factor, likely because it offers many of the same benefits as co-ops, some students also considered other

activities, such as conducting research. Kayla, for example, decided not to pursue co-ops, opting instead to pursue a mixture of research and industry internship experiences.

> *"But after this summer, I got into the SURF [Summer Undergraduate Research Fellowship] Program, so I'm kinda like debating whether I want to go. If I get into the co-op program my summers are like taken up 'til I graduate like I cannot do anything else. So, I'm kinda debating whether I want to stay in the co-op program or do research and finding another internship."*

A few students indicated that they were not fully prepared for the application process. Mike, for example, explained that he was unsure and this was exacerbated by not having a resume ready:

> *"I did start on the application process. … and the reason I actually didn't like end up doing co-op is really because I didn't have a resume prepared beforehand.*

Discussion

Our quantitative results demonstrate the differences in participation rates by race/ethnicity and engineering discipline; whereas our qualitative results shed some light into the reasons why students decide not to pursue co-op further. Our future work will continue to examine the relationships between co-op participation and student's academic and employment outcomes. We will also conduct more in-depth exploration of students' decision-making processes and experiences with co-op related events. Research findings have the potential to be applied toward the development of strategies to further enhance co-op recruitment and engagement of engineering students from a broader range of backgrounds, interests, and experiences as a pathway to potentially increase the overall diversity of the professional engineering labor force.

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