Academic Outcomes of Cooperative Education Participation

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Abstract

Outcomes and benefits of cooperative education (co-op) participation have been well documented; however, they have focused primarily on grade point averages (GPA) and career outcomes. Previous work on predictors of participation shows no significant differences by gender in the aggregate, but there are significant differences by ethnicity and major. One reason students may not participate in co-op is the perception of increased time to graduation; however, other benefits may outweigh the perceived limitations. This research furthers the literature by examining academic outcomes not previously considered, such as persistence in engineering and time to graduation. The work aims to answer the following questions: 1) what are the academic outcomes of co-op participation, and 2) focusing on diversity, which underrepresented groups and disciplines benefit academically from co-op participation?

This study uses a longitudinal database of engineering students across six institutions, including co-op participants and non-participants. The sample includes undergraduate students from Aerospace, Chemical, Computer, Civil, Electrical, Industrial & Systems, and Mechanical Engineering majors. Regression modeling is used to calculate the relationships between co-op and outcome variables, including whether or not a student graduated from a particular institution, persistence in engineering, and time to graduation. Results show that co-op students are more likely to graduate in engineering with higher GPAs than their non-participant counterparts, although they will take longer to graduate. The implications of this study can be used by administrators and educators to understand differences in how co-op affects diverse student populations, especially those from underrepresented groups. The research will also inform co-op program policy making.

Introduction

Since the creation of the first cooperative (co-op) education program at the University of Cincinnati in 1906, programs have been affording students the opportunity to gain industry experience before graduation. That program that would serve as one of the most widely accepted innovative teaching and instruction techniques in engineering education [1 2]. Co-op programs are partnerships between academia and industry employers who hire students for alternating semesters, usually completing three or five school/work rotations. Co-op programs thus represent a rich implementation of an experiential learning approach [3]. Students are often hired by their co-op employers after they graduate and they may benefit from higher salaries. Socialization into the industry environment, including mentoring experiences, may also be easier for co-op participants.

Although the structure of co-op programs is similar, institutions have different policies regarding eligibility requirements. Furthermore, employers may also place requirements on the students they accept. For example, an employer may be recruiting only Mechanical engineers, limiting the employment opportunities for students of other majors. It is important to understand the factors that affect co-op participation, because there are several complicating factors, including student attributes and differing program requirements. Students consider benefits and drawbacks when choosing to participate in a cooperative education program. Eligibility requirements such as student classification, grade point average, and courses completed assure that companies are receiving qualified students at their workplaces [4].

While researchers have examined career outcomes and benefits[5-7]; few have taken prior experience into account[8]. We aim to provide a comprehensive quantitative study of the association between co-op participation, student demographic and academic performance variables that are associated with graduation outcomes, guided by the following research questions:

(1) What are the academic outcomes of co-op participation?
(2) Which underrepresented groups and disciplines benefit academically from co-op participation?

This work will contribute to the body of knowledge regarding which students participate in co-op programs and the role co-op plays in their academic outcomes. A better understanding of factors that are associated with engineering students' co-op participation will be useful for various co-op stakeholders, especially administrators and employers.

Background

Academic Benefits

Students begin to experience the benefits of co-op before they graduate and begin their careers. They experience benefits to academic performance, learning outcomes, and subjective well-being [5 9]. Students who completed a three-term co-op program had higher GPA than their non-participant counterparts. Students who started a co-op, but did not complete the total required terms, also experienced this benefit [5]. Academic performance, post-graduate salary, and time-to-graduation are all significant outcomes of co-op participation. Completing the three-term co-op increased students' time-to-graduation by two terms [5], which may particularly discourage students from lower economic strata.

Aside from quantitative measures, co-op participation may affect learning and subjective well-being. Students who exhibit proactive behavior during their first co-op term experience significant impact on learning outcomes [9]. Early socialization experiences, including social and content aspects, positively affect students' non-technical skills [9 10]. Studying the effects of co-op education before graduation will help educators and administrators understand student's learning experiences, especially the non-technical skills that participants build outside of the classroom. Co-op participants show increased self-efficacy, which is beneficial in sustaining academic performance and persistence to graduation [11]. Additionally, co-ops students report greater certainty about career choice (increased career identity) and are more likely to get job related to their major at graduation. Students who persisted in STEM participated more frequently in co-op and related field experience (students who drop out spent more hours working off campus – unrelated to major) [12].

Importance of Diversity

It is well documented that ethnic minorities do not participate as often as majority students in cooperative education programs. Ethnic minority students typically come from families that earn approximately $10,000 less in annual income in comparison to the general population of students in the co-op program [4]. Enrollment of Black, Hispanic, Native American and other minorities has shown low co-op participation rates [13], even though they could potentially benefit the most. Low achieving students can benefit from co-op experiences especially during difficult job markets [4]. Research suggests that industry partners must improve co-op work environments for minority groups by improving ethical conditions [14].

One of the two most distinguishing characteristics of the engineering population is that it is "disproportionately male" [15]. While women persist in undergraduate engineering programs at the same rate as men, a lower percentage of women pursue engineering careers after graduation and those who do enter engineering careers are less likely to persist [16]. Since students with prior work experience with an employer report higher levels of interpersonal support from their mentors, and women without that experience were the least satisfied with their mentors' knowledge [17], cooperative education holds promise for encouraging women to enter and persist in engineering employment after graduation.

Career Benefits

The majority of the literature focuses on post-graduate benefits of co-op participation, emphasizing the pecuniary advantages [5 7 6]. One study finds that co-op completers earn a higher salary after graduation, while those who started but did not finish the program earn the same amount as their non-participant peers [5]. These effects hold even when taking gender, major, and prior GPA into account [8].

Some non-pecuniary benefits include socialization into the workplace and mentoring experiences that make it easier for students to transition into their careers; although, there remains a dissonance between skills obtained in the classroom and those that are used in industry [9]. The gap between academia and industry is one more reason that cooperative education programs are necessary and why it is critical that we, as educators, understand the factors that surround them.

Method

While studies have examined the academic and employment outcomes of co-op participation [5, 7], few researchers have accounted for prior academic variables in their analyses [8]. This study aims to narrow the gap between co-op outcomes and prior experiences.

Based on our research questions and the current body of knowledge, we hypothesize that:

(1) Co-op participation will increase time to graduation and cumulative GPA.

(2) There will be significant differences by engineering major, gender, and ethnicity.

The goal of this study is to determine academic outcomes of co-op participation, including the likelihood of graduating in engineering, the number of months at a student's institution, and their final cumulative GPA. One of the input variables is major discipline recorded at the end of the second semester as an indicator of when a student is eligible to apply for co-op. Other input variables include institution, year of matriculation, gender, ethnicity, high school GPA, and Peer

Economic Status (PES). These variables are selected to represent students' academic preparation before entering college and at the time they are eligible to consider co-op participation as well as their demographic backgrounds. The population is extracted as a subset of the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD).

MIDFIELD

MIDFIELD includes over twenty years of student record data from eleven partner institutions, including four of the ten largest U.S. engineering programs in terms of undergraduate enrollment. The subset of MIDFIELD contains records for 226,221 students who ever declared engineering as a major from 1988 through 2011. We include six institutions from the database in this research, selecting only those schools with significant co-op participation data (>1%). Table 1 describes each institution based on Carnegie Classifications and specific co-op program requirements. The sample selected from the population at those institutions includes students who were enrolled in an engineering major at the end of the second semester and excludes students who started their studies at another institution and are present in MIDFIELD as transfer students. Only engineering disciplines that are offered at two of more of the six institutions and have enrollment greater than zero are included in the sample. Those majors include Aerospace, Chemical, Civil, Computer, Electrical, Industrial and Systems, and Mechanical engineering. After applying these criteria, there are 52,070 engineering students remaining, of whom 15,771 participated in co-op. All students in this sample meet co-op eligibility requirements, but we do not account for the number of co-op terms or their successful completion of the co-op program. It is important to note that co-ops are non-mandatory at these institutions. Although some institutions serve non-engineering majors as well, all programs in this study accept engineering majors.

Table 1. Institution and co-op descriptions

Carnegie Classification	# Co-op Terms Required	Min. GPA and Credits Required
High undergraduate More selective Very high research activity	3 or 5	2.6 for 3-term 2.8 for 5-term Freshman
High undergraduate Selective Doctoral/research university	3	2.5 > Freshman
High undergraduate More selective Very high research activity	> 3	2.5 > 30 credit hours
Majority undergraduate More selective Very high research activity	3	2 > 1 semester
Majority undergraduate More selective Very high research activity	Not specified	2 > Freshman
High undergraduate More selective Very high research activity	> 1 pending employer agreement	2 > Freshman

The institutions are similar, but there are key differences in the requirements of each co-op program. The number of required co-op terms, minimum GPA and grade/class may contribute to significant institutional differences in co-op participation.

Academic and Demographics Variables

Using both academic and demographic variables provides a holistic view of students' background from a quantitative perspective. We include male and female engineers from Asian, Black, Hispanic, Native American, White, International, and other backgrounds. In addition to demographics, high school variables may be indicative of prior academic preparation. High school GPA is cumulative at graduation, while Peer Economic Status (PES) is a socioeconomic variable specific to MIDFIELD. It is computed as 100% minus the percentage of students at a student's high school who are eligible for free lunch. While PES does not describe a student's household economic status, it describes their educational environment, and higher PES values represent higher economic strata [18].

Post-secondary academic inputs include major discipline during the second semester. Previous MIDFIELD research shows that institution is also an important consideration based on a myriad of explanations, including policies that may vary across different institutions [19]. The academic year in which a student first matriculates to a particular institution, referred to as start year, is also taken into account. The outcome variable is whether or not a student participates or is likely to participate in a co-op program at their institution.

There are three response variables: 1) whether a student graduated in engineering, 2) duration of attendance, and 3) final GPA (at graduation or the GPA at the end of the last semester of attendance). The graduation variable is determined by a student's major at graduation. If a student graduates in any engineering discipline, they are categorized as graduating in engineering. Because of this definition, the subset of students includes those who did not graduate or graduated in a non-engineering major. The second outcome, duration of attendance, is measured in months from the time a student enters an institution to the time they leave regardless of graduating. Months attended includes work terms in which students are not on campus. It is important to include months in which students are working, because co-op programs still count students as being enrolled in school. It is also important to consider students' perceptions of time to graduation being increased by co-op participation, even if they are physically on campus for the same amount of time. We count months of attendance instead of semesters since we have multiple institutions that count terms or semesters differently. The final GPA is the cumulative GPA at the end of the last semester a student attended an institution. We are mainly focused on the relationship between co-op participation and the three outcome variables.

Descriptive Statistics

Table 2 illustrates the percentages of co-op participants and non-participants aggregated across all institutions based on ethnicity and gender. Overall, 30% of eligible engineering students participated in co-op programs from 1988 – 2009. Percentages are calculated from the number of engineers in each sub-population. International students are defined as non-domestic students; all others are domestic. For example, 7.2% of co-op participants are Asian compared to 8.9% of non-participants. While males are overrepresented in engineering, a higher proportion of co-op participants are females (21.2%) than the non-participant group (18.3%). Although the percentages in each sub-population are similar, the overall number of students is vastly different.

Table 2. Composition of co-op participants and non-participants

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/Unknown	0.7%	1.4%
Native American	0.2%	0.3%
Male	78.8%	81.7%
Female	21.2%	18.3%
Graduated	83.9%	63.5%
Average final GPA	2.73	2.57
Average PES	89.7	88.5
Number of observations	15,771	36,299

Table 3 illustrates the average time it takes for engineering majors to graduate. Note that this subset includes only those who are eligible for co-op. That may be one explanation why the overall average time to graduation is less than previously reported average six years to graduation [19]. The last column calculates the average time difference between co-op participants and their non-participant peers.

Table 3. Time to graduation by engineering major

Engineering Discipline	Co-op Participant		Non-Participant		**Δ Co-op**
	Months	Std. Dev.	Months	Std. Dev.	Months
Aerospace	52.4	14.1	46.4	16.5	**6.0**
Chemical	48.7	11.4	42.9	14.3	**5.8**
Computer	51.8	13.3	44.6	14.8	**7.2**
Civil	47.1	12.8	47.4	16.0	**-0.2**
Electrical	52.4	14.1	45.7	16.5	**6.7**
Industrial and Systems	46.1	10.8	45.0	13.7	**1.1**
Mechanical	50.3	12.5	45.6	15.0	**4.8**
Overall Average	49.8		45.4		**4.5**

*Compare to 6-year graduation (72 months)

The greatest difference is for Electrical Engineering students who take, on average, and additional 7.2 months to graduate if they participate in co-op. This average does not take into account other factors that are associated with time to graduation. We control for those factors later in the paper. The average of 4.5 months is similar to Blair et al. findings that co-op students took, on average, an additional 4.8 months to graduate [5], although there are differences in the time it takes all engineers to graduate. Blair et al. found that students took about 5 years to graduate [5], while students in our sample (Table 3) graduate closer to 4 years. Differences in co-op eligibility requirements may be one factor in the difference between the two studies.

Analysis

Analysis consists of two types of multivariate models: 1) stepwise logistic regression and 2) linear regression. The logistic regression model estimates the probability of whether students will graduate in engineering considering several demographic, academic, and co-op variables. The linear models include duration of attendance and their final cumulative GPA as response variables. The full statistical model includes co-op participation, engineering major/discipline, race/ethnicity, gender, high school GPA, PES, institution, the year of matriculation and co-op interactions. Previous research indicates that institutional differences explain a significant amount of variance among student outcomes [15 18 20], so adding other academic and background variables allows us to determine how much more variance is explained.

Since graduated in engineering is a dichotomous variable, logistic regression is favored over a linear model. Stepwise logistic regression automatically enters variables into the model that will maximize the likelihood of observing the chosen outcome (ex. graduated in engineering = Y). Duration of attendance and final cumulative GPA are continuous, so linear regression is suitable for the analysis. We use the same input variables and interactions in all three of the models. Gender and co-op participation are both binary, while ethnicity, major discipline, start year, and institution are categorical. PES and high school GPA are continuous. The β values Table 5 correspond to the maximum likelihood estimates, where β_0 is the intercept. Based on the types of predictor and outcome variables in this study, regression is the most appropriate method of analysis. Regression techniques have been used in prior cooperative education studies [5 8]. Furthermore, several researchers have used multivariate models to study the effect of co-op on post-graduation salaries [7 6].

The study has two main limitations. Missing values of high school variables reduces the sample to 20,717 students included in the regression analysis. We include those students with missing values in this paper to provide a more complete picture of who is and who is not participating in co-op. In MIDFIELD, missing high school variables are correlated with public versus private high schools; therefore, we include students with missing values. The co-op participation rate of students in the reduced sample is similar to the overall participation rate of 25%.

Results

Logistic regression shows significant, positive impacts of co-op participation on likelihood of graduating in engineering. The odds ratios in Table 4 show differences by engineering major and ethnicity. Gender differences are not statistically significant, implying that women who participate in co-op graduate in engineering at the same rate as non-co-op females. The largest difference is for Industrial and Systems Engineers who are Black and participate in co-op. They are more 3.43 times more likely to stay and graduate in engineering than if they did not participate. The analysis includes both graduates and non-graduates.

Table 4. Odds ratios of graduating in engineering

Co-op Participants vs Non-participants				
Engineering Major	**Ethnicity**	**Odds Ratio**	**95% Confidence Limits**	
Aerospace	Black	2.15	1.32	3.51
Aerospace	White	1.76	1.32	2.36
Chemical	Black	3.28	2.10	5.14
Chemical	White	2.69	2.11	3.43
Chemical	Hispanic	2.13	1.24	3.65
Chemical	Asian	1.62	1.14	2.32
Civil	Black	3.03	1.88	4.89
Civil	White	2.49	1.88	3.29
Civil	Hispanic	1.97	1.13	3.42
Civil	Asian	1.50	1.01	2.22
Computer	Black	1.92	1.26	2.94
Computer	White	1.58	1.29	1.93
Electrical	Black	2.28	1.47	3.53
Electrical	White	1.87	1.48	2.36
Industrial and Systems	Black	3.43	2.15	5.47
Industrial and Systems	White	2.81	2.13	3.71
Industrial and Systems	Hispanic	2.22	1.29	3.83
Industrial and Systems	Asian	1.69	1.16	2.47
Mechanical	Black	2.40	1.56	3.69
Mechanical	White	1.97	1.63	2.37

* Includes only significant relationships

Results in Table 5 show that co-op participation is significantly associated with the time a student attended an institution and their final GPA for both graduates and non-graduates. Controlling for other dependent variables, co-op participation increases time to graduation by 4.93 months for graduates and 4.53 months for non-graduates.

Final GPA is positively affected by co-op as well (Table 5). There are also significant differences among engineering disciplines. For example, Chemical and Electrical engineering students take 0.96 and 0.78 months, respectively, less than the Mechanical engineering baseline. When compared to their White peers. Black and Hispanic students take significantly more time to graduates, while females take less time to graduate than their male counterparts. Both high school variables are significantly associated with time to graduation and final GPA. The higher a student's PES and high school GPA the sooner they graduate and with higher GPA's.

Table 5. Maximum likelihood estimates for time attended and final GPA

	Time attended (months)				Final GPA			
	Graduates		Non-Graduates		Graduates		Non-Graduates	
	β	SE	β	SE	β	SE	β	SE
Intercept	63.36*	1.78	63.39*	4.03	1.00*	0.06	0.08	0.19
Participated in co-op	4.93*	0.80	4.53*	1.76	0.17*	0.03	0.22*	0.08
Engineering major								
Aerospace	0.42	0.51	0.44	0.44	0.05	0.02	0.01	0.02
Chemical	-0.96**	0.48	0.93***	0.54	0.09*	0.02	0.04	0.03
Computer	-0.34	0.43	1.17*	0.42	0.03***	0.02	-0.01	0.02
Civil	-0.41	0.47	-0.04	0.49	0.04***	0.02	0.03	0.02
Electrical	-0.78***	0.44	0.81***	0.47	0.07*	0.02	0.06*	0.02
Industrial and Systems	-0.71	0.55	0.64	0.55	0.08*	0.02	0.03	0.03
Ethnicity								
Asian	-0.65	0.46	1.00**	0.47	-0.08*	0.02	0.01	0.02
Black	3.89*	0.66	4.93*	0.70	-0.17*	0.02	-0.13*	0.03
Hispanic	1.32***	0.75	-0.99	0.68	-0.04	0.03	-0.02	0.03
Native American	3.43	2.66	5.09**	2.09	0.00	0.10	0.03	0.10
International	1.24	1.74	1.12	1.41	-0.02	0.06	0.13	0.07
Other	0.27	2.04	-1.45	1.29	0.00	0.07	0.09	0.06
Gender	-1.72*	0.38	-1.65*	0.42	0.02	0.01	0.03***	0.02
Highschool GPA	-4.79*	0.30	-1.80*	0.40	0.39*	0.01	0.43*	0.02
PES	-0.063*	0.011	0.002	0.012	0.002*	0.000	0.003*	0.001
N =	12,204		8,513		12,204		8,513	
R-square	0.18		0.55		0.28		0.29	

* $p < 0.01$ ** $p < 0.05$ *** $p < 0.1$

Note: Engineering major = Mechnical, Ethnicity = White, and Gender = Male are used as baselines for comparison. Startyear, Institution, and interaction terms are omitted from the tables, although they are significant. Also, for comparison, 6-year graduation = 72 months.

Interactions between co-op participation and demographic variables are essential pieces of the story to understand how co-op is related to academic outcomes for a diverse population of students. The interaction between co-op and major is statistically significant for some majors. For example, of those graduates who are in Aerospace at the time they are expected to apply for co-op and participate in co-op take 1.7 months longer to graduate than Mechanical co-op participants. There is a similar trend for Computer and Electrical students, taking 1.48 and 1.39 months, respectively, longer to graduate. These numbers are in addition to the values in Table 5. In total, it takes Aerospace students an additional 6.63 months to graduate. The interaction of gender and co-op participation is not significant.

Conclusions and Discussion

Using data from six institutions with engineering cooperative education programs, we show several factors related to co-op participation that significantly affect the likelihood graduating in engineering, the time it takes to graduate, and academic performance in terms of final GPA. There is a gap in the literature that we aim to fill with these results. Academic variables and demographics factors are important considerations when structuring co-op programs. Our results show that institutional differences are statistically significant in participation and we posit that it may be due to differences in program requirements and policies. The academic year in which a student first matriculates to an institution is also related to co-op participation. Ethnicity is a significant predictor that could potentially interact with the institution variable, especially if institutions have different ethnic compositions. There is an imbalance in the ethnic backgrounds of students that co-op programs attract.

This study confirms findings that participating in co-op increases time to graduation [5]. While the authors include similar demographic and academic variables[5], they fail to account for the student's major. This study shows that the increase duration to graduation varies by major. Prior research shows that there are differences in participation among students from difference engineering disciplines[21]. Students in majors other than Mechanical Engineering are less likely to participate in co-op [21]. Time to graduation differs significantly among various majors. Using linear regression modeling we show that there are statistically significant differences among majors. Aerospace co-op participants take 6.63 more months to graduate than their Mechanical engineering peers.

Co-op participation is positively related to the likelihood of graduating in engineering and has the greatest impact for minority students; however, the interaction of co-op participation and gender is not statistically significant. Prior research shows that gender is not a significant predictor of co-op participation [21], but women may have different co-op experiences. Research highlights the perceptions of mentoring experiences of women in a co-op program, indicating a potential gender difference [22].

Although co-op participation of the reduced sample is similar to the overall participation rate of 25%, understanding any patterns of missing values is important. The data is also limited by the lack of information about co-op completion. The literature shows that there are academic benefits for non-completers [5] that may contribute to a more complete understanding of students that are currently aggregated into the participant category. A minor limitation is the assumption that students across all institutions enter co-op after the second semester. A more in depth understanding of co-op program policies will allow us to predict which term/semester students will enter co-op.

Future work will address institutional differences by examining specific program policies and trends. We will use these results to compare with prior academic performance and personal backgrounds. A qualitative inquiry will complement our findings. We will be surveying and interviewing co-op and non-co-op engineering students to understand the benefits and barriers to the program. Student perceptions may help explain the quantitative findings in this paper, including the perception of increased time to graduation as a deterrent from participating. Our results have implications for students, employers, institutions, educators, and program administrators. By providing stakeholders with valuable insights, co-op research reaches beyond academia, making industry and classrooms more inclusive and effective.

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