Undergraduate engineering applicants' perceptions of cooperative education: A text mining approach

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Benefits of cooperative (co-op) education have been investigated, mainly by surveying students already enrolled in co-op programs. In contrast, this paper investigates prospective students' perceptions of co-op. This was done by analyzing over 33,000 applications to undergraduate engineering programs in a large North American university. Text mining was applied to analyze applicants' responses to the question "Tell us about your reasons for applying". Overall, 58% of students mentioned co-op in their response; this percentage was higher for female applicants, applicants to chemical engineering, domestic students and students applying directly from high school. Based on words frequently occurring in sentences that mentioned co-op, applicants were attracted to co-op programs to learn new skills, gain practical work experience leading to a desirable career, and leverage the reputation and size of the institution's co-op program, with the first two reasons mentioned more often by female applicants and the last by male applicants.

Keywords: Cooperative education, engineering, admissions, gender differences, text mining

Cooperative education (co-op) is a form of experiential learning based on the concept of learning by doing (Kolb, 1984). In co-op programs, students alternate between on-campus classes and off-campus workterms. Studies have shown that co-op is associated with enhanced learning experiences, skill development, better academic performance, higher satisfaction with the field of study, and better career prospects (Ambrose & Poklop, 2015; Blair et al., 2004; Eames & Coll, 2010; Gault et al., 2000; Raelin et al., 2011; Strubel et al., 2015; Thiel & Hartley, 1997; Wyonch, 2020).

Co-op programs help align graduate competencies with employer expectations, serving as a talent pipeline for employers (Coll et al., 2002; Hodges & Burchell, 2003). Some studies investigated the impact of co-op as a recruiting tool in terms of the role of co-op in students' decisions to pursue postsecondary education and students' expectations of co-op (Anderson et al., 2012; Ramirez et al., 2016). These studies are based on responses from existing students who were requested to think back to the time before starting their program and answer the questions retrospectively. To the best of the authors' knowledge, there is no previous work on *prospective* students' perceptions of co-op, which is the topic of this paper.

This analysis is based on a unique dataset with over 33,000 undergraduate applications to the engineering faculty of a large North American university with mandatory co-op programs. In addition to submitting academic transcripts, applicants were required to describe why they are interested in studying at the university (in a short free-text response) and provide other information such as their gender, program of choice, and details about the last academic institution they attended.

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In this paper, a text mining approach that uses word frequency analysis was applied to applicants' responses to the question "Tell us about your reasons for applying." The goal was to answer the following research questions, for all applicants and for various groups of applicants (grouped by gender, program of choice, and location and level of last academic institution attended)

1. How many undergraduate engineering applicants mention co-op as a reason for applying?
2. Why is co-op important to undergraduate engineering applicants?

While the main focus of the study is to understand applicants' perceptions of co-op (second research question), calculating the proportion of applicants who mention co-op as a reason for applying (first research question) can provide context and illustrate the importance of studying this topic.

Understanding what prospective students think about co-op can enhance recruitment efforts, student satisfaction, and student retention. For example, recruiting material and outreach programs may highlight aspects of co-op that potential students find desirable and explain any misconceptions. In particular, information collected from underrepresented groups such as women in engineering can be used to increase diversity. Additionally, applicants' perceptions of co-op can reveal inconsistencies between their expectations and reality. Clarifying what co-op has to offer can help students transition to co-op programs, and in turn increase satisfaction and retention.

The remainder of this paper is organized as follows: the section Related Work summarizes prior work on students' expectations from co-operative education, Data and Methods discusses the dataset and the methodology used to analyze it, the sections Importance of Cooperative Education and Perception of Cooperative Education present results addressing the two research questions studied in this work, section Discussions presents insights, and Conclusions concludes the paper with directions of future work.

Permission for this secondary data analysis was granted by the university's office of research ethics (application number 40471).

RELATED WORK

Co-op programs and their effects on student learning and career growth have been studied extensively. Prior work focuses on the role of co-op in improving learning, grades, satisfaction and retention in post-secondary programs (Blair et al., 2004; Eames & Coll, 2010; Strubel et al., 2015). Studies show that co-op experiences contribute towards skill development, helping students gain technical, workplace and job-seeking skills (Ambrose & Poklop, 2015; Raelin et al., 2011; Thiel & Hartley, 1997). Participation in co-op has also been shown to develop self-awareness in career planning (Jackson, 2015, 2017b). Furthermore, studies have found that co-op experiences provide a head start in students' careers (Gault et al., 2000; Thiel & Hartley, 1997; Wyonch, 2020;), making it easier for co-op students to find jobs after graduation, usually with higher salaries than non-co-op students (Blair et al., 2004; Gault et al., 2000; Wyonch, 2020). While most of this work surveys co-op students or graduates to examine the eventual impact of co-op, limited research has been conducted to understand why students apply to co-op programs in the first place, which is the goal of this paper.

Some studies have analyzed the potential of co-op as a recruitment tool. Martin (1997) found that the existence of co-op programs contributed to institutional outreach and recruitment programs. Skledar et al. (2009) found that the vacancy rate in a pharmacology program decreased from 27% to 4% with the introduction of an internship program. In a survey conducted by Anderson et al. (2012), 50% of respondents said that the availability of a co-op program was a factor in choosing their post-secondary

institution. The study by Anderson et al. surveyed students who were already enrolled in a co-op program and had held a co-op job, meaning that questions were answered retrospectively. In contrast, this paper examines the proportion of prospective students who mention co-op as one of the reasons for applying. In addition, this paper investigates whether different groups of students (defined by gender, program of choice, and location of last academic institution attended) state different reasons for applying to co-op programs.

Several studies were based on interviewing students to understand differences between those who choose co-op programs versus those who do not. Some researchers examined the costs and benefits these students associated with joining their programs (Drysdale et al., 2007; Ramirez et al., 2016; Strubel et al., 2015). Additionally, past studies examined student backgrounds, including gender, ethnicity, and country, to understand their effects on participation in co-op programs (Ramirez et al., 2016; Strubel et al., 2015). A study found that high-school students who matched a "serious student" profile enrolled in co-op programs more often than others (Drysdale et al., 2007, p. 54). Additionally, they found that fewer women enrolled in co-op programs at the university level, and, in an attempt to support their education, students with a low socio-economic status selected co-op programs more often (Drysdale et al., 2007). Finally, Rowe (1989) noted differences in career decision-making maturity and work preferences between co-op and non-co-op students. This paper is orthogonal to these previous works: rather than comparing co-op and non-co-op students, this paper examines applicants' perceptions of co-op.

Lastly, some studies have noted students' expectations from co-op programs. Marshall (1975) interviewed co-op students to understand what they would like to see in an ideal co-op program, and Miller (2018) interviewed 11 co-op graduates to understand how classroom, college, industry, community, program marketing and program experiences affect enrollment in co-op programs. Furthermore, Anderson et al. (2012) surveyed over 2,500 co-op students and asked them retrospective questions to understand why they had enrolled in a co-op program. To the best of the authors' knowledge, this is the first work that analyzes the views of prospective engineering students towards co-op.

DATA AND METHODS

Data

This study analyzed four years of anonymous data extracts, from 2013 to 2016 inclusive, corresponding to 33,763 students applying to the engineering faculty of a large North American university with mandatory co-op programs. For every application, the dataset contains the following information:

- Response to the question "Tell us about your reasons for applying to this University" (150 word limit).
- Gender: male or female.
- Engineering program of choice (all engineering programs have mandatory co-op).
- Location of last academic institution attended: domestic or international. In the remainder of this paper, applicants whose prior academic institution was abroad are referred to as "international applicants" and applicants whose prior academic institution was located within the country are referred to as "domestic applicants." Note that these labels do not necessarily correspond to applicants' citizenship.
- Level of last academic institution attended: applying from high school, or currently attending a post-secondary institution and wishing to transfer.

The dataset was studied as a whole and for groups of applicants split by gender, program, location and level of last institution attended. Group sizes are summarized in Table 1. For example, 77% of the applicants are male and 23% are female. Table 1 also shows the percentage of applicants within each group who mention co-op in their response to why they are applying to the university. For example, 62% of female applicants mention co-op. This will be further discussed in the section Importance of Cooperative Education.

TABLE 1: Percentage of applicants who mention "co-op."

|	Group	% of applicants	% of applicants in the group who mention "co-op"
Gender	Male	77%	57%
	Female	23%	62%
Program of Choice	Mechanical	25%	58%
	Computer	22%	58%
	Electrical	11%	58%
	Chemical	11%	62%
	Civil	10%	57%
	Biomedical	6%	61%
	Industrial	6%	58%
	Nanotechnology	5%	50%
	Environmental	4%	58%
Location of last academic institution attended	Domestic	79%	62%
	International	21%	45%
Level of last academic institution attended	High School	95%	59%
	Post-secondary	5%	48%

Methods

Figure 1 summarizes the text mining method used to analyze applicants' responses to the question "Tell us about your reasons for applying to this University." The method was implemented in the Python programming language and uses standard information retrieval techniques to extract words from text (Croft et al., 2010).

The steps shown in Figure 1 are as follows:

1. Pre-processing: For each applicant, their response was converted to lower case and split into sentences. Stopwords (words that serve a grammatical purpose but do not contain any meaningful information, such as and, the, etc.), special characters, digits, and punctuation were removed, and various forms of certain words were converted into a common form using regular expression matching (e.g., occurrences of "co-operative education", "co-op", "cooperative program", and "cooperative" were converted to "coop".).
2. Filter: To answer the second research question (why is co-op important to applicants?), only sentences containing "coop" (or one of its alternative forms listed above) were retained. This step was skipped to answer the first research question (what fraction of applicants mention co-op?).
3. Tokenize and Stem: Finally, tokens (words) were extracted from sentences and stemmed using the NLTK snowball stemmer. Stemming converts related words with different endings to a

common *stem*. For example, the words "learned", "learning", and "learn" were converted to "learn", and "studying", "studious", and "study" were converted to "studi".

FIGURE 1: Text mining method used to analyze applicant responses. (to preserve data privacy, the figure includes a synthetic response similar in style to those in the dataset)
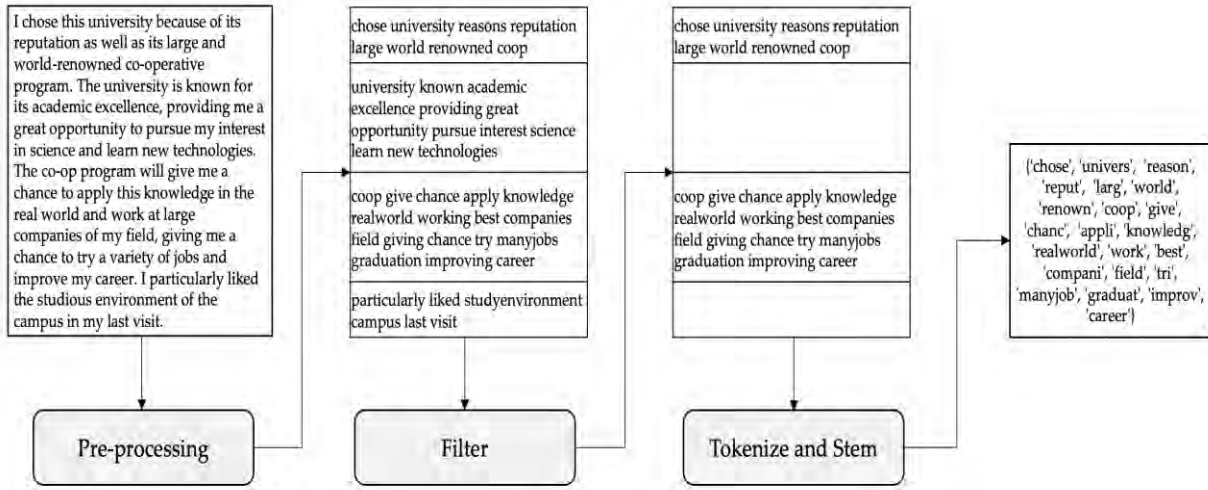
Overall, each response was converted to a set of tokens (also referred to as "words" or "terms" in the remainder of the paper), and a *term frequency analysis* of these tokens was conducted and reported in two ways:

- Frequent terms: sorted by their frequency, these are tokens that occurred at least once in a large percentage of responses, and
- Significant differences: these are tokens that were more frequently used by one group of applicants than another (e.g., men vs. women). A two-tailed two proportion z-test was used to determine whether the difference in token frequencies is statistically significant. The null hypothesis states that the proportion of applicants who mentioned a particular token are the same in both groups. Only differences that were statistically significant at a p-value of 0.05 and had a statistical power greater than 80% were reported. In addition, for each difference, the paper reports the odds ratio (OR) of the difference, calculated according to the formula below.

$$Odds\ ratio\ for\ Token\ W\ in\ Group\ A\ versus\ B = \frac{\frac{\#\ of\ applicants\ in\ Group\ A\ who\ mention\ W}{\#\ of\ applicants\ in\ Group\ A\ who\ do\ not\ mention\ W}}{\frac{\#\ of\ applicants\ in\ Group\ B\ who\ mention\ W}{\#\ of\ applicants\ in\ Group\ B\ who\ do\ not\ mention\ W}}$$

The odds ratio indicates the strength (or size) of the difference and can be interpreted as follows. Suppose the odds ratio of token W is 1.5. This means that Group A is 1.5 times more likely than Group B to mention the token W.

Limitations

The nature of the data introduced the following potential limitations:

- The dataset reflects the views of applicants to a North American university with a large engineering co-op program. In addition, participation in co-op is mandatory for all engineering students at the university. Therefore, inferences drawn from this dataset may not apply to other co-op programs or other disciplines.

- It was assumed that any sentence containing the term "coop" (or one of its alternative forms) reflects an applicant's opinion on co-op. This may lead to some "false positives" (sentences that mention "coop" but focus on a different topic) and "false negatives" (sentences that discuss co-op without mentioning the word). Manual inspection of a random sample of 50 responses revealed one false positive and four false negative sentences. False positives occurred when applicants mentioned their program of choice, such as "I am applying to the Biomedical Engineering co-op program because it is unique". False negativities occurred when students wrote multiple sentences about co-op but did not include the term "coop" in every sentence. In the random sample that was manually inspected, these additional sentences paraphrased topics mentioned by the sentences containing the term "coop", meaning that removing these sentences resulted in minimal information loss.

- It was assumed that any sentence containing the term "coop" (or one of its alternative forms) specifies a reason why an applicant is interested in a co-op program, instead of why they were not interested in it. To confirm this, each sentence containing the term "coop" (or one of its alternative forms) was inspected by a sentiment analyzer (used to determine whether a given text is negative, positive, or neutral). Examples of synthetic sentences tagged as positive include: "Participation in Co-op will help me find a full-time job after graduation," "I am applying to the University's Chemical co-op program." Examples of synthetic sentences tagged as negative include: "Learning the theory feels purposeless without the chance to apply it, and co-op would solve this," "I want to join the University in spite of its co-op program." The analyzer assigned a positive score to 99% of the sentences in the dataset. Manual inspection of all the sentences with a negative score revealed that they contained a strong negative word (for example, "purposeless" in the sentence above), but this word was not directed towards co-op.

- Responses provided by applicants were assumed to be representative of their reasons, even though their actual reasons may have been different.

IMPORTANCE OF COOPERATIVE EDUCATION

Frequency analysis of entire applicant responses (i.e., skipping Step 2 of the methodology) was done to answer the first research question – how many applicants mention the term "coop" at least once?

Overall, 58% of the applicants mentioned "coop" in their response at least once. "coop" was the third most frequent token, after the university's name (mentioned by 95% of the applicants) and the token "interest" (58%).

Table 1 shows the percentage of applicants in various groups who mentioned "coop" at least once. In terms of academic programs, students applying to Nanotechnology engineering mention "coop" less, and those applying to Chemical engineering mention "coop" more, in comparison to the 58% of all the applicants who mention "coop." Table 1 also shows that female applicants, domestic applicants, and high school students mention "coop" 5%, 17%, and 11% more often than males, international applicants, and post-secondary applicants, respectively. These differences are statistically significant with a p-value less than 0.001.

For international applicants, the frequency of the token "intern" (which captures "intern" and "internship") was examined in addition to "coop." This was done because international applicants may not be familiar with the word "coop" and may have used the words "intern" or "internship" instead. It was found that, in comparison to domestic applicants, 3% more international applicants mention "intern."

PERCEPTION OF COOPERATIVE EDUCATION

This section addresses the second research question – why is co-op important to applicants? This is done by focusing on sentences that mention "coop" at least once (i.e., including Step 2 of the methodology). The first subsection below reports frequent terms occurring in these sentences, and the second subsection reports terms whose differences in frequency was statistically significant for different groups.

Frequent Terms

Twenty-two percent of students who mention "coop" also mention "opportunity." This is the most frequent token among students who mention "coop", after tokens including the university's name, and "experi" (stem of the word "experience"). Appendix A shows the 100 most frequent tokens mentioned in sentences with the word "coop." Aside from tokens related to co-op, Appendix A contains common English words and other words common in the context of university applications (e.g., "appli", "educ", "provid", "student"). Appendix A provides examples of words that are stemmed to a particular token. For example, it shows that 22% of applicants who mention "coop" also mention "opportun" (or its variants such as "opportunity" or "opportunities", all stemmed to "opportun"). Frequent tokens that indicate applicants' perceptions of co-op are categorized below.

1. To gain knowledge and skills*:* "learn" (14% of applicants who mention "coop" in a sentence mention "learn" in the same sentence), "interest" (10%), "knowledge" (9%), "skill" (7%), "valuable" (6%)
2. To gain work experience*:* "work experience" (14%), "work" (14%), "field" (9%), "many jobs" (5%), "research" (4%)
3. To gain practical experience*:* "practical experience" (8%), "practic" (6%), "realworld" (4%). Upon manual inspection, it was found that applicants described co-op as an opportunity to apply the "theory" (2%) learned in the "classroom" (3%) to solve real-world problems**.**
4. Reputation and size of the co-op program*:* "reput" (13%), "best" (9%), "world" (7%), name of country where the institution is located (7%), "rank" (5%), "renown" (4%), "largest" (4%)
5. Career prospects*:* "career" (9%), "future" (8%), "graduat" (7%), "job" (6%), "employ" (4%), "degree" (4%), "placement" (3%).

Other tokens mentioned include: "unique" (5%), "connect" (3%), "compani" (3%), "explore" (2%), "network" (2%), "finance" (1%), "tuition" (1%), and "entrepreneur" (1%).

Group Differences

To understand whether different groups of applicants perceive co-op differently, the terms with statistically significant differences in frequencies are analyzed below.

    Gender

Table 2 shows the differences in frequencies of tokens mentioned by male and female applicants. Even though these differences are below 5%, they are statistically significant, have statistical power greater than 80%, and have an odds ratio greater than one. Table 2 shows the top 10 tokens that are mentioned significantly more frequently by male applicants than by female applicants (on the left), and vice versa (on the right). The lists are sorted by the difference in frequencies, abbreviated Δ, computed as the percentage of male (or female) applicants who mention a token minus the percentage of female (or male) applicants who mention this token. For example, male applicants mention "reput" 3% more often than female applicants. In addition, Table 2 mentions the odds ratio for each difference. For example, female applicants are 1.3 times more likely than male applicants to mention "opportun" (word stem of "opportunity") when talking about "coop."

TABLE 2: Differences in frequencies between tokens mentioned by male and female applicants (in responses containing sentences with "coop")

Token	Male	Female	Δ (↓)	OR	Token	Female	Male	Δ (↓)	OR
reput	14%	11%	3%***	1.33	opportun	26%	21%	5%***	1.30
reason	10%	7%	3%***	1.46	learn	16%	14%	2%**	1.13
best	10%	8%	2%***	1.23	career	10%	8%	2%**	1.20
excel	8%	6%	2%***	1.30	attract	6%	4%	2%***	1.39
(city)	9%	7%	2%**	1.21	explor	3%	1%	2%***	1.94
industri	4%	2%	2%***	1.66	practicalexperi	9%	8%	1%**	1.19
compani	4%	2%	2%***	1.59	uniqu	6%	5%	1%***	1.29
world	11%	9%	2%**	1.23	think	3%	2%	1%***	1.64
(country)	7%	6%	1%**	1.24	love	3%	2%	1%***	1.61
employ	4%	3%	1%**	1.28	different	4%	3%	1%***	1.38

Note. ***: p < .001; **: p < .01; *: p < .05

Male applicants, more often than female applicants, mention tokens related to reputation, size, and the companies that participate in the co-op program (tokens include "reput", "best", "renown", "prestig" "largest", "world", name of the country where the institution is located, names of employers that participate in the co-op program, etc.). Male applicants also mention "employment" slightly more often than female applicants.

Female applicants mention tokens related to gaining knowledge ("learn", "knowledge"), practical experience ("practical experience", "practice", "workplace", "theory", "classroom", "field"), and exploring a variety of career options ("explore", "different", "various", "variety", "divers", "options", "paths") including research more often than male applicants.

Program of Choice
Frequencies of terms mentioned by students applying to different programs do not differ by more than 5%. Nevertheless, these differences are statistically significant, have statistical power greater than 80%, and have an odds ratio greater than one. Tokens mentioned by applicants to each program are compared with tokens mentioned by applicants to all other programs. Table 3 summarizes the terms mentioned more frequently by applicants to each program. For brevity, the table only mentions words relevant to co-op, and does not mention common English words or terms frequent in the context of university applications. The odds ratio of all the word frequency differences mentioned in Table 3 range between 1.25 and 6.06.

Table 3 indicates that students applying to Mechanical engineering mention gaining "practical experience" and learning to work in "teams" more often than students applying to other programs. Additionally, those applying to Computer engineering mention gaining knowledge ("scienc", "technolog"), "work experience" at large companies ("compani", names of large companies), the co-op program's reputation ("best", "large"), connecting with "people", and learning to be an "entrepreneur".

TABLE 3: Tokens mentioned more frequently by applicants to certain programs in comparison to applicants to all other programs.

Group	Tokens
Mechanical	practicalexperi (2%***), industri (1%**), team (1%***), robot (1%***)
Computer	scienc (6%***), compani (3%***), technolog (2%***), workexperi (2%**), math (2%***), best (2%***), industri (1%**), (company) (1%***), cours (1%**), peopl (1%***), entrepreneur (1%***), larg (1%**), startup (1%***)
Electrical	futur (2%**), practic (2%**), theori (1%**), famous (1%**), communic (1%***)
Chemical	studi (3%***), chemistry (1%***), research (1%**)
Civil	(country) (1%***), good (1**), attention (1***), firm (1%***), structure (1%***), infrastructure (1%***)
Biomedical	opportun (4%**), field (3%***), life (3%***), research (2%***), renown (2%**), explor (2%***), new (1%***), scienc (1%*), challeng (1%***)
Industrial	business (2%***), passion (1%***), problemsolv (1%***), corporate (1%***), complement (1%***)
Nanotechnology	uniqu (2%**), physic (1%***)
Environmental	love (2%***), deal (1%***), issu (1%***), water (1%***), earth (1%***)

Note. ***: $p < .001$; **: $p < .01$; *: $p < .05$

Students applying to Chemical engineering mention using their co-op terms for "research" more often than students applying to other programs. Students applying to Nanotechnology engineering mention "unique" and "physics" more often than other programs. Recall from the section Importance of Cooperative Education, that students applying to Chemical engineering mention "coop" more often than others, and those applying to Nanotechnology mention it less often.

Table 3 also shows that in sentences that mention the word "coop," students applying to Mechanical and Electrical engineering mention "practical experience," those applying to Computer engineering mention "work experience," and those applying to Chemical and Biomedical engineering mention "research" more often than applicants to other programs.

Location of last academic institution attended

Table 4 shows the differences in frequencies of tokens mentioned by domestic and international applicants. Both groups mention reputation, though they express it using different words: domestic students mention "reput," "renown," and "best" international students use "largest," "unique," "famous" and "world."

In addition, international students mention "practic," "knowledge," "course," and "theory" more often than domestic students, suggesting a desire to apply theoretical concepts in practice. International students also mention "research," "industri," "profession," "exposure," "enable," and "chance" more often than domestic students, suggesting that they view a co-op as a chance to obtain research and industry experience. On the other hand, domestic students mention "experience," "placement," "many jobs," "connect," "employ," "job," and "degree" more often than international students, indicating that they want to pursue a co-op program to find a job after graduation, try various career paths, and make connections in industry. Even though the magnitude of these differences is small, all of them are statistically significant at a p-value of 0.05, have statistical power greater than 80%, and have an odds ratio greater than one.

TABLE 4: Differences in frequencies between tokens mentioned by domestic and international applicants (in responses containing sentences with "coop")

Token	Domestic	International	Δ (↓)	OR	Token	International	Domestic	Δ (↓)	OR
reput	14%	10%	4%***	1.49	practic	11%	5%	6%***	2.31
opportun	23%	19%	4%***	1.28	world	11%	7%	4%***	1.61
(city)	9%	5%	4%***	1.79	research	7%	4%	3%***	1.96
placement	4%	0%	4%***	9.02	attract	7%	4%	3%***	1.89
experi	23%	20%	3%***	1.20	knowledg	11%	8%	3%***	1.34
valuabl	6%	4%	2%***	1.72	cours	5%	2%	3%***	2.11
field	10%	8%	2%***	1.32	enabl	3%	1%	2%***	2.47
manyjob	6%	4%	2%***	1.62	chanc	5%	3%	2%***	1.60
goal	6%	4%	2%***	1.52	profession	4%	2%	2%***	1.68
connect	3%	1%	2%***	2.64	uniqu	6%	4%	2%**	1.30

Note. ***: p < .001; **: p < .01; *: p < .05

Level of last academic institution attended

Table 5 shows the differences in frequencies of the tokens mentioned by students applying from high schools and post-secondary institutions. Even though the magnitude of these differences is small, they are statistically significant at a p-value of 0.05, have statistical power greater than 80%, and an odds ratio greater than one. In addition to the tokens mentioned in Table 5, students transferring from post-secondary institutions mention the following tokens more often than high school students: "research," "skill," "profession," "curriculum," "challenge," "motivat," "advanced," "meet," "like-minded," "competition," and "entrepreneur." Even though these differences are statistically significant and have an odds ratio greater than one, their statistical power is between 65% to 80%, and therefore they are excluded from Table 5.

TABLE 5: Differences in frequencies between tokens mentioned by students applying from high-schools and post-secondary institutions (in responses containing sentences with "coop")

Token	High-School	Post-Secondary	Δ (↓)	OR	Token	Post-secondary	High-school	Δ (↓)	OR
work	28%	22%	6%*	1.28	system	5%	3%	2%***	1.90
opportun	22%	18%	5%**	1.34	decid	3%	1%	2%***	2.28
provid	15%	11%	4%**	1.42	found	2%	1%	1%***	2.43

life	4%	2%	2%**	2.03	resourc	2%	1%	1%***	2.37
placement	4%	2%	2%*	1.78	current	2%	1%	1%***	2.65
prestigi	2%	1%	1%*	2.55					
number	1%	0%	1%*	6.10					

Note. ***: p < .001; **: p < .01; *: p < .05

Overall, high school students appear to be attracted to the reputation of the institution's co-op program and wish to obtain work experience to help find a job after graduation. Post-secondary students appear to emphasize aspects that may have been missing in their current program.

DISCUSSION

The main findings of this study and their significance are as follows: the section Importance of Cooperative Education found that when applicants were asked to write why they applied to the university, co-op was the third most frequent word in their response (after the university's name and the word "interest"). Overall, 58% of all applicants mentioned co-op in their response. In addition, students mentioned a variety of reasons for applying to a co-op program. The most common reasons were:

- to increase technical knowledge in their field,
- to gain practical work experience by applying the theory learned in the classroom to the real world,
- to gain workplace skills, including, teamwork and people skills,
- to explore different jobs in their field, allowing them to make informed career decisions,
- to improve their chances of finding a full-time job after graduation, and
- reputation, size, and the companies that participate in the University's co-op program.

Some applicants mentioned other reasons such as making connections in the industry, financing their education, and training to be an entrepreneur.

Knowing what prospective students think about co-op can help institutions manage students' expectations. For example, many applicants stated that they want to participate in co-op to learn specific technical skills or apply theories learned in the classroom to real-world problems. However, co-op positions filled by junior students are not always directly related to their field of study (Chopra & Golab, 2018). Additionally, past studies have noted reduced satisfaction with co-op when jobs are not relevant to students' academic programs (Chopra et al., 2018). These findings can help institutions identify such inconsistencies between expectation and reality, help students manage their expectations, increase their satisfaction with co-op, and in turn their retention in the program.

Institutions may wish to align the co-op program to suit students' needs. For example, some students stated that they want to explore different jobs in their field in order to make an informed career choice. To accommodate this, institutions may consider recruiting employers who are willing to rotate students among different groups or business units during a workterm. In addition, institutions may provide career consultation sessions to such students. Past studies have indicated that institutional factors, including a lack of engineering advising, can lead to attrition, especially in junior students (Meyer & Marx, 2014). Incorporating student needs into co-op programs should therefore attract new students as well as retain current students.

Being aware of incoming students' mindsets towards co-op can increase the likelihood of meeting students' expectations. For example, many students stated that they want to work in large technology

companies. Institutions may want to organize information sessions in which representatives from these companies explain their talent needs. Students who have worked for these companies in the past may also share their experiences. In addition, many students stated that they want to gain technical, practical, and workplace skills through co-op. Institutions may want to survey existing co-op students to find out what skills are commonly acquired in various types of co-op roles, and this can be communicated to incoming students.

Moreover, co-op employers offering entry-level positions may want to align their co-op positions to suit the expectations of prospective students. For example, prospective students mentioned that they want to gain teamwork skills. Employers that require working in large teams can highlight this to attract more applications. Past studies show that co-op job descriptions commonly contain sections with required skills and job responsibilities (Chopra, 2017; Leung, 2007). An additional section describing skills students can expect to learn on the job may help students understand what they will learn and encourage them to apply.

Applicants' perceptions of co-op reported in this study are similar to the benefits of co-op stated by current or graduated students. Prior work surveyed co-op students and graduates to find that participation in co-op helped them in the following ways:

- to gain knowledge, work experience, and soft skills, including interpersonal skills, confidence, and exposure to company culture (Ambrose & Poklop, 2015; Thiel & Hartley, 1997),
- to identify personal development strategies (Jackson, 2017b),
- career choice and planning (Ambrose & Poklop, 2015; Jackson, 2015, 2017b; Strubel et al., 2015). Students mentioned that co-op placements not only gave them more information and insight into their intended careers, but they also aided them in their decision-making process on which career to pursue,
- increased chances of finding a job after graduation, that too with higher salaries, in comparison to students who do not participate in co-op (Strubel et al., 2015; Wyonch, 2020),
- to make network connections and find a possible culture fit (Jackson, 2015; Thiel & Hartley, 1997), and
- to pay for their education (Ambrose & Poklop, 2015).

Similarly, the findings reported in this paper agree with past studies that asked retrospective questions about why current co-op students chose to pursue a co-op program in the first place, including:

- to gain work experience and job training (Anderson et al., 2012; Ramirez et al., 2016),
- to learn in a different way (Anderson et al., 2012; Marshall, 1975),
- to "safely" explore career options (Anderson et al., 2012; Ramirez et al., 2016),
- to improve career prospects and ensure a "good job" after graduation (Anderson et al., 2012; Ramirez et al., 2016),
- to gain access to unique co-op job opportunities (Anderson et al., 2012),
- to build a network (Anderson et al., 2012; Ramirez et al., 2016), and
- to finance their degree (Anderson et al., 2012; Ramirez et al., 2016).

However, engineering co-op students in past studies did not mention the desire to work at startups or receive entrepreneurship training. This may indicate a new expectation from students. In response, institutions may recruit startups into their co-op programs, invite entrepreneurs to give talks to co-op students, and provide entrepreneurial training resources such as courses and workshops. Furthermore, offering an entrepreneurial co-op program that encourages students to start a company while earning

a co-op credit may attract more students to engineering programs. Past studies have noted the economic impact of entrepreneurship on co-op job creation (Andrade et al., 2018). These studies also found that students working for startups were more satisfied with their workterms than other students.

Therefore, promoting entrepreneurship interest through co-op can be beneficial to students and institutions. Furthermore, this study identified differences in perceptions of co-op among various groups of applicants:

Gender

Female applicants mentioned co-op 5% more often than male applicants as a reason for applying. Thus, institutions wishing to increase female enrollment in male-dominated engineering programs may want to emphasize co-op in their outreach efforts. Furthermore, male applicants were more likely to mention the institution's size and reputation of the co-op program, whereas female applicants were more likely to point out opportunities to gain knowledge and practical experience, and to try a variety of career options. Outreach programs and recruitment material aimed at attracting more female students should therefore emphasize these benefits. In addition, past research found that masculine language in job descriptions discourages women from applying (Collier & Zhang, 2016). The findings reported here point out why female applicants are interested in co-op programs, which can help employers diversify their talent pool.

A combination of reasons may explain gender differences in applicants' perceptions of co-op. For example, past studies found that many women prefer a kinesthetic learning style over visual, auditory, or read and write styles (Wehrwein et al., 2007). This may explain why women emphasize co-op and practical experience more than men. Other studies suggest that employers have a higher hiring standard for women (Renes & Ridder, 1995). Perception of this gender bias may explain why female applicants emphasize gaining work experience as a reason for applying (Ensmenger, 2012; Knobloch-Westerwick et al., 2013; Moss-Racusin et al., 2012; Reuben et al., 2014). Additionally, Chopra et al. (2018) found that, on average, female applicants to engineering have less technical experience in terms of part-time jobs and extracurricular activities. Thus, female applicants may view co-op as a way to obtain technical skills and work experience in their fields. Chopra et al. (2018) also found that female applicants mentioned a wider variety of interests and experiences than men. This may explain why female applicants mentioned the desire to try different career options through co-op.

Program of Choice

Students who applied to Chemical engineering mentioned co-op as a reason to apply slightly more often than other students (62% of Chemical engineering applicants compared to 58% of all applicants). Moreover, applicants to Chemical engineering expressed a desire to conduct research more frequently than applicants to other programs. Informing prospective Chemical engineering students about the availability of research-centric co-op placements may therefore be beneficial. However, as noted by Chopra and Golab (2018), advanced co-op positions that include a research component may only be available to senior students, meaning that it is important to manage junior students' expectations when it comes to their early co-op opportunities. At the same time, institutions may encourage its faculty members to create research co-op positions in Chemical engineering.

On the other hand, only 50% of students who applied to Nanotechnology engineering mentioned co-op. This may indicate that students are not aware of the kinds of co-op positions available in this field.

Institutions may want to add common co-op roles and common employers to descriptions of this program and other unique programs.

Location of Last Academic Institution Attended

Compared to international applicants, 17% more domestic applicants mentioned co-op as a reason for applying. Both groups mentioned the reputation of the University's co-op program, but there were some differences. Domestic applicants mentioned the desire to try various career paths, make connections in industry, and find a job after graduation. International students mentioned the desire to gain practical and research experience in the industry. This observation is consistent with past work that found that international students are attracted to co-op programs as a way to gain exposure and entry to an international workplace (Jackson, 2017a). Thus, recruiting material highlighting how participation in co-op can increase the chances of finding a job after graduation (Strubel et al., 2015; Wyonch, 2020) may be useful. Other studies indicate that international students struggle to obtain co-op jobs and find it difficult to fit into an international workplace (Jackson, 2017a; Tran & Soejatminah, 2016). This may explain why fewer international students mention co-op as a reason for applying. To overcome this, institutions should ensure that co-op opportunities are available for international students. Additionally, institutions may want to provide training sessions for international students to help them adapt to a new work culture.

Level of Last Academic Institution Attended

Students who applied from high school mentioned co-op 11% more often than students who wanted to transfer from another post-secondary institution. These students may have been enrolled in a co-op program in another institution and therefore co-op was not a major reason for transferring. Prior work indicates that the most common reasons behind transfers include access to a unique academic program and the university's reputation, followed by access to a co-op program (Gupta et al., 2019).

High school students applied to an engineering co-op program due to its reputation, to gain work experience, and to obtain a job after graduation. Applicants wanting to transfer from another post-secondary institution mentioned aspects that may have been missing in their current program, including a competitive environment and exposure to research and entrepreneurship. Thus, institutions offering unique co-op positions related to research and entrepreneurship should emphasize this in their outreach efforts. As observed by Anderson et al. (2012), students (not restricted to transfer students) are attracted to co-op programs to gain access to unique co-op job opportunities.

CONCLUSIONS

As part of the application process to the engineering faculty of a large North American university with mandatory co-op, more than 33,000 applicants answered the following question: "Tell us about your reasons for applying to this University." This paper used text mining methods to analyze these responses. Overall, 58% of students mentioned "coop" in their response. Sentences containing the term "coop" additionally contained words suggesting several reasons for applying to a co-op program, including to learn new skills, to gain practical work experience leading to a desirable career, and to leverage the reputation and size of the institution's co-op program. Additionally, some differences were found when comparing various groups of students split by gender, program of choice, location (domestic vs. international) and level of previous academic institution (applying directly from high school vs. wishing to transfer from a post-secondary institution).

These findings are relevant to students, institutions, and co-op employers. Institutions may use prospective students' perceptions of co-op to inform outreach and recruitment efforts, and to attract diverse talent. Additionally, gaps between perceptions and reality may be identified, and managing students' expectations early in the co-op process should increase satisfaction and reduce attrition. Institutions and co-op practitioners may use these findings to meet students' expectations and adapt to students' needs. Finally, co-op employers offering entry-level positions may use these findings to attract new and diverse talent.

Some of the findings reported in this study focused on female applicants as an underrepresented group in engineering. A possible direction for future work is to investigate the perceptions of co-op of other minority groups such as racial minorities (this requires student demographic information that was not collected by the institution under study and therefore was not available for this analysis). Furthermore, this study was based on one (large) North American institution. Thus, another direction for future work is to investigate differences in students' perceptions of co-op across the world.

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APPENDIX A: Top 100 frequent tokens in sentences containing "coop"

No.	Token	Common Word Forms of the Token	Frequency
1	coop	['coop', 'co-op', 'co-operative', 'cooperative', 'coperative']	100%
2	(institution)	(forms of name of institution)	71%
3	experi	['experience', 'experiences']	23%
4	opportun	['opportunities', 'opportunity']	22%
5	appli	['applying', 'applied', 'apply']	22%
6	educ	['education', 'educational', 'educated', 'educate', 'educators', 'educative']	18%
7	offer	['offered', 'offer', 'offers', 'offerings', 'offering']	17%
8	provid	['provides', 'provide', 'provided', 'providing', 'provider']	15%
9	learn	['learned', 'learn', 'learning', 'learns', 'learnings', "learning's"]	14%
10	student	['students', 'student', "student's"]	14%
11	workexperi	['workexperience', 'work experience', 'work-experience']	14%
12	work	['working', 'work', 'works', 'workings', 'worked']	14%
13	reput	['reputable', 'reputation', 'reputed', 'repute', 'reputability']	13%
14	allow	['allow', 'allowing', 'allows', 'allowed']	13%
15	gain	['gained', 'gain', 'gaining', 'gains', 'gainfully', 'gainful']	12%
16	help	['help', 'helped', 'helping', 'helpful', 'helps']	10%
17	interest	['interest', 'interested', 'interests', 'interesting']	10%
18	studi	['studying', 'studies', 'study', 'studied']	9%
19	reason	['reason', 'reasons', 'reasonable', 'reasonably']	9%
20	field	['field', 'fields', 'fielding']	9%
21	school	['school', 'schooling', 'schools', "school's"]	9%
22	knowledg	['knowledge', 'knowledgeable', 'knowledges']	9%
23	best	['best', 'bests']	9%
24	great	['great', 'greatly', 'greatness']	9%
25	career	['career', 'careers']	9%
26	well	['well', 'wells', 'wellness']	9%
27	(location)	(forms of location of institution)	9%
28	believ	['believe', 'believer', 'believes', 'believing', 'believed']	8%
29	one	['one', "one's", 'ones']	8%
30	practicalexperi	['practicalexperience', 'practical experience', 'hands-on experience']	8%
31	give	['give', 'gives', 'giving']	8%
32	futur	['future', 'futures']	8%
33	world	['world', "world's", 'worlds', 'worldly']	7%
34	skill	['skills', 'skilled', 'skill', 'skillful']	7%
35	graduat	['graduation', 'graduate', 'graduating', 'graduated', 'graduates', 'graduators']	7%
36	excel	['excellent', 'excellence', 'excel', 'excelling', 'excelled', 'excellently', 'excellency']	7%
37	(country)	(forms of country of institution)	7%
38	chose	['chose']	6%
39	get	['get', 'getting', 'gets']	6%
40	practic	['practical', 'practice', 'practically', 'practicality', 'practicalities', 'practicability']	6%
41	goal	['goals', 'goal']	6%
42	like	['like', 'likely', 'likes', 'liked', 'liking']	6%
43	valuabl	['valuable']	6%
44	job	['job', 'jobs']	5%
45	manyjob	['many jobs']	5%
46	academ	['academics', 'academic', 'academically']	5%
47	choic	['choice', 'choices']	5%
48	scienc	['science', 'sciences']	5%
49	univers	['universities', "university's", 'universe', 'universal', 'universally']	5%
50	want	['wanted', 'want', 'wanting', 'wants']	5%
51	uniqu	['unique', 'uniqueness', 'uniquely']	5%
52	environ	['environment', 'environments', 'environs']	5%
53	high	['highly', 'high']	5%
54	research	['researched', 'research', 'researching', 'researches', 'researcher', 'researchers']	4%
55	attract	['attract', 'attracts', 'attracted', 'attractive', 'attracting', 'attraction', 'attractions']	4%
56	comput	['computing', 'computer', 'computers', 'computational', 'computation']	4%

57	renown	['renowned', 'renown']	4%
58	employ	['employers', 'employed', 'employable', 'employ', 'employments', 'employability']	4%
59	first	['first', 'firstly', 'firsts']	4%
60	degre	['degree', 'degrees']	4%
61	life	['life', "life's"]	4%
62	develop	['develop', 'development', 'developing', 'developed', 'developer']	4%
63	top	['top', 'topped']	4%
64	innov	['innovative', 'innovation', 'innovate', 'innovatively', 'innovator', 'innovativeness']	4%
65	abl	['able']	4%
66	success	['success', 'successful', 'successfully', 'successfulness', 'successes']	4%
67	realworld	['realworld', 'real world', 'real-world']	4%
68	addit	['additionally', 'addition', 'additional']	4%
69	largest	['largest']	4%
70	known	['known']	4%
71	prepar	['prepare', 'preparing', 'prepared', 'preparation', 'prepares', 'preparations']	4%
72	strong	['strong', 'strongly']	3%
73	worldrank	['world rank', 'rank in the world']	3%
74	import	['important', 'importantly', 'importance', 'imported']	3%
75	choos	['choose', 'choosing', 'choosed']	3%
76	compani	['companies', 'company', "company's"]	3%
77	year	['year', 'years', 'yearly']	3%
78	amaz	['amazing', 'amazed', 'amazes', 'amazingly', 'amaze']	3%
79	chanc	['chance', 'chances', 'chancing']	3%
80	industri	['industry', 'industries', 'industrial', "industry's", 'industriousness', 'industrious']	3%
81	due	['due']	3%
82	placement	['placements', 'placement']	3%
83	pursu	['pursue', 'pursuing', 'pursued', 'pursues']	3%
84	connect	['connected', 'connections', 'connect', 'connecting', 'connection', 'connects']	3%
85	option	['options', 'option']	3%
86	hope	['hopefully', 'hope', 'hopes', 'hoping', 'hoped', 'hopeful']	3%
87	differ	['different', 'difference', 'differently', 'differences', 'differing']	3%
88	achiev	['achieve', 'achievements', 'achieving', 'achieved', 'achievement', 'achievable']	3%
89	math	['math', 'maths']	3%
90	system	['systems', 'system', 'systemic']	3%
91	cours	['course', 'courses']	3%
92	classroom	['classroom', 'classrooms']	3%
93	lead	['leading', 'lead', 'leads']	3%
94	way	['ways', 'way']	3%
95	main	['main', 'mainly']	3%
96	find	['find', 'finding', 'finds', 'findings']	3%
97	faculti	['faculty', 'faculties', "faculty's"]	3%
103	applic	['application', 'applications', 'applicable', 'applicants', 'applicant', 'applicability']	2%
99	use	['used', 'uses', 'useful', 'use', 'using', 'usefulness']	2%
100	theori	['theories', 'theory']	2%