

Toward Broadening Participation: Understanding Students' Perceptions of Industrial Engineering

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Introduction

Advances in engineering are critical to addressing societal challenges. Conveying this message is essential to efforts to recruit and retain a diverse community of future engineers. A study by the National Academy of Engineering (NAE) suggests that students are most drawn to messages that emphasize the impact that engineers have on real-world problems that affect people's lives³. There is evidence to suggest that this is especially true for students from underrepresented groups^{3,5}, and that freshman women in engineering may have a lower perception of how engineers contribute to society than do men in the same cohort¹. These findings have implications for recruitment, retention, and graduation of students in industrial engineering (IE) curricula.

In this paper, we describe the findings of a pilot study that measured current IE students' interest in solving operations research problems in different industry sectors and their perceptions about industrial engineering careers. The aim of the study is to gain greater understanding about the interests and perceptions of current IE students at Kansas State University (KSU). While the specific results are most directly applicable to the institution where the study was conducted, we comment on broad insights of interest to the industrial engineering education community.

The pilot study described here is part of a planned long-term effort to understand the perceptions of prospective (pre-college) students and those of students at multiple stages in the curriculum. The overarching objective is to design recruitment and retention activities that emphasize the ways in which industrial engineering is applicable in domains that are of interest to students. Thus, in addition to findings from the pilot study, we also discuss opportunities to use these preliminary results to guide future studies and to inform recruitment activities and curriculum design.

Literature Review

Engineering has traditionally been portrayed as a difficult discipline. Excellence in mathematics and science are often promoted as primary criteria for success, and job elements requiring creativity, interaction with people, and impact on pressing societal problems have not been highlighted. The National Academy of Engineering undertook a series of efforts to gauge public understanding of and response to different messages about engineering, and subsequently to recommend strategies for implementation of effective messaging^{3,4}. In particular, this work identified the need for messages that emphasize creative aspects of engineering careers and the opportunities engineers have to make a difference on the most challenging problems that face our society.

Importantly, the NAE work and other studies provide evidence that students from underrepresented groups in particular are drawn to messages that emphasize the human and societal impact that engineers have^{3,4,5}. One study found that freshman women in engineering

may have a lower perception of how engineers contribute to society than do men in the same cohort¹. However, activities that introduce pre-college students to the human impact potential of engineering have been shown to increase students' interest in engineering careers⁷. The changes were most significant among female, African American, and Hispanic students. The results point to an opportunity to design recruitment and retention efforts with these messages in mind.

A diverse community of future engineers is needed to address the challenges faced by society. Women and persons from several racial/ethnic groups continue to be underrepresented in engineering curricula and careers. As of 2009, undergraduate engineering enrollment nationwide included 17.9 percent females and 16.1 percent Black, Hispanic, and Native American students⁶. Women make up 31 percent and Blacks, Hispanics, and Native Americans are 8.8 percent of industrial engineering undergraduate students at KSU². A significant majority of students come from within the state of Kansas, and one goal for the department is to recruit and retain students such that the undergraduate demographic more closely matches that of the state, where women make up 50.3 percent and the aforementioned minority groups approximately 18.4 percent of the population. This study aims to provide initial insights upon which further studies can be based to understand students' interest in and perceptions of industrial engineering as a career, which in turn may help in those recruitment and retention efforts.

Methodology

Two cohorts of undergraduate IE majors in a required operations research course at KSU responded to a survey. The survey consisted of four categories of questions. Questions in the first category measured students' level of interest in different industry sectors that employ industrial engineers. Students were given short descriptions of hypothetical problems, class projects, and career fair job postings, with descriptions being drawn from the entertainment, financial, humanitarian, and manufacturing sectors. Respondents indicated their interest levels in each problem or job opportunity using a five-point Likert scale (very interested, interested, neutral, uninterested, or very uninterested).

In the second category of questions, students were asked to indicate their reasons for pursuing an industrial engineering degree. They were first asked to select all applicable reasons from a set of five choices (see Figure 1), with the opportunity to specify 'other' for reasons not on the list. Students were then asked to select the one top reason that they chose to major in industrial engineering from the same list of options.

Figure 1. Survey Options: Reasons for Choosing Industrial Engineering Major

- I knew someone who had majored in IE.
- I thought that becoming an IE would provide job security.
- The starting salary of an IE was attractive.
- I thought that becoming an IE would help me make positive changes in the world and in my community.
- The variety of types of jobs I could do as an IE was attractive.

The third category of questions asked students to select phrases that they felt best described industrial engineering. The questions from this category are summarized in Figure 2. Phrases and keywords for this question category were selected in part based on those suggested by NAE reports about messaging in engineering. These reports introduced messages that portray engineering as a creative endeavor that makes a difference in people's lives^{3,4}.

Figure 2. Survey Questions: Descriptions of Industrial Engineering

<p>Which best describes what an industrial engineer does, from your point of view?</p> <ul style="list-style-type: none">• IEs create efficient systems and processes that advance manufacturing.• IEs create efficient systems and processes that are essential to our health, happiness, and safety.• IEs create efficient systems and processes that improve companies' financial strength.• IEs create efficient systems and processes that make our world a better place. <p>Which adjective best describes industrial engineers?</p> <ul style="list-style-type: none">• visionary• creative• efficient• diverse
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The final category of questions consisted of demographic information. Students were asked to indicate their class standing (freshman, sophomore, junior, or senior), gender, and high school graduating class size. These data were collected to make it possible to identify differences in responses to questions in the first three categories among different subgroups within the surveyed cohorts. If identified, such differences could support more detailed studies, which in turn could lead to differentiated recruitment or retention strategies. High school graduating class size is of particular interest because the Department of Industrial and Manufacturing Systems Engineering at KSU draws students both from very rural high schools and from urban areas, and these students may benefit from different approaches. Although race and ethnicity information about respondents would also have been useful, the survey did not include a question about this. The small number of persons from underrepresented racial and ethnic groups in the sample could have made it possible to identify individual respondents from the answers to such a question.

The survey responses were analyzed to gain insight about the following questions:

- Do students express stronger interest in solving problems or pursuing jobs in particular industry sectors than in others?
- What factors contribute to students' choices to major in industrial engineering?
- To what extent do students describe industrial engineering as a career that makes a difference in society?
- Do the responses of majority group students differ significantly from those of students from underrepresented groups?

The results of these analyses are described in the next section.

Results

A total of 39 complete survey responses were received from the two cohorts of students. Of these, 16 respondents were female, 22 were male, and one chose not to provide his/her gender. Among those respondents that indicated class standing, three were sophomores, 22 juniors, and 13 seniors. The breakdown of respondents by high school graduating class size is provided in Table 1. On average, students took about six minutes to complete the survey.

Table 1. High School Graduating Class Size of Survey Respondents

Class Size	Number of Respondents
1-50	5
51 - 150	6
151 - 250	13
251 - 350	5
351 - 450	8
greater than 450	1

Responses to four survey questions about problems, projects, and career fair job postings in the entertainment, financial, humanitarian, and manufacturing industries were aggregated to gain insight to students' overall interest levels in these sectors. The aggregated response totals are illustrated for all respondents in Figure 3. The entertainment industry received the most 'Very Interested' and 'Interested' responses. This category included questions about sports scheduling, movie cinema management, and amusement parks, for example. Although the financial sector received the fewest 'Very Interested' responses, many students were 'Interested' or 'Neutral' about these problems, which included examples about insurance and investments. This sector registered the largest number of 'Uninterested' and 'Very Uninterested' responses. Interest in the humanitarian sector was fairly strong. Problems and job opportunities related to blood drives, food banks, and international public health received the second largest numbers of 'Very Interested' and 'Interested' responses (the latter being tied with the financial sector), and relatively few responses in the bottom two categories. Finally, descriptions from the manufacturing sector received the second largest numbers of responses in the 'Interested', 'Neutral', and 'Uninterested' categories. These examples included automobile, consumer electronics, heavy equipment, and fashion manufacturing descriptions. Importantly, all four industries received significantly more favorable or neutral responses than unfavorable ones.

Figures 4 and 5 illustrate the differences in interest levels between female and male students. Among female students, the entertainment and humanitarian sectors received many more 'Very Interested' responses than did the financial and manufacturing sectors. Male students were most interested in entertainment, followed by manufacturing, with financial and humanitarian sectors receiving the fewest 'Very Interested' responses. Among both female and male students, the financial and manufacturing industries received the greatest number of 'Uninterested' responses. Overall, the distribution of female students' responses for all industries is toward greater interest in the problems and jobs described, whereas for male students the distribution includes a larger fraction of 'Uninterested' and 'Very Uninterested' responses.

Figure 3: Students' Interest Levels in Problems and Jobs in Different Industries

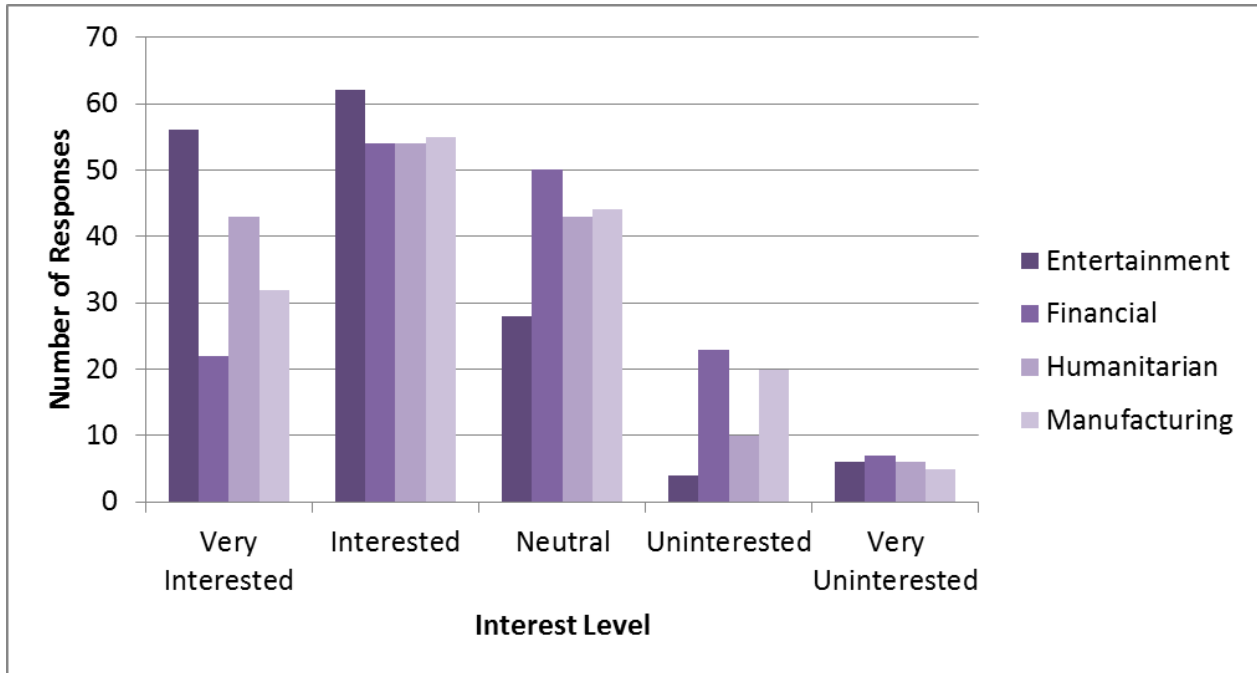


Figure 6 summarizes the reasons that students identified for choosing to major in industrial engineering, where each student could choose all applicable reasons. Among the full sample, the variety of jobs available to industrial engineers received the most responses (34), followed by starting salary (29), job security (26), and the potential to make positive changes in the world and community (22). Fifteen respondents said that knowing someone else who studied industrial engineering contributed to his/her choice of major. Ten students identified another reason, such as interest in the concepts or a fit with his/her personality. Differences between genders are also illustrated in Figure 6. The top three reasons among female students included variety of jobs (16), job security (11), and starting salary (9). Among male students, starting salary received the most responses (19), followed by variety of jobs (17), and job security and the opportunity to make positive changes (each with 14).

Figure 4: Female Students' Interest Levels in Problems and Jobs in Different Industries

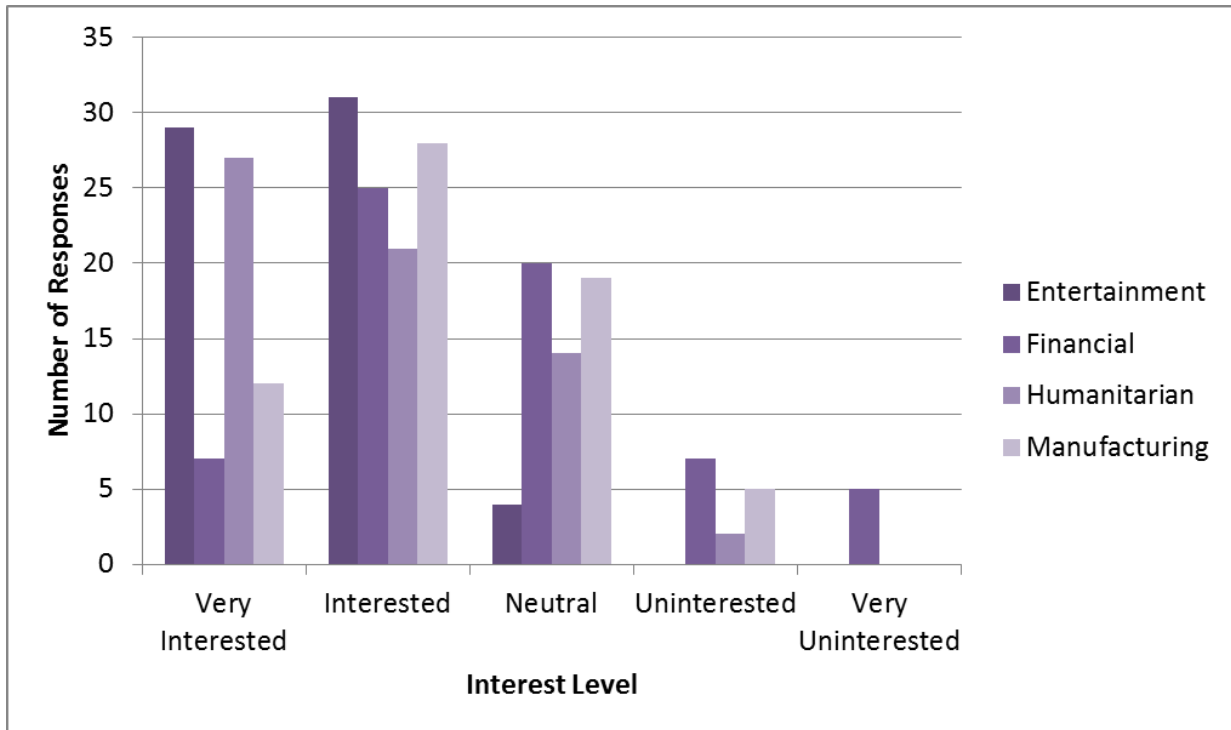


Figure 5: Male Students' Interest Levels in Problems and Jobs in Different Industries

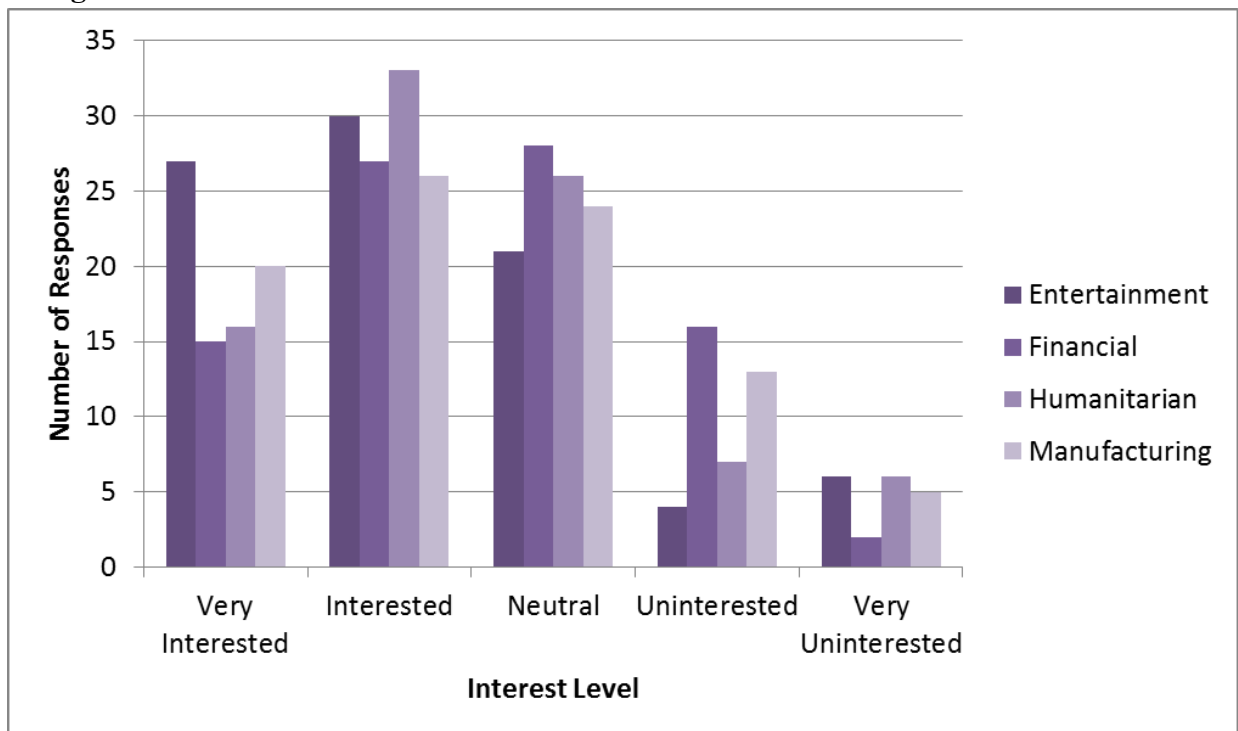


Figure 6: Students' Reasons for Choosing to Major in Industrial Engineering
 (note: sum of female and male responses may not match totals since not all respondents provided gender)

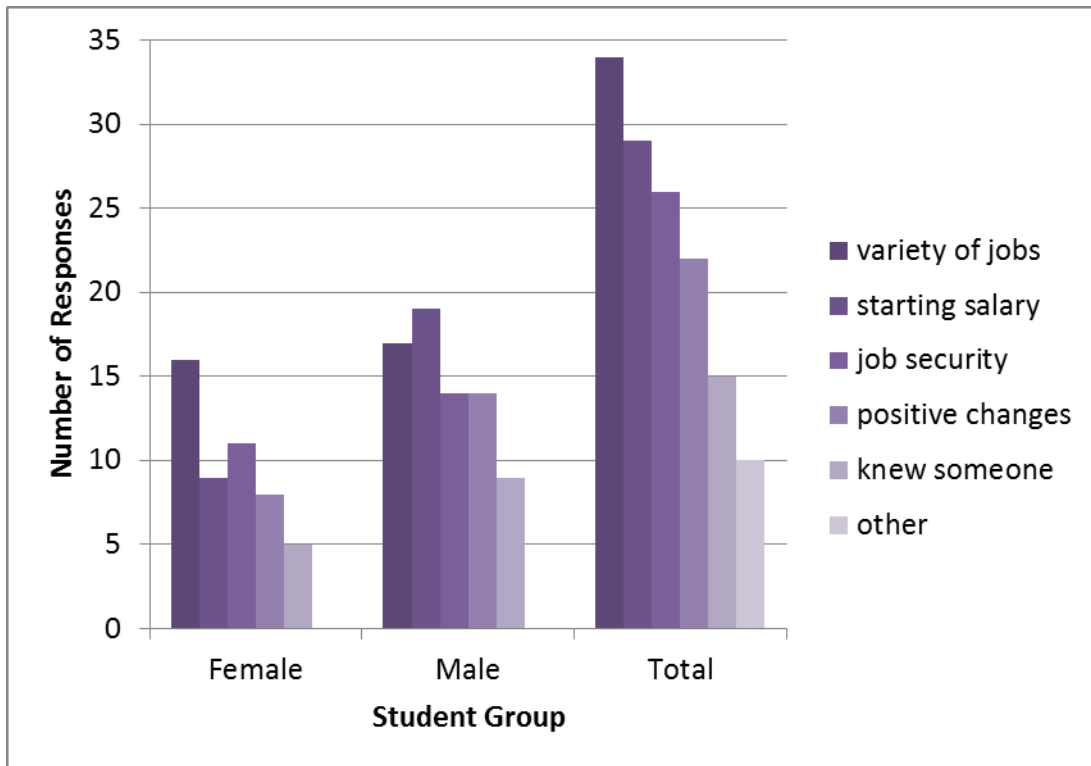
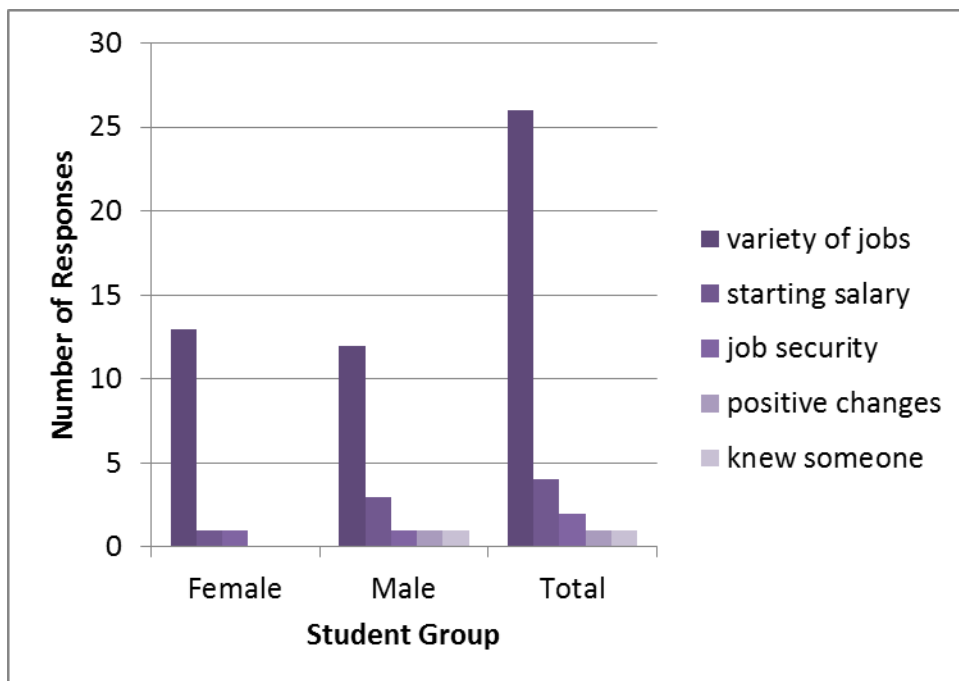


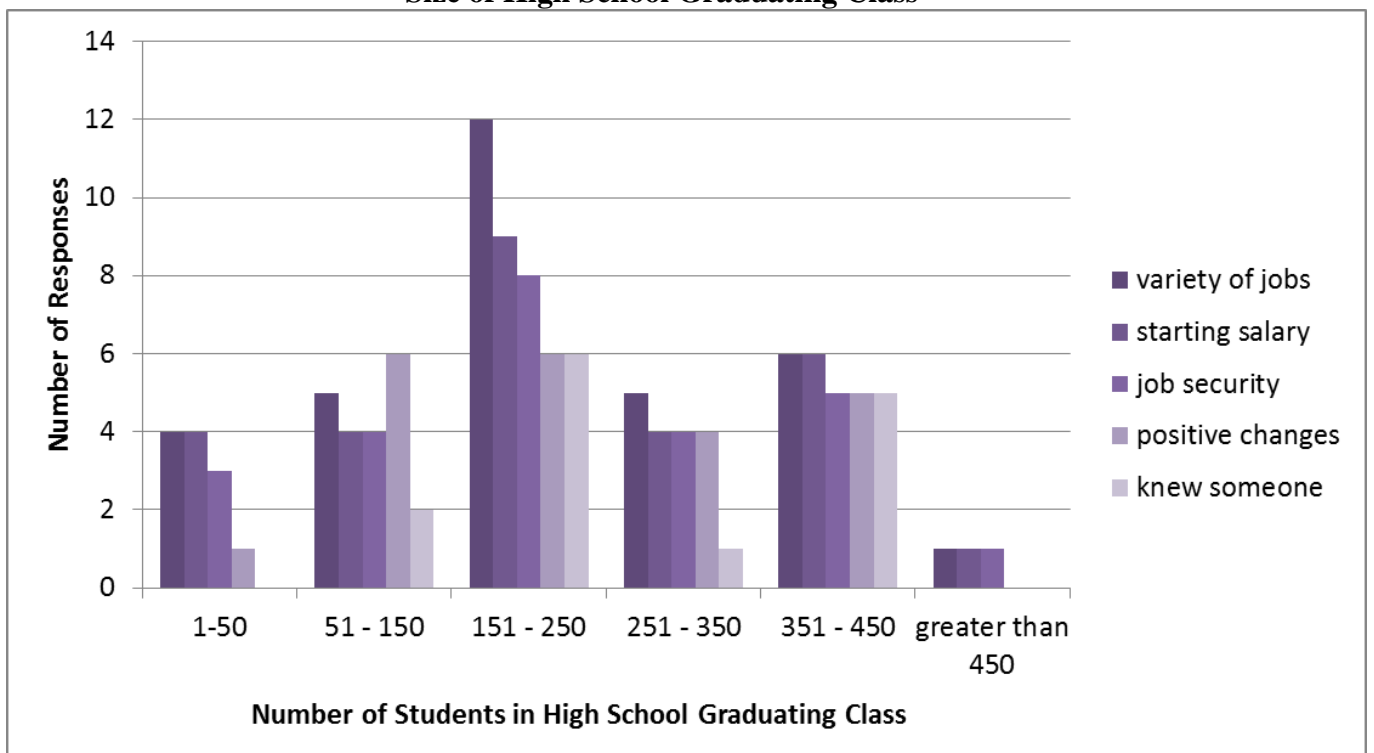
Figure 7: Students' Top Reasons for Choosing to Major in Industrial Engineering
 (note: sum of female and male responses may not match totals since not all respondents provided gender)



When asked to identify the one top reason for choosing to major in industrial engineering, the variety of jobs available received the most responses among the whole group (26), as well as among both female (13) and male (12) students. Each other reason received four or fewer responses. Figure 7 summarizes these results.

In Figure 8, students' reasons for majoring in industrial engineering are broken down by their high school graduating class sizes. Almost uniformly, the ordering of responses (from greatest to least, although there are some ties) is variety of jobs, starting salary, job security, the opportunity to make positive changes, and knowing someone else who majored in IE. The exception to this order occurs for students graduating in a class of 51 – 150 students. In this group, the opportunity to make positive changes was selected most frequently.

Figure 8: Students' Reasons for Choosing to Major in Industrial Engineering, Given by Size of High School Graduating Class



When asked to select the best description of what an industrial engineer does, most students responded that industrial engineers 'make our world a better place' (see Table 2). Eighteen students selected this statement, while 10 indicated that industrial engineers 'improve companies' financial strength'. Fewer students (7) selected the statement that specifically emphasized manufacturing. The statement describing industrial engineering as 'essential to our health, happiness, and safety' received the fewest responses.

Table 2: Responses to Question about What Industrial Engineers Do

Which best describes what an industrial engineer does, from your point of view?	
Description	Number of Responses
IEs create efficient systems and processes that advance manufacturing.	7
IEs create efficient systems and processes that are essential to our health, happiness, and safety.	4
IEs create efficient systems and processes that improve companies' financial strength.	10
IEs create efficient systems and processes that make our world a better place.	18

The overwhelming majority of students (26) selected ‘efficient’ as the adjective that best describes industrial engineers. Each of the other options also received some responses, however: ‘diverse’ was selected by six students, ‘visionary’ by four, and ‘creative’ by three.

Table 3: Responses to Question about Industrial Engineering Descriptors

Which adjective best describes industrial engineers?	
Description	Number of Responses
visionary	4
creative	3
efficient	26
diverse	6

Discussion and Conclusions

The results of the survey provide useful insights about current IE students at KSU and also point to opportunities for further study. A common theme that emerged across the different question categories was students’ broad interests in multiple industries and the appeal of a variety of future job opportunities for those with an IE degree. These findings support course or curriculum designs that maintain or increase the number of opportunities that students have to solve problems related to industries that spark their interest, especially in sectors such as entertainment or humanitarian work that may not typically be represented in textbook problem sets. Messages for prospective industrial engineering students should highlight the wide variety of jobs available to industrial engineers, with attention to jobs in emerging sectors in addition to more established ones. Future research could expand the scope of this survey to explore

additional sectors in which industrial engineers work and present additional problem or job descriptions for each sector.

The survey suggests that the many reasons that contribute to a decision to study IE may differ between genders, but there appears to be little difference among students from different high school graduating class sizes. Furthermore, an overwhelmingly common reason that students chose IE is the variety of jobs that IEs are prepared to do. Future recruitment and retention efforts may benefit from messages that account for the differences suggested here but that also emphasize the overarching common themes. Additional research could explore more deeply whether the message that IEs make a positive impact on society is being received by current students and whether this message is more appealing to students from particular backgrounds or prior educational experiences.

Students' responses related to descriptions of IE offer evidence that students do describe industrial engineering work as making a difference in society, although further study is needed to fully understand students' perceptions. IEs are, not surprisingly, identified most strongly as being 'efficient'. There may be opportunities to use this descriptor in conjunction with messages that emphasize the ways that efficiency requires creativity, diversity, and vision.

This study focused on current IE students in the middle-to-late stages of their studies. An important limitation of this study was the inability to capture race/ethnicity of respondents. While this pilot study was limited in scope, it is part of a broader planned effort. Future work, including surveys of pre-college students and of students at multiple stages in the IE curriculum, is planned and is expected to provide a more complete picture of interest in and perceptions of industrial engineering.

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