

# **Engineering Students and Group Membership: Patterns of Variation in Leadership Confidence and Risk Orientation**

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# **Engineering Students and Group Membership: Patterns of Variation in Leadership Confidence and Risk Orientation**

### Abstract

This paper examines variance in leadership confidence and risk orientation attributes across a sample of n=1,061 senior year mechanical engineering students drawn from nine U.S. engineering schools. These attributes theoretically relate to students' development within engineering leadership educational programs and to students' career choice behaviors. Data were collected as part of a larger forthcoming study that will analyze the attributes' association with students' demonstrated engineering job and task preferences. In this paper, we introduce our conceptualization and measurement methods for the leadership confidence and risk orientation variables following a review of the related literature. We hypothesize that these attributes vary, on average, in association with observable student participation choices, such as the choice to join a fraternity/sorority or to participate in varsity athletics; we also hypothesize that the attributes vary in association with socioeconomic background and gender. We then present results demonstrating statistically significant differences in these attributes, on average, depending on students' association with one or more of such groups or demographics. Meanwhile, we find no statistically significant differences in average values of the leadership confidence or risk attributes across the universities participating in the study.

Our results suggest that pockets of higher and lower average leadership confidence or risk orientations can be expected to exist within a given university's student body, as associated with group memberships and demographics. These results are important in light of engineering educators' increased attention in recent years to the development of leadership capabilities in engineering students, since attributes such as these may relate to how students perform and progress in engineering leadership courses and to how they progress in their careers. For engineering leadership educational courses that are optional or elective, educators may wish to assess the cross-sectional representativeness of their course cohorts to be aware of whether they are over- or under- sampling from certain student groups. Additionally, our data suggests implications for assessing cohort composition within such courses, for methods employed in courses' learning outcomes assessment, and for course or program degree-credit and recruitment approaches.

## Introduction

Despite their increasing prevalence, most Engineering Leadership (EL) courses are still optional or elective for engineering undergraduates [1]. Herein, we present data showing variation among engineering students in key attributes related to leadership and career development – and, correspondingly, related to learning experiences in EL courses. This variation appears to be at least partly systemic: attributes vary, on average, in association with student group affiliations and demographics. This paper discusses how knowledge of these patterns of student variation can help EL educators better assess their courses' student composition, outcomes attainment, recruitment, and reach.

Today's engineering employers seek graduates with leadership capabilities in addition to their technical capabilities [2-4]. In response, engineering educational programming centered on leadership learning objectives has grown rapidly in recent years. Though programming continues to evolve, it currently tends to manifest as co-curricular coursework in engineering schools [1, 5-9]. Such coursework is usually voluntary [1; as examples, see: 10, 11], though exceptions that are mandatory exist [12]. Evidence thus suggests that engineering leadership courses at universities often do not reach all engineering students, but rather a self-selected subset. While literature indicates that EL programming is more effective when integrated into the core curriculum rather than distributed in optional activities [13], other studies reveal that changing the engineering core curriculum can be quite difficult [6, 14, 15]. These latter studies, coupled with the observed trend of optional EL course implementation, suggest that the self-selective nature of students' EL course participation will continue to be commonplace – at least in the near term.

Given the voluntary status of many undergraduate EL courses, it may be appropriate for EL educators to consider the cross-sectional representativeness of their course cohorts relative to their university's overall engineering student body. Beyond the important diversity dimensions of academic major, gender, and underrepresented minority status, this study examines two additional dimensions of diversity that theoretically relate to both students' developmental experiences within engineering leadership programs and to their career development. We hypothesize that measures of *leadership role confidence* and *risk orientation* vary among students in consistent patterns in association with certain student group affiliations and demographics. We base these hypotheses on a literature review presented herein and test the hypotheses using empirical data. Specific measures employed for the two attribute variables are described in the Methods section of this paper. The group affiliations and demographic dimensions that correlate with these two attributes may serve as appropriate additional diversity metrics for evaluating the balance and representativeness of EL course cohorts and student teams.

We began this study by posing a general question: *how might undergraduate engineering student populations be heterogeneous in ways that are important for engineering leadership educators to be aware of*? We primarily concerned ourselves with the interests of educators leading courses or programs that sample a relatively small percentage of their host institutions' engineering students, and thus may be particularly susceptible to cohort non-representativeness due to student self-selection effects. We focused our literature review on identifying attributes suspected of varying widely among students, that have known or posited attributions to student group membership or demographics, and that have theoretical implications for students' engineering leadership and career development – two areas of development that we presume relate to the aims of many EL courses and programs. We were also most interested in student attributes that are consistent, on average, across universities, yet vary significantly within them. Based on the above aims and search results, this study then considered an array of student-specific social, economic, and education variables measured as part of a larger forthcoming study in which engineering students' job and task preferences will be examined (n = 1,061 student participants across nine universities); this dataset also includes information about student group affiliations and demographics. Leadership role confidence and risk orientation variables stand out as meeting the criteria of interest and carrying implications for EL educators.

We generally conceptualize leadership role confidence as an individual's assuredness that they can fulfill leadership roles, and generally conceptualize risk orientation as an individual's tolerance for monetized risk, ranging from risk-averse to risk-seeking. These simplified definitions unify concepts from the various literatures we reviewed, which often employed subtly different conceptualizations and measures of leadership confidence and risk orientation. Some studies of leadership applied to students, for example, use a self-efficacy approach [16, 17] or employ broad multi-dimensional assessment instruments [18], while others use more focused measures of certain skills or abilities [19, 20]. Our data collection was subject to practical constraints that led us to employ simple, generalized measures, as described in the Methods section alongside a more detailed discussion of the rationales behind our conceptualization of these variables.

## Literature Review

Research suggests that students' confidence in their leadership abilities correlate with their participation in various voluntary student groups or activities, such as athletics, fraternities/sororities, or non-academic clubs [16, 18, 19, 21]. Additionally, students' incoming leadership confidence and abilities may affect their developmental experiences and those of the other students around them in leadership courses or programs that involve team-based work or activities [22 - 24]. The data linking leadership confidence and various student group participation is correlative in nature and has been measured in differing ways. Nevertheless, these trends prompt concerns about the impact that either over- or under-sampling students from various groups may have on the overall developmental environment in voluntary EL programs. Reinforcing this concern for representative balance is data suggesting that student participants in varsity athletics and fraternities/sororities exhibit a reduced likelihood of taking on an engineering career at graduation [25] – while, on the other hand, research demonstrates an overall team performance benefit of including those with developed leadership abilities on diverse student teams [22].

Varsity athletics participation and fraternity/sorority (hereafter, "Greek Life") participation stand out amongst the literature discussing students' leadership development in non-academic extracurricular activities. Other non-academic student club experiences may also have important associations with students' leadership development [13, 19]; such other clubs and their associated experiences and levels of commitment, however, may vary across universities in ways that are not easily observable. We consequently chose to focus our multi-university analysis on varsity athletics and Greek Life based on an assumption that these are relatively consistent activities nationwide. Existing literature suggests that participation in athletics correlates with higher leadership self-confidence or abilities. For example, based on an empirical study, Galante and Ward observe: "female [university] athletes are more likely than non-athletes to be categorized into profiles reporting higher levels of self-esteem and leadership characteristics" [18]. McFadden and Stenta suggest a framework linking leadership development to students' recreation and athletics experiences [21]. Dugan and Komives note higher levels of "leadership efficacy" in incoming college students who had been active in varsity sports in high school [16]. And Ro and Knight observe increased "leadership skills," on average, among university students who participated in athletics (among other non-academic student groups) [19]. This literature prompts us to expect that measures of students' leadership confidence will be higher, on average, for those who participate in varsity athletics compared to others.

Similarly, past studies suggest a link between Greek Life participation and leadership confidence or abilities. Routon and Walker, for example, note relative increases in Greek Life participants' self-assessed leadership abilities [20]. Mills and Bruce observe high self-ratings of Greek Life participants across several measures of a standardized leadership skills instrument [26]. Ro and Knight associate Greek Life participation (among other non-academic collegiate experiences) with higher levels of "leadership skills" [19]. It is important to note the correlational nature of these studies' results, and to point out that this scholarship also indicates developmental areas for improvement associated with Greek Life participation [see: 20, 26]. We nonetheless expect, based on this literature, that measures of students' leadership confidence will be higher for Greek Life participants, on average, compared to others.

Extant research also suggests connections between two key demographic variables and students' risk orientation. Both family wealth [27, 28], and gender [29 - 32], have been shown to correlate with students' attitudes toward and tolerance of risks. Engineering Leadership educators may be interested in these relationships for two reasons. First, handling risks is an important facet of engineering project execution [33] and student project team members' assessment of risks and associated decision-making may be influenced by the collective risk orientations of project team members. Toh and Miller, for example, found that engineering students' design concept generation and concept selection behaviors were significantly related to levels of risk-aversion [34]. Similarly, Charyton and Merrill found that individuals' degree of risk tolerance influences creative design processes [35]. Secondly, risk orientation has been shown to be a key factor in career choice [27, 28], with risk-aversion correlating significantly with the choice of engineering as a career, and risk-seeking propensity correlating with choices of other (non-engineering) career types [27]. Given the varied implications of differing risk orientations, EL educators may wish to be aware of representativeness and balance of risk orientations in EL program cohorts.

Economics research relates student risk orientation to family wealth. Saks and Shore [27] and Caner and Okten [28] find that students from wealthier families are more likely, on average, to possess a higher risk tolerance. Additionally, literature suggests a correlation between family wealth and likelihood of carrying student loan debt [36-38]. Since student loan debt may influence individuals' choice of extracurricular or co-curricular activities during college [39], it may also be a factor related to the sorting of risk-seeking and risk-averse individuals into different voluntary activities or programs on campus. Based on the literature, we expect an association between student loan debt and risk orientation among engineering students.

Finally, researchers have examined the relationship between gender and risk orientation. Correlation between female gender and risk-aversion, and male gender and risk-tolerance, are documented by several studies [29-32]. This research, combined with the research describing risk orientation's role in engineering design execution [34, 35] reinforces the significance of gender make-up in student teams' deliberation processes during design and decision-making. Gender diversity in EL course cohorts is an important factor that can shape the developmental

environments in courses – gender-diverse teams may provide students with valuable practice opportunities for navigating differences in risk orientations among team members. Based on extant literature, we expect to find that female gender will correlate with risk-aversion in our dataset.

# Aims and Hypotheses

In sum, prior literature suggests that athletics participation, Greek Life participation, and student loan debt status may signal potentially meaningful differences in expected student characteristics that relate to leadership and career development. This paper constructs and tests unifying hypotheses derived from prior work to validate (or call into question) these group signifiers as important diversity metrics for EL educators. We also acknowledge prior conclusions about the association between gender and risk orientation and aim to test whether the conclusions replicate in this study.

We test the following four hypotheses based upon the literature review:

*Hypothesis 1A:* higher leadership role confidence among engineering students, on average, is associated with varsity athletics participation.

*Hypothesis 1B:* higher leadership role confidence among engineering students, on average, is associated with fraternity or sorority membership.

*Hypothesis 2A:* increased likelihood of having a risk-averse orientation among engineering students, on average, is associated with carrying student loan debt.

*Hypothesis 2B:* increased likelihood of having a risk-averse orientation among engineering students, on average, is associated with female gender.

Following a discussion of the methods employed for data collection, hypothesis tests, and presentation of results, we discuss implications for EL educators and suggest follow-on research. Our overarching aim is to help EL educators better understand heterogeneity among students that may relate to both engineering leadership development and career development of students in EL courses or programs. Constituent aims include better equipping EL educators to optimize recruitment and retention strategies for representative cohort formation (in the case of voluntary EL programs), to suggest metrics for diverse team formation within cohorts (in the cases of both required and voluntary EL programs), and to discuss implications for programmatic assessment related to potential self-selection biases and means of control. It is also our hope that this paper sparks conversations and follow-on work related to any of these constituent aims.

# Methods

# Conceptualization and Measurement of Key Variables

Data collection for this study leveraged an opportunity to acquire student-specific information as part of a larger study involving job preference experiments. Aligning this research with the larger study presented a unique opportunity to obtain a robust sample – over 1,000 survey responses at close to 90% participation rate among target respondents – yet, one that was accompanied by the

tradeoff of a highly constrained paper-based survey form. In light of the constraints, our research approach involved pilot testing and refining concise, generalized measures of the variables of interest. The leadership role confidence and risk orientation measures presented in this section were designed based on the literature, tested in advance with a smaller sample of 99 respondents, and then refined based on pilot test respondent feedback about clarity. We believe this approach aligns with this paper's scope of testing unifying hypotheses that support and generalize upon prior findings.

In conceptualizing a leadership confidence variable, we utilize a "role confidence" approach similar to Cech et al.'s measurement of confidence toward achieving professional outcomes [40]. We designed our measure as a means of differentiating among students who felt they were ready to lead in professional settings at a young age, compared to those less confident in such readiness. While we do not connect our notion of self-perceived leadership assuredness to a particular career discipline, our conceptualization broadly follows the social-cognitive career theory approach of relating role confidence to expectations of role fit [41]. The question prompt for this measure is: "How likely is it that you will be appointed to a formal leadership position early in your career? (e.g., by age 25)." A 7-point scale, ranging from "very unlikely" to "unsure" to "very likely", accompanies the prompt. Figure 1 shows the prompt and response scale as presented to survey respondents.

We conceptualize the risk orientation variable based on the literature relating risk and career choice. Saks and Shore [27] and Caner and Okten [28] discuss subjects' aversion toward (or tolerance of) monetary risks of specific jobs; these risk orientations are shown to be factors predictive of subjects' pursuit of or avoidance of jobs. We designed a measure to characterize subjects' risk orientation in a similar manner. Our prompt (again, tested for clarity and refined based on the pilot sample's feedback) asks for respondents to choose between two compensation schemes, where one option is conceptualized as a "safe bet" but with limited prospects for outsized monetary returns, and the other mentions prospects for large returns but at the expense of certainty. We strategically employ a forced choice measure given the real world nature of choice described in the above literature. Figure 2 shows the prompt and response measures as presented to survey respondents.



Figure1. Leadership role confidence measure



Figure 2. Risk orientation measure

Other variables also collected via the survey instrument include demographic measures (e.g., gender, race, and student loan status), and student group affiliation measures (e.g., varsity athletics participation and Greek Life participation). The student loan status question asks respondents to indicate agreement with the statement: "I will personally owe \$10,000 or more in

student loan debt that I'll need to repay" (true/false/unsure). This measure reflects pilot study feedback about the measure's validity and reliability: students were likely to know, with greater confidence, whether or not they would carry some substantive amount of student debt compared to knowing about their exact student loan value or about specifics of their family's wealth. The question on athletics asks: "have you participated in a collegiate varsity athletics program?" (yes/no), and, "if yes, how many seasons will you have participated before graduating?" We then constructed a dichotomous variable of varsity athletics participation based upon 2 or more seasons of participation. The Greek Life participation question asks: "as an undergraduate, were you a member of a fraternity or a sorority?" (yes/no).

### Sampling and Data Collection

This study queried a near-nationally-representative sample of U.S. senior year mechanical engineering undergraduates. To minimize sample biases and maximize respondent participation, a paper-based survey was administered during class time within required senior year capstone design courses across several universities between November 2016 and April 2017. The set of participating universities consisted of public and private institutions of varied sizes and from diverse geographical areas. Nine participating universities were recruited via an email campaign to capstone course instructors and department chairs. Such institutional representation, inclusive of several large public universities, reflects how at least 80% of accredited U.S. engineering Bachelor's degrees are earned annually [40]. Following the university invitation period, partnering negotiations with the host departments ensued, resulting in a unified set of constraints for survey administration. A key constraint included minimizing in-class surveying periods to within 15 minutes. We also agreed to decouple university identity from university-averaged student response data in published work, and to avoid publishing any university-to-university comparative statistics. Independent Review Board (IRB) approvals or concurrences were obtained from all participating universities. The choice to employ paper surveys was made in an attempt to maximize response rates during the instructor-endorsed in-class survey periods. A summary of universities sampled and the survey response rates associated with each is provided in Table 1. Senior capstone class representation directly corresponds with total graduating class representation in all cases except one: at Penn State University, senior year mechanical engineering students are given the opportunity to pursue interdisciplinary capstone projects housed in a differing department (e.g., other than mechanical engineering) and about half do so. The students sampled from Penn State are those mechanical engineering seniors completing their capstone project in their home department.

The choice to sample entirely mechanical engineering students during their senior year was driven primarily by the larger study that this study is associated with. The larger study sought to sample students at or very close to the time period during which they will select their occupational or graduate school plans, and to sample consistently from a single college major that had relatively stable enrollments and career prospects. The latter criteria help minimize unobservable error in job preference measurement due to market effects. The leadership confidence and risk orientation relationships discussed in the Literature Review section of this paper have no known theoretical inconsistencies across the range of engineering majors; however, while we believe that this study's results should generalize across all engineering majors, our dataset does not allow us to empirically validate such a proposition.

University	Location (U.S. State)	Public / Private?	Percentage of university's mechanical engineering senior capstone class represented in sample
Boston University	МА	private	88.2
		privato	00.4
Carriegie Mellon Oniversity	FA	private	90.4
Massachusetts Inst. of Tech.	MA	private	92.0
Penn State University	PA	public	81.9
Santa Clara University	CA	private	85.7
Tufts University	MA	private	83.0
Texas A&M University	ТХ	public	85.8
University of Connecticut	СТ	public	92.0
University of Michigan	MI	public	82.8

#### Table 1. Universities represented in sample

### Analysis

Manual data entry from the paper-based surveys was carried out independently by two individuals and then reconciled to ensure accuracy. Data was saved as a .csv and subsequently loaded into Stata v.15 statistical software for analysis. Analysis began with tabulation of summary statistics for each of the variables of interest: the measures of leadership role confidence and risk orientation, as well as student group identifier variables and demographic identifier variables. Bivariate statistical tests were then carried out in Stata to test each of this study's four primary hypotheses. Following the basic hypothesis tests, we carried out robustness checks by dividing the sample into subgroups that encompass the larger four and smaller five of the sample's nine engineering schools in order to verify whether the observed trends hold for both subgroups. The robustness checks are presented in the paper's Appendix. Finally, several additional permutations of hypothesis tests were run to check for other (e.g., non-theoretic) relationships among the data; we expect null results for these tests and report on them for completeness in the paper's Appendix.

### **Results and Discussion**

### Overview of Dataset

Table 2 provides summary statistics for the dataset. Results show that half of respondents rate themselves above the leadership role confidence scale midpoint (with a mean scale value at 4.61 / 7.00), and 20.5% of respondents identify as risk-seeking. Varsity athletes and Greek Life participants were substantive minority groups, at 13.1% and 21.5% of the sample, respectively. The sample includes 38.9% who will graduate with student loan debt. And 23.1% of the sample are female, which is similar to the 21.4% female proportion of all enrolled engineering undergraduates in the U.S. in 2015 [42].

#### Table 2. Summary statistics

			Number of	_
	Mean	(SD)	Observations	Percentage
Total in Sample:			1,061	100.0%
Subject Characteristics of Interest:				
Leadership Role Confidence:				
7-pt scale assessment Subject rates self above scale midpoint	4.61	(1.37)	531	50.0%
Risk Orientation:				
Subject identifies as risk-seeking			217	20.5%
Student Group Variables:				
Subject is a Varsity Athlete (at least 2 seasons)			139	13.1%
In NCAA Division I			51	4.8%
In NCAA Division III			88	8.3%
Subject is a Member of a Fraternity or Sorority			228	21.5%
Other Key Variables:				
Subject's Student Loan Status: Will graduate with loan debt (at least \$10k)			413	38.9%
Subject Demographics:				
Female			245	23.1%
White			752	70.9%
Asian			205	19.3%
Hispanic or Latino/Latina			87	8.2%
Black or African American			40	3.8%
Other (non-White)			24	2.3%
Subject's Institution Type:				
Public			624	58.8%
Private			437	41.2%

### Leadership Role Confidence

Table 3 shows differences in mean values of the leadership role confidence measure for the two groups of interest – varsity athletes and Greek Life participants – each compared to all others in the sample. Here we also show percentages of participants who rate themselves above the leadership role confidence scale midpoint for each subgroup of interest: athletes, non-athletes, Greek Life participants, and non-Greek Life participations. We observe the expected results: in support of Hypothesis 1A, athletes are shown to assess themselves higher in leadership role confidence, on average, than non-athletes; in support of Hypothesis 1B, Greek Life participants are shown to assess themselves higher in leadership role confidence, on average, than non-athletes; in support of Hypothesis 1B, Greek Life participants are shown to assess themselves higher in leadership role confidence, on average, than non-athletes; in support of Hypothesis 1B, Greek Life participants are shown to assess themselves higher in leadership role confidence, on average, than non-Greek Life participants. We employ Mann-Whitney rank-sum tests of independence (similar to t-tests, but for ordinal variables [43]) to formally test these two hypotheses. The tests confirm support for both Hypothesis 1A (at p < 0.01) and for Hypothesis 1B (at p < 0.001). We next evaluate

robustness of these results by subdividing our overall sample into groupings of the smaller five and larger four of the nine engineering schools in the sample and observe similar magnitudes and directionalities of the results across the subgroups: athletes and Greek Life participants consistently rate themselves higher, on average, than non-athletes and non-Greek Life participants (see Figures A.1 and A.2 in the Appendix). We repeat this robustness test across universities with NCAA Division I and Division III athletics programs and again find consistent results (see Figure A.3 in the Appendix).

Leadership Role Mean and (SD) fr	Confidence: om 7-pt scale	_	Leadership Role	• Confidence: ves Above Scale Midpoint
Varsity Athlete	Otherwise	Test Statistic <sup>3</sup>	Varsity Athlete	Otherwise
4.91	4.56	-2.92**	60.4%	48.8%
(1.30)	(1.37)			
Greek Life Participant	Otherwise	_	Greek Life Participant	Otherwise
4.91	4.52	-3.88***	60.8%	47.6%
(1.26)	(1.39)			

Table 3. Leadership role confidence comparison across student groups<sup>1, 2</sup>

Notes:

1. 1,045 subjects responded to the athletics and leadership survey questions;

1,048 subjects responded to the fraternity/sorority and leadership questions

2. Sample subgroups consist of 139 varsity athletes who have played at least 2 seasons and 227 Greek Life participants

3. Test statistics are Z-statistics based on Mann-Whitney rank-sum tests of independence of ordinal variables:

\*\*\*p < 0.001; \*\*p < 0.01; \* p < 0.05

We next test for significant differences in leadership role confidence across the other student categorizations of interest in this study – student loan status and gender – and find the expected null results. Neither those with student loan debt nor females rate themselves significantly differently from the rest of the sample in terms of leadership role confidence (see Table A.1 in the Appendix). We run this test for Black and Hispanic underrepresented minorities and also find no significant difference in leadership role confidence compared with the rest of the sample (see Table A.2 in the appendix). Low subsample sizes of underrepresented groups can sometimes make it difficult to draw statistical inferences; however, in this case we note that the subsample of Black and Hispanic students (n = 127) is similar in size to the subsample of athletes (n = 139) for which we observed a statistically significant outcome. Finally, we note that a Kruskal-Wallis analysis of variance [43] of role confidence across universities is also null (at p > 0.5), indicating statistical similarity in average student leadership role confidence ratings across all universities in the study.

The results in this section support existing theory suggesting that varsity athletics participation and Greek Life participation are associated with higher self-assessment of leadership confidence. Results also indicate that variation in leadership role confidence is primarily a within-university phenomenon, rather than a cross-university phenomenon.

### Risk Orientation

Table 4 shows differences in percentages of respondents indicating they have a risk-seeking orientation for the two groups of interest – those with student loan debt and females – each compared to all others in the sample. Results support the associated hypotheses. In support of Hypothesis 2A, we find that those with loan debt exhibit a higher likelihood, on average, of being risk-averse than those without debt; in support of Hypothesis 2B, we find that females exhibit a higher likelihood, on average, of being risk-averse than those without debt; in support of Hypothesis 2B, we find that females exhibit a higher likelihood, on average, of being risk-averse than males. Given that our risk orientation variable is dichotomous, we employ Pearson chi-square tests to formally assess the statistical significance of these group differences [43]. The tests confirm support for both Hypothesis 2A (at p < 0.05) and Hypothesis 2B (at p < 0.001). Similar to our analysis of the leadership role confidence variable, we again evaluate the robustness of this result by repeating the risk orientation comparisons for separate subgroups of smaller and larger engineering schools, and find similar results throughout: student loan debt and female gender are associated with reduced likelihood of risk-seeking orientation (see Figures A.4 and A.5 in the Appendix).

Risk Orier Percentage Rating Thems	ntation: selves as Risk-seeking			
Has Student Loan Debt <sup>3</sup>	Otherwise	Test Statistic <sup>4</sup>		
17.4%	23.0%	4.60*		
Female	Male	_		
12.4%	23.5%	13.70***		
<ul> <li>Notes: <ol> <li>1, 1,038 subjects responded to both student loan and risk survey questions, of which 407 subjects indicate they have loan debt</li> <li>1,036 subjects answered the risk survey question and identified as either female (241 subjects) or male (795 subjects)</li> <li>"Has student Loan Debt" indicates that the subject has acknowledged they will carry \$10k or more of student debt at graduation</li> <li>Test statistics are Pearson chi-square statistics from tests of independence of dichotomous variables:</li> </ol> </li> </ul>				

Table 4. Risk orientation comparison across demographics<sup>1, 2</sup>

We next test for significant differences in risk orientation across the other student categorizations of interest in this study – athletes and Greek Life participants – and find null results. Neither athletes nor Greek Life participants exhibit significantly different risk orientations, on average, compared to the rest of the sample (see Table A.3 in the Appendix). We also run this test for Black and Hispanic underrepresented minorities and find no significant difference in risk orientation compared with the rest of the sample (see Table A.4 in the Appendix). Finally, we note that a Pearson chi-square analysis of variance [43] of the risk orientation variable across the universities subsamples is also null (at p > 0.5), indicating similarity in average student risk orientations across the universities.

The results in this section support existing theory suggesting that student loan debt and female gender are associated with an increased likelihood of being risk-averse. Results also indicate that

variation in risk orientation is primarily a within-university phenomenon, rather than a crossuniversity phenomenon.

### Limitations of Results

Readers should take limiting factors into account before assuming generalizability of this study's results to broader student populations of interest. First, as Kagan cautions, the generalizability of any social science empirical research that uses self-reported survey data depends upon respondents' valid and consistent interpretation of survey question prompts [44]. Practical survey constraints limited our ability to ask questions in a multitude of ways to gauge respondents' understanding. Instead, we tested and refined questions based on a pilot study to gain confidence that the target population would interpret the questions correctly. Furthermore, the replicability of our results from prior studies and across subgroupings of universities within our study provides confidence in the consistent interpretation of the survey questions (see: Appendix). Follow-on research in less constrained settings could more formally assess consistency. For example, future researchers could employ an expanded survey instrument capable of measuring variables' internal reliability among respondents [45] and could collect data on additional theoretically relevant subgroupings within the groups of interest (for instance, Greek Life participants could be categorized in terms of elected leadership position status within their fraternity/sorority) to use an intra-class correlation approach to check for expected response stratification [46, 47]. Additionally, future work could be done to confirm the validity of these results for substantively different populations of interest (e.g., students of different ages, from different locales, or at different types of universities, etc.).

Our use of student loan debt as a proxy for students' socioeconomic status - inclusive of the practical need to measure it in a binary manner – is another limiting factor of this study. We directly inquire about each of the other student group identifiers we examine (e.g., varsity athletics participation, Greek Life participation, and gender); yet, our inference about socioeconomic status is indirect. Student loan debt is an imperfect proxy for socioeconomic status, though the two correlate significantly [36-38]. And, as one might expect, the relationship between student loan debt and risk-aversion is not as significant as the other relationships we report (e.g., p < 0.05, compared to p < 0.01 or p < 0.001). Setting the binary threshold of the student loan measure at a different debt value (e.g., higher than \$10,000) may have resulted in increased significance of the measured association; however, there is likely a trade-off between choice of threshold and validity of the self-reported information obtained via survey. In our case, only 3% of the sample, or 32 respondents, responded "unsure" to the loan question (compared to 96% responding either "true" or "false"). Measuring statistical significance of the student loanrisk orientation association with the "unsure" responses also included as their own category (via a Mann-Whitney rank sum test) sustains the statistical significance of the association at p < 0.05. While the existing research [27, 28] and our own results give us confidence in the relationship between socioeconomic status and risk-aversion, we make special note that "group membership" in a certain socioeconomic class is particularly nuanced and more difficult to measure compared to the other group membership variables we examine – and binary student loan status may be a reasonable proxy, at least for the purposes of identifying a general trend.

### Discussion

Education research suggests that diverse composition of student cohorts and teams can affect the social learning environments experienced by students [22, 48-50]. This study sheds light on specific dimensions of student diversity – leadership role confidence and risk orientation – that may be salient in shaping these environments in EL courses. Much work remains in building an understanding of optimal cohort and student team configurations in EL courses; in the interim, we assume that voluntary EL courses aim to achieve cohorts that are cross-sectionally representative of the broader engineering student populations they target (while required EL course instructors aim to assemble teams within their cohorts that both voluntary and required EL course instructors aim to assemble teams within their cohorts that best assist students in achieving EL learning objectives. While future research is needed to understand ideal team make-up within EL courses, the ensuing discussion highlights several relevant team compositional effects related to the leadership role confidence and risk orientation student attributes.

Engineering student teams on which there is a relative shortage of incoming student leadership confidence or abilities (e.g., compared to the broader student population) may perform comparatively poorly on team activities or projects [22]. Yet, team environments with a relative excess of leadership confidence may limit opportunities for "agentic behavior" among those who are less confident, reducing the likelihood that these less confident individuals will have the chance to emerge as leaders (and practice leading) [51]. Structured rotation of leadership roles on student teams, in addition to balancing team rosters, could possibly mitigate the latter phenomenon. Existing literature suggests a similar impetus for balance with regard to students' risk orientations: teams with relatively high risk-aversion are less likely to generate, select, and develop novel design concepts during engineering projects [34, 35]; yet those with a relatively high risk-seeking orientation may be prone to shortsighted project decision making, especially if team members lack prior risk management experience or training [52]. Further, the variety of career intentions resident within a cohort – specifically, the proportions intending to remain in, versus exit, engineering – may relate to the proportion of students from groups possessing, on average, higher or lower leadership confidence or risk tolerances [25, 27]. If EL educators are concerned with creating learning environments where students with differing incoming levels of leadership confidence and risk orientations can all thrive – and where a critical mass is interested in applying their developing leadership capabilities toward engineering careers – then educators' cognizance of cohort composition and population-representativeness may be key.

Cohort representativeness also has implications for learning outcomes assessment. Given that differences in leadership role confidence and risk orientation are at least partly systemic – associated, on average, with student group affiliations and demographics – literature suggests reasons why voluntary EL course cohorts are susceptible to being non-representative of overall student populations. For example, students' personal social networks can influence their choices of optional courses and activities [53, 54], and their socioeconomic status (as marked by student loan debt) may reduce their likelihood to sign up for optional courses or activities [39, 55]. Learning outcomes assessments aiming to make comparative claims about EL course participants' achievement of leadership-related outcomes (compared to non-participants) may be biased, for example, if a peer network of Greek Life participants is over-represented or if loan recipients are underrepresented. These implications point to the well-known advantages of using

comparative control groups, of employing pre- and post-intervention assessments, and of collecting information on pertinent student "pre-treatment control variables" (e.g., as highlighted by this study: athletics participation, Greek Life participation, student loan status, and gender) for the purposes of experimental control in empirical assessments of outcomes [56].

Finally, we ask: what can educators do to achieve more population-representative EL course cohorts in the first place? The best and most straightforward answer may be the most difficult to implement: making EL course content a compulsory part of the engineering curriculum, as has been suggested [13]. Short of that, EL educators can consider the mechanisms that may cause imbalanced student sorting and work to counter such mechanisms. For example, if student loan recipients are less likely to voluntarily expand their courseload and commit to co-curricular experiences, instead opting to put discretionary time toward working a part-time job or graduating earlier [39, 55], then cross-listing EL courses so that they count toward required degree credit may help mitigate underrepresentation of loan recipients. Similarly, if social networks increase some students' informedness of the availability and benefits of EL courses (e.g., due to information passed within Greek Life or athletics networks), then EL educators may seek to specifically identify under-informed pockets of the student population and focus active recruitment efforts in those areas. In the case of voluntary EL courses, clearly some degree of student self-selection will continue to persist by the very nature of the courses being voluntary yet, the reach and impact of EL courses may be improved if student selection mechanisms shift more toward random, and away from dependence on systemically-sorted factors linked to learning outcomes. Our research thus suggests that educators in voluntary EL courses should collect incoming student data on group membership and demographics to better understand the make-up of their cohort with respect to leadership role confidence and risk orientation.

It is our hope that this study sparks future work in related areas. First, the continued evaluation of the reach of EL programs across student groups and demographics is needed to better assess the presence or extent of the cohort non-representativeness of which we warn. We make the assumption that EL educators aim to reach a representative cross-section of engineering students, but it is important to note that this paper offers no proof that this reach is not presently being achieved. We merely caution of the possible effects of cohort non-representativeness. Additionally, we draw on implications from prior studies in highlighting the effects that cohort composition could have on learning environments within EL courses, but we do not study such environments directly. Further research that characterizes EL learning environments as a function of cohort make-up would build upon this study. Lastly, we note that the student groups we examined in this study are certainly not the only groups of interest regarding sorting of student characteristics; various extra-curricular student clubs and project teams (including those explicitly within engineering) may also experience systemic student sorting. We were unable to reliably measure student participation in such groups within the practical limits of our study, but follow-on research to examine these other groups would benefit the community of EL educators.

## Conclusions

The heterogeneity of the engineering student population implies an onus for EL educators to consider the student composition in EL course cohorts – and to be mindful of the effects of cohort composition upon the learning environments within courses and on student teams. This

study reports on variation in engineering students' leadership role confidence and risk orientation, two variables with key implications for learning and development in EL classes. Variation in these student attributes is shown to follow consistent, statistically significant patterns in a nine-university 1,061-student sample:

- Varsity athletes, on average, possess higher self-assessed leadership role confidence than non-athletes.
- Greek Life participants, on average, possess higher self-assessed leadership role confidence than non-Greek Life participants.
- Student loan recipients, on average, are more likely to self-identify as risk-averse.
- Females, on average, are more likely to self-identify as risk-averse.

Notably, average levels of leadership role confidence and risk-aversion (or risk-tolerance) are found to be statistically similar across all nine universities, implying that these observed sorting phenomena predominantly reflect within-university effects. In other words: it is likely that most EL educators are faced with these types of student differences among their target student populations.

Finally, this study reviewed various literatures suggesting potential learning environment impacts of imbalanced representation of leadership confidence or risk orientation attributes. This body of literature suggests – in the absence of more in-depth research on the impacts of student sorting effects upon EL learning environments – that cohort and team composition of these four student group and demographic affiliations may be of concern to EL educators.

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## Appendix



Figure A.1. Robustness check: association of athletics participation to leadership role confidence across university subgroups



Figure A.2. Robustness check: association of Greek Life participation to leadership role confidence across university subgroups



Figure A.3. Robustness check: association of athletics participation to leadership role confidence across university NCAA Divisions (I and III)

able A.1. Associations between student loan status and gender to leadership role confidence <sup>1,2</sup>
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Leadership Role Confidence: Mean and (SD) from 7-pt scale			Leadership Role Confidence: Percentage Rating Themselves Above Scale Midpoint		
Has Student Loan Debt <sup>3</sup>	Otherwise	Test Statistic <sup>4</sup>	Has Student Loan Debt <sup>3</sup>	Otherwise	
4.56 (1.41)	4.64 (1.34)	0.66	48.8%	51.6%	
Female	Male		Female	Male	
4.51 (1.35)	4.64 (1.37)	0.20	46.7%	51.9%	

Notes:

1. 1,047 subjects responded to both student loan and leadership survey questions, of which 406 subjects indicate they will have loan debt

2. 1,043 subjects responded to the leadership survey question and identified as either female (242 subjects) or male (801 subjects)

3. "Has student Loan Debt" indicates that the subject has acknowledged they will carry \$10k or more of student debt at graduation

4. Test statistics are Z-statistics based on Mann-Whitney rank-sum tests of independence of ordinal variables:

\*\*\*p < 0.001; \*\*p < 0.01; \* p < 0.05

Table A.2. Associations between	n underrepresented	minority status	and leadership role	e confidence
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Leadership Role Confidence: Mean and (SD) from 7-pt scale		_	Leadership Role Confidence: Percentage Rating Themselves Above Scale Midpoint		
_	Underrepresented Minority <sup>1</sup>	Otherwise	Test Statistic <sup>2</sup>	Underrepresented Minority <sup>1</sup>	Otherwise
	4.78 (1.36)	4.59 (1.36)	0.29	51.6%	48.4%

Notes:

1. 1,038 subjects responded to the race and leadership survey questions, of which 124 identify with underrepresented (Black or Hispanic) groups

2. Test statistics are Z-statistics based on Mann-Whitney rank-sum tests of independence of ordinal variables:

\*\*\* p < 0.001; \*\* p < 0.01; \* p < 0.05



Figure A.4. Robustness check: association of student loan debt status to risk orientation across university subgroups



Figure A.5. Robustness check: association of gender to risk orientation across university subgroups

Table A.3. Associations between varsity athlete and Greek Life participation and risk orientation<sup>1, 2</sup>

Risk Orien Percentage Rating Thems	_	
Varsity Athlete	Otherwise	Test Statistic <sup>3</sup>
22.8%	20.6%	0.34
Greek Life Participant	Otherwise	_
22.7%	20.3%	0.58

Notes:

1. 1,038 subjects responded to both the athletics participation and risk survey questions;

- 1,041 subjects responded to both the fraternity/sorority and risk survey questions
- 2. Sample subgroups consist of 136 varsity athletes who have played at least 2 seasons, 225 self-identified fraternity/sorority members and

3. Test statistics are Pearson chi-square statistics from tests of independence of dichotomous variables:

\*\*\*p < 0.001; \*\*p < 0.01; \* p < 0.05

#### Table A.4. Association between underrepresented minority status and risk orientation

Risk Orienta	tion:	
Percentage Rating Themsel	ves as Risk-seeking	-
Underrepresented Minority <sup>1</sup>	Otherwise	Test Statistic <sup>2</sup>
16.0%	21.4%	1.97

Notes:

1. 1,031 subjects responded to both the race and risk survey questions,

of which 125 identify with underrepresented (Black or Hispanic) groups

2. Test statistics are Pearson chi-square statistics from tests of independence of dichotomous variables:

\*\*\*p < 0.001; \*\*p < 0.01; \* p < 0.05