



Comparison of Job Market and Employer Interest in Undergraduate Engineering Students: An Exploratory Analysis

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Comparison of Job Opportunity and Undergraduate Engineering Student Job Fair Participation: How Different are Opportunities for Undergraduate Engineering Majors?

Introduction

In 2019, approximately 1.68 million engineers were employed in the United States, with a predicted growth of four percent by 2028 (U.S. Bureau of Labor, 2019). Despite the high demand for engineers, not all engineering majors have equal industry demand. Job recruitment analyses have shown that traditional engineering fields (e.g., civil and petroleum) and the fastest-growing fields (e.g., software and robotics) are currently the most in demand (Moalloy 2018, McFadden 2019). However, demand for engineers in other areas like biomedical engineering is one-tenth of traditional and fastest-growing fields (U.S. Bureau of Labor, 2019) despite the growing interest of students in majoring in BME. One empirical study shows that BME majors are sought after, with a high number of pre-majors in our university. On the other hand, industry has the lowest interest in BME students compared to other engineering majors at one institution (Nocera et al. 2018, Ortiz-Rosario et al. 2019). BME students reported three possible career outcomes with accepted industry positions (30%), further education (54%), and looking for a job (16%) upon their graduation. Herein, we present an exploratory analysis of career data from a large Midwestern research-intensive university comparing the interest of various engineering majors in acquiring industry jobs.

The biomedical engineering career path to industry

Three factors may influence Biomedical Engineering (BME) graduates' desire and ability to apply and be hired for industry positions. First, BME students may perceive that job opportunities (internships, co-ops, or full-time jobs) are comparatively scarce for their major. Second, although graduates may have the competencies required for many engineering jobs, if they are not hired for these pre-graduate jobs (e.g., internships and co-ops), this restricts and discourages them from applying to more engineering companies. Third, stakeholders may not be familiar with BME graduates' abilities and may not have additional resources to look closely at how students' engineering competencies fit their company job descriptions. BME departments provide a diverse and broad curriculum for students. Students may take courses based on their faculty's research interests, and each institution provides different courses based on their department's focus. Stakeholders require additional resources and efforts to look carefully for BME graduates' engineering competencies compared to other traditional engineering majors, including civil, chemical, electrical, and mechanical engineering. However, there is little empirical research that provides a broad understanding of graduates' interests in industry and engineering job opportunities.

RQ 1: How are the industry work opportunities different between different engineering majors at a large Midwest institution?

RQ 2: How do job fair participants and hiring in engineering industry differ for BME students from other engineering majors at a large Midwest institution?

Case study institution setting (institutional effort on connecting engineering students to industry jobs)

Methods

A quantitative approach was used to address the above research questions. This paper presents an exploratory analysis of aggregated undergraduate engineering student data collected by the college of engineering and Engineering Career Services (ECS) at The Ohio State University. The majors selected for this investigation include Biomedical Engineering (**BME**) and three comparison majors, namely Chemical Engineering (**ChE**), Material Science Engineering (**MSE**), and Mechanical Engineering (**ME**). These majors were purposefully selected because they were the most highly preferred transfer alternatives for BME undergraduate students in and out of the major at this university.

The data in this paper were collected with the approval of the Institutional Review Board (IRB) of the university studied. The dataset includes several companies present in two annually held job fairs, a company's interest in the majors, a company's available positions (co-op, internship, and full-time), the number of students attending

each job fair, and the number of students recruited by position (co-op, internship, and full-time). The timeline for this dataset is between the autumn 2013 and summer 2018 semesters. The results are expressed in academic years (ex. 2013 – 2014 will be presented as ‘13-‘14).

College of Engineering Job Fairs

The College of Engineering holds two job fairs annually, one each semester. In the autumn semester, the engineering expo (**EXPO**) is organized by ECS and offers a larger number of recruiting employers. It is also the job fair with the highest attendance numbers. In the spring semester, the Society for Women Engineers (**SWE**) holds their SWE Career Fair in partnership with ECS; this job fair is open to all majors and years. These two job fairs will be analyzed separately as they attract a different number of students. SWE job fair has a cap on companies that can attend.

Company Interest in Major

The total number of companies in this dataset is 2,036 (‘13-‘14 = 366, ‘14-‘15 = 384, ‘15-‘16 = 436, ‘16-‘17 = 430, ‘17-‘18 = 420). This count only includes companies that reported interest in undergraduate students. The analysis in this paper looked at a company’s reported interest in a major. Some companies were interested in hiring from multiple majors; therefore, the total company interest count is higher than the total number of companies. The total number of companies interested in each major for the EXPO was 107 for BME, 417 for ChE, 874 for ME, and 348 for MSE. The total number of companies for SWE was 63 BME, 219 ChE, 492 ME, and 195 MSE.

The type of position each company had available was also considered in the analysis. Companies could report interest in hiring for either an internship, co-op, or full-time employment. Companies looking for research-related or academic/student positions were not included. For the scope of the paper, each type of position was divided into pre-graduation (**PRE-GRAD or PG**) and full-time positions (**Full-Time or FT**). Pre-graduation positions included co-op and internships, while full-time positions were for after-graduation hires. A single employer could select more than one type of position. These observations were counted as two instances for analysis purposes.

Student Attendance and Recruitment

The total attendance of students to the EXPO was 18,679 (‘13-‘14 = 2586, ‘14-‘15 = 3527, ‘15-‘16 = 3917, ‘16-‘17 = 4414, ‘17-‘18 = 4235) and to the SWE was 8,718 (‘13-‘14 = 1625, ‘14-‘15 = 1849, ‘15-‘16 = 1819, ‘16-‘17 = 1869, ‘17-‘18 = 1556). Table 1 presents the total number of students by major who attended each job fair. It is important to note that these major designations were self-reported by the students, and attendance to the job fair allowed both pre-major and major students. Students pre-registered through ECS for each job fair and had to *swipe-in* with their university ID’s to gain access. Pre-major students are typically in their first year and have not been accepted to their chosen major. The main focus of this paper is major students or students who have been accepted and declared a specific major.

Table 1: Attendance Numbers by Major for each Job Fair

Job Fair	Year	BME	ChE	ME	MSE
EXPO	13-14	89	395	484	94
	14-15	156	483	613	120
	15-16	216	590	695	110
	16-17	249	681	853	114
	17-18	235	611	745	133
SWE	13-14	54	266	279	64
	14-15	74	345	302	58
	15-16	73	350	292	68
	16-17	86	355	341	52

17-18	59	265	276	69
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The total number of students recruited for employment during the timeframe of this study was 9,252 (BME = 528, ChE = 3348, ME = 4626, MSE = 750). Recruitment was further subdivided into pre-graduation and full-time positions. There were a total of 6,196 students recruited to an internship or co-op position (BME = 324, ChE = 2184, ME = 3216, MSE = 472) and a total of 3,056 students recruited to a full-time position (BME = 204, ChE = 1164, ME = 1410, MSE = 278). The number of recruited students does not take into consideration where or how the student was recruited, nor if the recruitment occurred as a result of a job fair.

Attendance and recruitment values were normalized for each major. They were divided by the total number of enrolled students in that specific major for that academic year-. This normalization reflects the percentage of students in a major that attended or were recruited. In some cases, this percentage is higher than 100%, due to the presence of pre-major students in both attendance and recruitment numbers. Pre-major students are not considered students of a specific major, but often reflect a desire for a specific major. The use of major enrollment instead of total enrollment was intentional as the scope of the work looks explicitly to understand undergraduate students in their major. It also allowed identifying instances in which a major went above their enrollment numbers representing the participation of pre-majors in both attendance and recruitment.

Averaged Student Recruitment-Attendance Ratios

Recruitment-Attendance ratios (**Rec/Att**) were calculated for each major per academic year. These ratios were calculated using only the total number of student recruitment and the average job fair attendance per academic year. These ratios can be considered a rough industry participation yield metric with recruitment being an outcome and attendance an effort. This metric only considered total recruitment, instead of separating pre-graduation and full-time and averaged the job fair attendance between the EXPO and SWE.

Statistical Analysis – Friedman Test

For the statistical analysis in this paper, the median value for each observation (e.g. company interest, recruitment, attendance, recruitment-attendance ratios) was taken for each major across all academic years. These median values were then tested using a Friedman test, a non-parametric version of a repeated-measures ANOVA test. The test is used to test differences between groups (e.g., majors) accounting for multiple measurements in each of those groups (e.g., academic year). This test was used to identify differences across major while considering the variance introduced by each academic year.

Results and Discussion

College of Engineering Career Fairs

The Ohio State University College of Engineering holds two job fairs annually. The first and more highly attended by both students and industry, held in the fall semester, is the Engineering Expo that, in the last year, had 295 companies visit campus to recruit undergraduate and graduate engineering students. The second job fair is held in the spring semester by SWE, which hosts 100+ companies and allows students another opportunity to acquire an internship, co-op, or a full-time position. Figure 1 shows the total number of companies present for each job fair for the academic years '12-'13 to '18-'19.

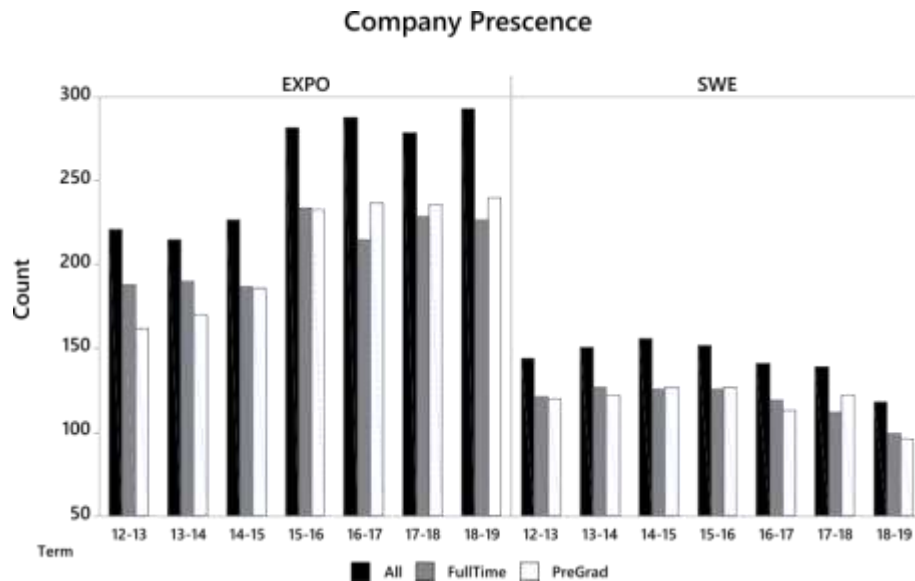


Figure 1: Total company recruitment participation for full time and pre-graduation (co-op, internship) employment during the EXPO and SWE career fairs, by academic year. (12'-13' represents fall semester 2012 to spring 2013.)

Company Interest by Major

Each company may pre-identify one or multiple majors from which they are aiming to recruit students. Figure 2 shows the average number of companies interested in a particular major. A single company can select more than one major, and only companies that specified at least one specific major were included. This graph does not include companies that selected *all majors* or *all undergraduate students*.

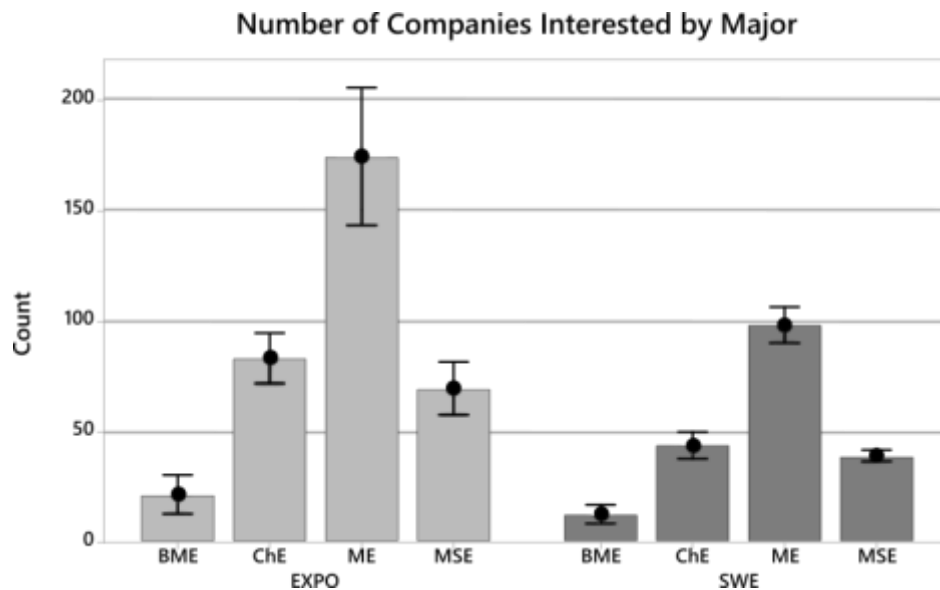


Figure 2: Company interest in majors by job fair.

The Friedman test indicated a significant differences in company interest between all four majors for the Expo ($\chi^2(3) = 15$, $p = 0.002$) and the SWE job fair ($\chi^2(3) = 14.04$, $p = 0.003$). This result confirms that the number of companies looking to hire a specific major are different for both job fairs. For the EXPO, the median values were: BME = 25.87, ChE = 86.87, ME = 187.12, MSE = 73.62. In the case of SWE, the median values were: BME = 10.5, ChE = 43.5, ME = 98.5, MSE = 37.5.

In Figure 3, the total number of companies interested in each major was further divided by the type of position. Companies looking to hire for a full-time role can be seen in Figure 3a, while companies looking to hire undergraduate students for a co-op or internship can be seen in Figure 3b. The similarity in values is due to most companies in the dataset aiming to fill both full time and co-op/intern positions simultaneously.

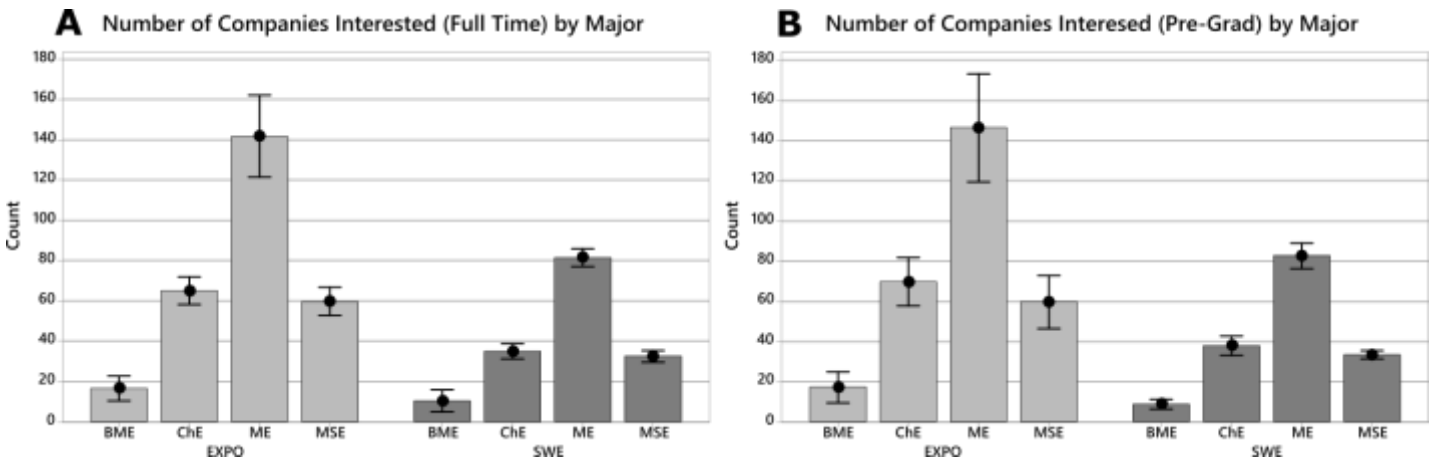


Figure 3: Company interest in majors divided by position type. Full time includes companies looking to fill a full-time position, whereas pre-grad include companies looking to fill a coop or internship.

The Friedman test found a significant difference in all cases. Companies looking to fill a full-time position were different for the EXPO ($\chi^2(3) = 14.76$, $p = 0.002$), and the SWE job fair ($\chi^2(3) = 13.56$, $p = 0.004$). Similarly, companies looking to hire undergraduate students for a co-op or an internship were significantly different for both EXPO ($\chi^2(3) = 15$, $p = 0.002$) and SWE ($\chi^2(3) = 14.46$, $p = 0.002$). This result indicates that the differences in company interest across majors do not change regardless of whether a company is aiming to fill a full-time or a pre-graduation position.

Student Normalized Attendance by Major

Student attendance to each job fair was collected through a registration process for all majors handled by ECS. The total number of reported students in attendance by major was then normalized versus the total major enrollment for that academic year. As mentioned before, this percentage can be above 100% given that pre-major students participate in the job fair and represent a sizable population. Figure 4 shows the average percentage of major students that participated in each job fair. It can be observed that the EXPO not only was the most attended but had the most amount of major and pre-major students present. On the other hand, the SWE had noticeably lower participation relative to major enrollment and more consistent participation between each term.

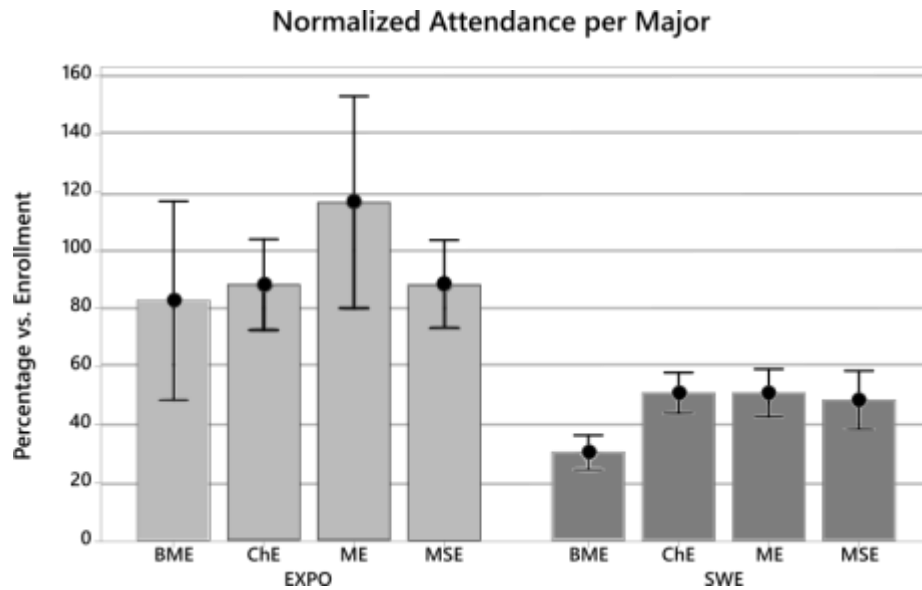


Figure 4: Normalized attendance per major for each job fair. It represents the average percentage of enrolled students in a major that participated in each job fair. This value can be higher than 100%.

The Friedman test of this data set yielded an unexpected result. There was only a significant difference between relative majors' participation in the EXPO ($\chi^2(3) = 9.24$, $p = 0.026$), but not in the SWE ($\chi^2(3) = 6.84$, $p = 0.077$). This indicates that, relative to major enrollment, student participation was found to be different only in the EXPO, and not the SWE. The median values for each major in the EXPO were: BME = 91.86, ChE = 91.95, ME = 123.06, MSE = 94.37. The median values for each major in SWE were: BME = 30.93, ChE = 54.0061, ME = 52.3954, MSE = 55.56. Considering these median values, it is possible that the EXPO yielded significant differences between majors simply because of ME's relatively large median value (123.06).

Student Normalized Recruitment by Major

The total number of undergraduate engineering students recruited by companies, by major and by position (pre-graduation vs. full-time), was obtained as a single value across an entire academic year. The data does not differentiate whether the position was obtained as a direct result of a job fair or from other efforts by the student. In Figure 5, the averaged percentage of students recruited for each major is shown. Similar to student attendance, recruitment values were normalized by the enrollment to a major.

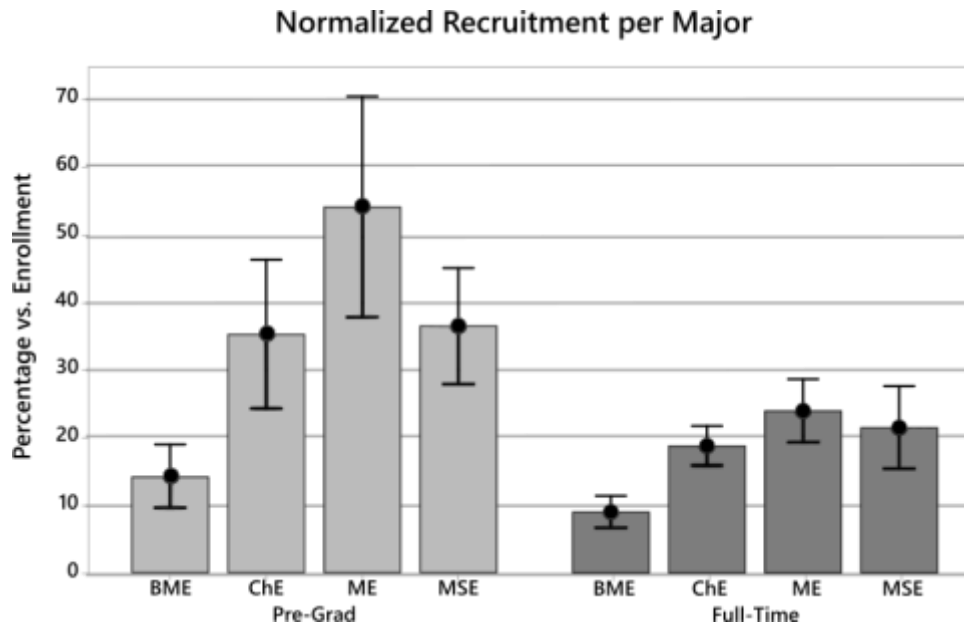


Figure 5: Normalized attendance per major for each position type. It represents the average percentage of enrolled students in a major that was recruited.

Through Friedman test analysis of the normalized recruitment values, it was observed that company recruitment was different across each major for both pre-graduation ($\chi^2(3) = 13.56$, $p = \mathbf{0.004}$) and full-time positions ($\chi^2(3) = 10.68$, $p = \mathbf{0.014}$). This result highlights that recruitment across majors is different for both pre-graduation positions (e.g. co-op and internships), as well as full-time positions. The median values for pre-graduation recruitment were: BME = 16.18, ChE = 39.35, ME = 56.36, MSE = 38.91. The median values for full-time recruitment were: BME = 9.18, ChE = 19.84, ME = 25.10, MSE = 21.09.

Recruitment/Attendance Ratios

A great deal of information can be gleaned from analysis of student attendance to each job fair, and the recruitment of students by companies each academic year. However, by calculating the recruitment-attendance ratios, it is possible to put in perspective how each student's outcomes by major (successful recruitment) relate to a measure of the student's effort by major (career fair attendance). Unlike normalized attendance and normalized recruitment, these ratios represent overall recruitment (including pre-graduation and full-time) relative to each majors' attendance to job fairs (averaged between job fairs). In this figure, a value higher than one represents that more students were recruited in that major compared to the average attendance between job fairs.

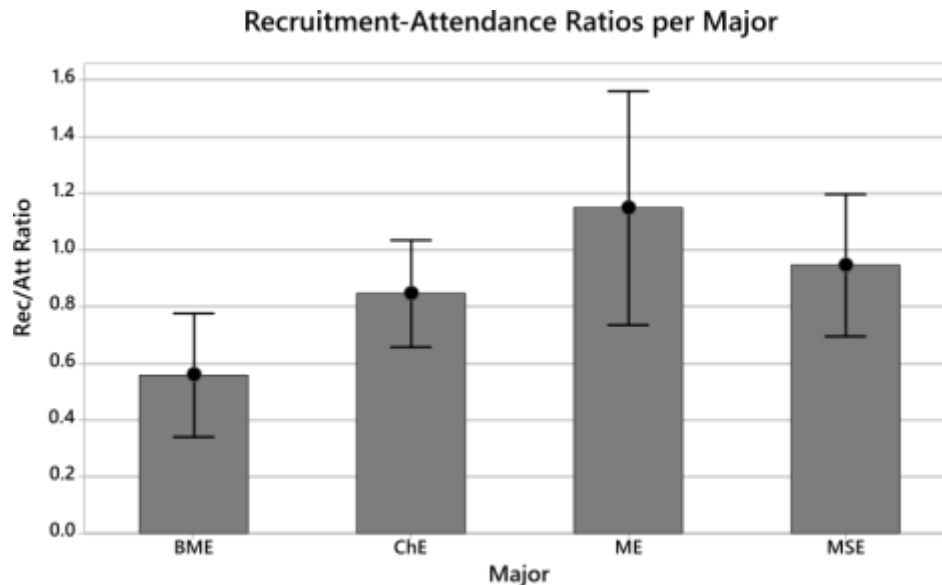


Figure 6: Recruitment-Attendance ratios for each major averaged across academic years. Recruitment includes both pre-graduation and full-time recruitment, and attendance is averaged across both job fairs.

The Friedman test found a significant difference in the recruitment-attendance ratios across majors ($\chi^2(3) = 12.84$, $p = 0.005$). This indicates that the recruitment yield (students recruited over those attending) is different across majors. The median recruitment-attendance ratios for each major were: BME = 0.46709, ChE = 0.77721, ME = 1.04163, MSE = 0.78912. These results indicate that roughly 46% of students that attended the job fair are recruited in BME, compared to 104% in ME. This means that ME students have more likelihood of finding jobs outside the job fair than BME students.

Conclusion and Future Direction

This study aimed to analyze differences in industry participation between engineering majors, undergraduate engineering student participation in job fair events, and student hiring recruitment trends. Gaining more knowledge of these similarities and differences would allow for better interventions as faculty and administrators. The Ohio State University Department of Biomedical Engineering has observed lower hiring trends for undergraduate biomedical engineering students pursuing industry relative to other engineering majors. In this study, the number of companies interested in a major was different between majors. This makes it clear that companies present in each job fair have a higher preference for some major over others.

On the other hand, relative student participation was noticeably different, at least for the **EXPO**. Understanding if that difference is more prevalent of pre-major students or a different effect would require further study. Undergraduate student hiring was observed to be different between majors, but this has been previously reported (Nocera et al. 2018, Ortiz-Rosario et al. 2019). This study also found that recruitment-attendance ratios, a rough metric of yield, were significantly different between engineering majors. With better recruitment data, these ratios could indicate differences in the effectiveness of job fairs for different engineering majors. Future work will continue to search for factors that explain *why* there is a gap in BME industry hiring, and on *ways* to bridge that gap.

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References:

McFadden, C. (2019). from <https://interestingengineering.com/7-of-the-most-in-demand-engineering-jobs-for-2019>.

Moalloy, T. (2018). "9 Popular (and High Paying) Engineering Careers." from <https://www.gijobs.com/9-popular-engineering-careers/>.

Nocera T.M., Delaine D.A., Ortiz-Rosario A., Shermadou A. (2018) Bridging the Gap between BME and Industry: A Case Study, ASEE, Salt Lake City, UT.

Ortiz-Rosario A., Shermadou A., Delaine D.A., Nocera T.M. (2019) To what extent does gender and ethnicity impact engineering students' career outcomes? An exploratory analysis comparing biomedical to three other undergraduate engineering majors, ASEE, Tampa, FL.

Torpey, E. (2018). "Engineers: Employment, pay, and outlook." from <https://www.bls.gov/careeroutlook/2018/article/engineers.htm>.

U.S. Bureau of Labor (2019). from <https://www.bls.gov/ooh/architecture-and-engineering/home.htm>.