Predicting Engineering Students' Desire to Address Climate Change in their Careers: An Exploratory Study Using Responses from a U.S. National Survey

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Abstract

More engineering students are needed to address climate change in their careers. These students are necessary because engineering includes designing and building machines, structures, and components that contribute large portions of society's carbon emissions. We surveyed a national sample of undergraduate engineering students (*n* = 4,605) in their last semester of college about their desire to address climate change in their careers and the factors that predicted these responses. Possible variables for wanting to address climate change in their career included course topics, co-curricular experiences, climate knowledge, political affiliation, religion, and other demographics. The strongest factors that predicted engineering students' desire to address climate change in their career were related to a feeling of personal responsibility to deal with environmental problems, recognizing climate change as a technical (not social) issue, believing climate change is caused by burning fossil fuels and livestock production, and their engineering discipline. Students majoring in environmental and architectural engineering were more likely to want to address climate change in their careers than others. Previous known factors to increase

motivation for climate action like course topics, political affiliation, student organization participation, undergraduate research experience, and environmental volunteering were not strong predictors among engineering undergraduate students.

Introduction

The vast majority of experts agree the climate is changing (Cook et al., 2013; Stocker et al., 2014), but there is little research to assess if engineering students are interested and ready to address such challenges in their careers. Society needs engineering students interested in addressing challenges associated with climate change. Engineers are uniquely needed to help create new manufacturing processes that reduce greenhouse gas emissions by developing closed-cycle loops (Clark, 2007; Ghadge et al., 2020). Material engineers are needed to create resilient roadway surfaces that combat buckling from increased temperatures, washouts from precipitation, and settling from thawing permafrost (Nasr et al., 2019). New methods for food production from agricultural engineers and water supplies from civil engineers are also needed (Dooley & Roberts, 2020; Karl, 2009). These problems are systemic (Shepardson et al., 2012) and will require engineers who recognize the interconnectedness of these problems and the changing climate (Fletcher et al., 2014).

Most education research on climate change examines middle and high school students' conceptual models (Monroe et al., 2019) without considering the link between understanding and interest to address such issues in student careers after college (Anderson, 2010). Prior to college, climate change and its global implications are not well understood by students in the U.S. (Gambro & Switzky, 1996; McNeill & Vaughn, 2010; Shepardson et al., 2009). Roughly half of the students entering engineering in college do not believe in human-caused climate change (Shealy et al., 2017).

The formation of engineers during their undergraduate engineering program is an opportunity to correct misconceptions about climate change and help students develop motivation to solve problems associated with climate change in their careers. The accreditation board for engineering and technology post-secondary education programs in the United States, called ABET, recognizes the need to teach engineering students about climate change and its implications for sustainability (ABET, 2018). ABET's mission aligns with the United Nation's Agenda 2030, which is an action plan for people, the planet and future prosperity (United Nations, 2015). For many students, the undergraduate engineering experience is the last step in their formal education. The majority of students who study engineering enter the workforce after their undergraduate degree (Yoder, 2012). The undergraduate degree is therefore a critical point to motivate students to achieve the educational goals outlined by ABET and to help them recognize the need to address climate change, outlined in the United Nations' Agenda 2030.

The research presented in this paper measures how college experiences, course topics, students' beliefs, understanding of climate science, engineering discipline, political affiliation, religion, and other demographic variables are related to their desire to address climate change in their careers. Knowing what types of college experiences and student characteristics are associated with wanting to address climate change in their future careers can help educators attract and retain more students during college and help shape students to solve the global challenges associated with climate change in the future.

The background section provides an overview of factors that likely influence students' willingness to address climate change in their careers. The research questions and methods outline specific items that were included as possible predictor variables. The results, discussion, and conclusion follow, providing new evidence and understanding about what variables are the strongest predictor for wanting to address climate change in students' careers.

Background

Students' willingness to take action to reduce greenhouse gas emissions and reduce the impact of climate change is based on the amount of effort they believe is required for the action. Some actions like switching off unused electrical items or individual recycling are easy to complete. Students are overwhelmingly willing to take part in these types of actions, even though the degree to which these action are useful to reduce greenhouse gas emissions is low (Monroe et al., 2019). Students generally are less willing to take more challenging actions, like using public transportation or buying smaller cars (Malandrakis et al., 2011). Lack of willingness to take action becomes more pronounced among students in high income countries (Lee et al., 2020). Students' intentions to address climate change in their careers goes beyond these simple actions. Wanting to address climate change in their career requires a significant and long-term commitment, which is likely motivated by one's beliefs. Students' concern about climate change is strongly, positively correlated to their belief that humans are causing climate change (Stevenson et al., 2016).

The perceived beliefs of family and friends are also strongly correlated to students' concern about climate change (Stevenson et al., 2016). Two in five students learn about climate change from family or friends (Leiserowitz et al., 2011). Climate change discussions with family and parents' behaviors to reduce climate change can predict the degree to which children will participate in individual-level climate mitigation behaviors (Lawson et al., 2019).

Family discussion and how students learn about climate change can also be shaped by politics (McCright & Dunlap, 2011). Students who identify as Democrat or Independent are more likely to believe climate change is caused by humans and are more willing to take action to mitigate the effects of climate change (Leiserowitz et al., 2016; McCright & Dunlap, 2011).

Beliefs about climate change are not only formed through interactions with family and friends and politics but also through formal education. A class experience that develops a personal understanding of climate change is likely to lead to student engagement toward climate change action (McNeill & Vaughn, 2010). The content students receive about climate change and mode of learning in their formal education contributes to a students' beliefs and intention to address climate change in their daily actions. Focusing on directly relevant information (e.g., how climate change will impact them personally in the future) and using active and engaging teaching methods (e.g., through film projects) help students construct their own beliefs about human-caused climate change. This can lead to increased motivation to address it (Monroe et al., 2019). Engaging in deliberate discussion about climate change and tackling misconceptions can help change beliefs (McNeal et al., 2014) and how students construe climate change (Trope & Liberman, 2010). For example, learning about climate change from science experts (Faria et al., 2015; Hallar et al., 2011) and through hands-on school projects are both helpful in constructing students' understanding and motivation to address climate change (Monroe et al., 2019). Hands-on engaged-learning curriculum can have a positive influence on climate change beliefs and intentions (Christensen & Knezek, 2018). Engaged learning can influence climate change beliefs because it can help students construe climate change in a way that aligns with climate science (Trope & Liberman, 2010). The subjective psychological distance at which students perceive impacts of climate change determines how concretely or abstractly events are mentally represented (Trope & Liberman, 2010). Events that lack contextual information are construed at a higher-level, are more abstract, and less likely to be acted upon (Brügger et al., 2015).

Out-of-school learning settings are also known to influence students' knowledge, attitudes, and ability to construe climate change (Sellmann, 2014). For example, experiences at the zoo can increase students' understanding of wildlife and their association between climate change and its impact on the environment and ecosystems (Clayton et al., 2014). Knowledge about climate change and recognition of the role that the forest and animals plays in modulating climate change lead to increased belief and attitude about mitigating it (Higuchi et al., 2018).

These prior studies point to an array of potential variables that contribute to a student's interest to address climate change in their future careers, including personal motivation, beliefs among family and friends, interactions with experts, and personally relevant information and experiences in and out of the classroom. One limitation of these prior studies is the focus on pre-collegiate experiences for middle and high school aged students (Monroe et al., 2019). Learning experiences in college differ from those in middle and high school. For example, the influence of friends compared to family increases in college compared to middle and high school. Additionally, college students compared to high school students have greater access to experts in topic areas like climate science. Understanding what college experiences and student characteristics are the strongest predictors for wanting to address climate change can help educators, administrators, and policymakers with the eventual goal of increasing the number of engineers working to address climate change in their careers.

This study examines variables that are most predictive of students wanting to address climate change in their career. We used a large national sample of undergraduate engineering students in the United States who were about to enter the workforce. Given the numerous educational and personal factors associated with a student's belief about climate change and motivation to address it, the research presented in this paper is exploratory. The results presented in this paper use multiple possible variables based on a national survey to understand which variables are most relevant to a student wanting to address climate change in their career. Our results present new information that point to particular variables of students wanting to address climate change in their career.

Research Questions

In this study, we answer the following research questions:

1. What factors about college experiences, beliefs about the environment, and demographics are most associated with a students' desire to address climate change in their careers?
2. What is the relationship between these factors and a student expressing an interest in addressing climate change in their career?

Methods

We surveyed senior engineering students in two rounds during the spring semester of 2018. A stratified random list of universities with ABET accredited engineering programs was compiled by separating small (< 5,400), medium (5,400-14,800), and large institutions (>14,800) by overall undergraduate enrollment. This procedure ensured that the sample was representative of varying sizes of institutions. Engineering department heads were the initial point of contact for each institution. After contacting the department head, capstone instructors were asked to distribute the survey to their students. Eighty-three capstone instructors agreed to distribute surveys during their class. No incentives were provided to the students or instructors. Capstone instructors were mailed paper surveys and were provided with instructions to distribute the surveys during their courses. Students were told the survey was not part of their course. They would not receive class credit or any type of grade for completing the survey. The survey was also anonymous. Sixty-six instructors returned completed surveys. A national sample of n =

4,605 senior engineering students was collected. Of those who disclosed their gender in the survey, 73% were male, and 25% were female, the remaining 2% did not disclose. This percent of male and female students is consistent with the national gender demographics of engineering students who graduate with bachelor's degrees (Yoder, 2018). Figure 1 illustrates the participants' home ZIP codes by state. The size of dots indicates the sample size from each ZIP code. The map was created using ggplot2 (Wickham, 2009), a package within the R statistical software (R Core Team, 2019).

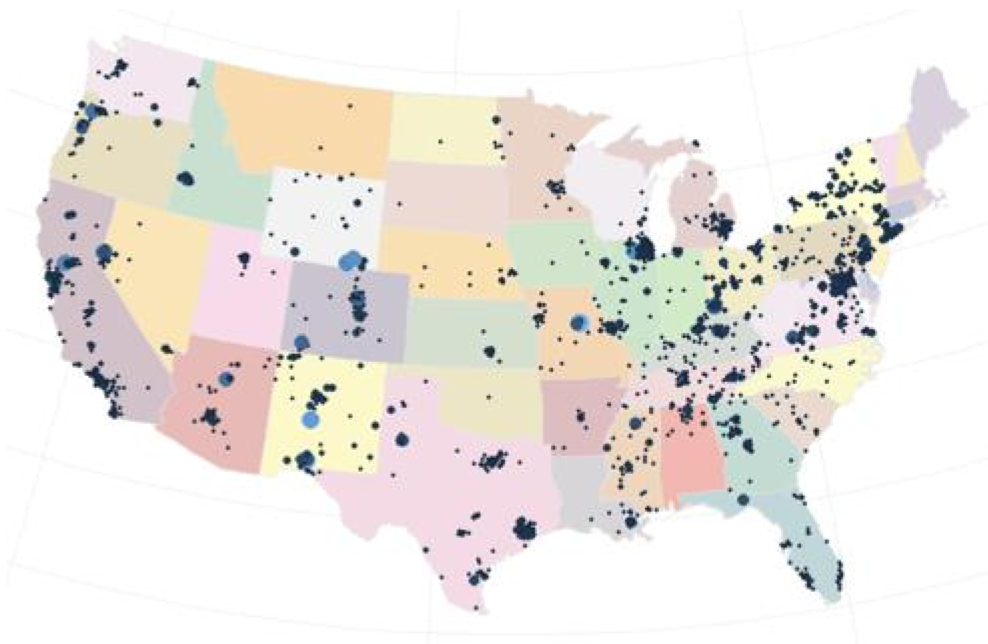

Figure 1: Participants home locations based on ZIP code.

Participant responses to multiple survey questions were used to answer research question one about the factors associated with students' desire to address climate change in their careers. Students who desire to address climate change in their careers were identified by the survey question, "Which of these topics, if any, do you hope to directly address in your career? (Mark all that apply)" with response option "Climate change." Students who selected climate change were compared to students who did not select climate change. Response options related to wanting to address other topics in their career were not included in our analysis as predictor variables because these additional response items did not directly address the research question about college experiences, beliefs about the environment, and demographics are most associated with a students' desire to address climate change in their careers.

The predictor variables were a collection of the remaining survey items corresponding to several categories: college experiences inside and outside the classroom, beliefs about themselves and engineering, beliefs about climate change, and demographic variables. Each topic comprised multiple questions answered on either an anchored numeric scale (e.g., rating from (0) Strongly disagree to (4) Strongly agree) or a nominal scale (e.g., participant's current major of study). In total, 36 additional survey items were included as predictor variables. The complete survey is included in the Appendix.

Some items within the survey were grouped together using exploratory factor analysis (EFA) to reduce the number of predictor variables. EFA examines student response patterns to identify common underlying (latent) variables. The question about students' beliefs about global warming (Question 28 in the Appendix) was grouped into factors representing technical and social issues. The question asked, "I believe that global warming is a(n)…". The response items grouped as technical issues, including **"**environmental issue," "scientific issue," "engineering issue," "health issue," "economic issue," "national security issue," and "agricultural (farming, food) issue". Items also grouped as social issues including, "religious issue," "social justice (fairness issue)," a "political issue," and a "poverty issue." The item that asked about "moral issue" was removed from the two factor groups because it loaded onto both factors with similar weights (Wright & Villalba, 2012, p. 292). The factor scores were calculated by summing the individual items loading on that factor and then dividing by the number of items. For example, if six items loaded onto one factor, then that factor score was calculated by adding those six items together and dividing by six. To estimate the internal consistency reliability of these factors, we calculated a Cronbach's alpha score for each factor. The Cronbach's alpha score for the technical issues factor was 0.91 and 0.80 for the social issue factor.

Another question with response items factored together asked, "To what extent do you disagree or agree with the following" with nine response options about engineering agency (Question 12 in the Appendix). Using exploratory factor analysis with a factor loading cutoff of 0.3, we found that these nine items loaded onto two factors, consistent with prior work on students' engineering agency (Godwin et al., 2013): global agency and personal agency. Global agency is students' beliefs about engineering to make a positive change in the world. Personal agency is students' beliefs about engineering to make changes directly to their lives and included first-person personal and possessive pronouns.

Response items in global agency included, "Engineering can improve our society," "I see engineering all around me," "Engineering can improve quality of life." Items in personal agency included, "Engineering allows me to think deeply about problems," "I can make an impact on people's lives through engineering," "Engineering knowledge is for the advancement of human welfare," "Engineering can improve societies globally," "Engineering will give me the tools and resources to make an impact," and "Engineering can help me improve my community."

The survey question about course topics that asked, "Please indicate whether the following topics were covered in your courses. (Mark all that apply)," (Question 7 in the Appendix) was treated as a weighted sum, indicating items covered in a "discipline-specific engineering" course (weight = 4), an "engineering elective" course (weight = 3), a "non-engineering elective" course (weight = 2), or "other course(s)" (weight = 1). The possible response options to this question included 21 different course topics, listed in the appendix. Each topic's weighted score ranged from 0 (i.e., the topic was never covered in any of the students' courses) to 10 (i.e., the topic was covered in each of the four course categories).

The remaining survey questions included items that were treated as potential independent predictor variables to include in the regression model. The remaining survey questions captured students' career goals, co-curricular experiences, beliefs about the planet and human's role, the new ecological paradigm scale (Dunlap et al., 2000), and demographics, such as religion, political affiliation, and race/ethnicity.

Several additional survey questions about belief in global warming (Question 20 in the Appendix), belief about a sustainable future (Question 18 in the Appendix), and major (Question 29 in the Appendix) are worth noting. The question about a sustainable future was previously included in a prior national survey about sustainability in engineering (Klotz et al., 2014).

Related to a student's major, students from mining (13 students), nuclear (3 students), agriculture/biological/biosystems (21 students), and engineering physics (6 students) were removed because of the low sample size in these groups.

Data analysis

We used a two-step workflow for the analysis to answer the research questions. The first step involved constructing a random forest classifier to identify which of the items from the survey were most predictive of the outcome (i.e., predicting whether a student indicated that they wanted to address climate change in their careers). The second step used the results from the random forest classifier to create a logistic regression model. The outcome (student interest in addressing climate change in their careers) was regressed against the top predictors identified from the random forest. To handle missing data, we removed cases missing more than 10% of the responses to all 470 items in the dataset (i.e., cases missing more than 47 responses). This left 3,127 responses. Among those remaining participants, we used median imputation to impute missing values. Zhou et al., (2001) suggests this method can perform better than complete case analysis, especially with larger datasets such as this one. We used median imputation rather than mean to account for the data being ordinal rather than continuous.

The random forest classifier was constructed using the survey items as predictors (Breiman, 2001; Cutler & Wiener, 2018). The random forest method (Breiman, 2001) was used to create ensembles of either classification or regression trees. Since the outcome of interest was a binary outcome (answer to the survey item: "Which of these topics, if any, do you hope to directly address in your career" and response answer being "Climate change"), we created a classification random forest. When splitting nodes of each tree in the forest, the random forest model can handle either discrete or continuous covariates at each of the nodes. The candidate predictor factors from the survey that we used in the random forest model were both continuous items (e.g., anchored numeric scale items about student beliefs or experiences) and categorical items (e.g., demographics and student major).

To identify which variables were most predictive of the outcome, permutation importance was used instead of Gini impurity because it leads to less biased variable importance estimates in the random forest model (Strobl et al., 2007, 2008). We set a variable importance threshold of greater than 0.005 permutation importance to identify which survey items were most predictive of the outcome and therefore which items we would use in the subsequent logistic regression model. The 0.005 permutation importance value was set based on the relative importance of all of the variables.

After identifying variables using the random forest and permutation importance value of 0.005, we created a logistic regression model. The goal of this step was to estimate the effects of changes in the identified covariates on the probability that a student would express an interest in addressing climate change in their careers. However, rather than creating a single regression model and obtaining single point estimates for the regression coefficients, we used a bootstrap resampling approach. This approach was used to approximate the entire distribution of the coefficient estimates by creating a large number of resampled datasets from an original dataset (Efron, 2003). Bootstrap resampling can be used as either a parametric or a non-parametric method (Carpenter & Bithell, 2000) to estimate a sampling distribution of a target statistic. The method can be used as an estimation technique for both small or large sample sizes. We elected to use this approach to characterize the distribution (rather than single point estimates) and make the estimates more robust to potential assumption violations in the regression models. In our case, the sampling distributions were the regression coefficient estimates (Austin & Tu, 2004; Davison & Hinkley, 1997). The general approach has been used to obtain logistic regression coefficient distribution estimates elsewhere (Hossain & Khan, 2004; Lee, 1990; Localio et al., 2007). For this study, we used 10,000 bootstrap resamples, as Moulton & Zeger (1991) suggest is appropriate for achieving consistent coefficient distribution estimation. Further adhering to their advice, we present boxplots of the distributions of these estimators rather than confidence intervals since the boxplots arguably convey more information about the degree of uncertainty around these coefficient estimates.

In practice, this approach translated to first drawing 10,000 bootstrapped samples from the original survey data. For each of these bootstrapped samples, we fitted a logistic regression model, regressing the binary outcome (career interest in addressing climate change) against the candidate covariates identified from the random forest classifier in the first step of the workflow. From these regression models, we obtained 10,000 estimates for each of the regression coefficients using maximum likelihood estimation. With this process, we created an entire distribution of coefficient estimates for each of the coefficients identified through the random forest that met our permutation importance value. We present these coefficient distributions in the results. All analyses were conducted using the R statistical software (R Core Team, 2019).

Results

The results of the random forest indicated seven of the potential items were important predictors of the outcome of students' desire to address climate change in their careers. Logistic regression was used to estimate the odds ratios of these predictors on indicating a desire to address climate change in students' careers. We present the results of these analyses below.

Variables associated with a students' desire to address climate change in their careers

The results from the random forest are illustrated in Figure 2. The figure includes variable importance using permutation importance (along the horizontal axis). We show the top 30 variables arranged in order of increasing importance. The relative values of the permutation highlight their degree of importance compared to each other. The vertical axis represents each of the 30 variables. The full list of numbers and letters associated with each of the 30 variables are detailed in the Appendix.

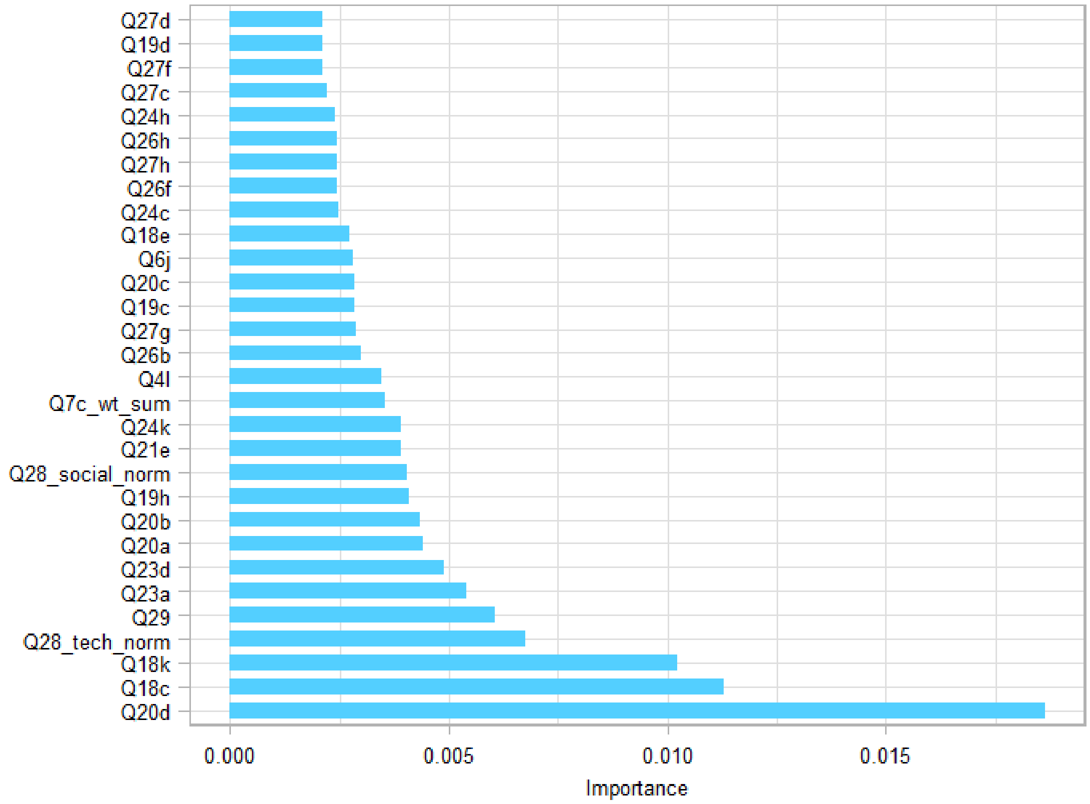

Figure 2: Variable importance from the random forest using permutation importance

From the random forest model, seven items met the permutation importance threshold of 0.005. We consider these to be the items most predictive of whether a student wants to address climate change in their careers. The items, including their question number, survey wording, and question type (i.e., categorical, continuous scale from 0-24, or anchored numeric scale from 0-4) are listed in Table 1. Five of these seven items are anchored numeric scale items, one is categorical, and one is a factor comprising several anchored numeric scale items summed together.

Table 1: Predictors used in the logistic regression model

Question Label	Question	Response Type
Q20d	Global warming is an important issue for me personally	Anchored Numeric (0-4)
Q18c	I feel a responsibility to deal with environmental problems	Anchored Numeric (0-4)

Q18k	We should be taking stronger actions to address climate change	Anchored Numeric (0-4)
Q28_technical	I believe that global warming is a technical issue	Factor (0-24)
Q29	What is your current major field of study? Please choose only one of the following	Categorical
Q23a	I believe that a cause of global climate change is…Burning fossil fuels	Anchored Numeric (0-4)
Q23d	I believe that a cause of global climate change is…Livestock production	Anchored Numeric (0-4)

Logistic regression model predicting student interest to address climate change in their career

We created a logistic regression model by regressing the binary outcome (i.e., expressing an interest in addressing climate change in career) on the seven predictors from the random forest that was about the 0.005 permutation importance value as a cutoff, listed in Table 1. Six of the seven items were treated as continuous covariates and one (student major) as a categorical covariate. For the continuous covariates, we added a pre-processing step to center each of the predictor variables by subtracting the mean. For the student major coefficient(s), we made mechanical engineering the reference level because it was the largest discipline in our sample. Additionally, mechanical engineering students could pursue a number of career paths related to climate change. For example, mechanical engineers are needed to develop renewable energy sources (e.g., wind turbines, bio-diesel engines) and more efficient systems (e.g., HVAC systems, optimized manufacturing processes that use less energy).

Figures 3 and 4 show the distributions of the coefficient estimates for each of the predictor variables. Each box plot is arranged in descending order of median coefficient estimates for the bootstrap coefficient distributions. The largest median coefficient estimate was for item Q18c (I feel a responsibility to deal with environmental problems). The smallest median coefficient estimate was for item Q23d (I believe that a cause of global climate change is livestock production).

Figure 3 presents the distribution of coefficient estimates for the six continuous predictor variables. The black line at zero corresponds to even odds of expressing an interest in addressing climate change and not expressing an interest in addressing climate change. Coefficient estimates for a predictor that is above zero suggest that a higher answer on the survey item corresponds to an increase in the odds of a student wanting to address climate change in their careers.

Conversely, estimates below zero suggest that a lower answer on the survey item corresponds to a decrease in the odds of a student wanting to address climate change in their career.

For each of these predictors in Figure 3, the trend is for the higher response to each predictor to be associated with an increase in the log-odds (and thus the odds ratio, since logarithm is a monotonic function) of a student expressing an interest in addressing climate change in their careers. For example, the coefficient distribution for Q18c (I feel a responsibility to deal with environmental problems) suggests that a one-unit increase on the five-point Anchored numeric scale (ranging from strongly disagree to strongly agree) corresponds to a 0.45-unit increase in the log-odds (or a 57% increase in the odds) of a student wanting to address climate change in their careers. This 0.45 log-odds unit estimate is the approximate median of the distribution of the 10,000 bootstrap resampled coefficient estimates for that predictor in the logistic regression models. The estimates for Q18c and Q20d (Global warming is an important issue to me personally) had relatively similar coefficient estimate distributions, suggesting that an increased sense of responsibility to deal with environmental problems and increased personal importance of global warming to a student are associated with similar increases in the probability a student will want to address climate change in their career.

A group of three items have similar distributions of their coefficient estimates, including item Q23a (I believe that a cause of global warming is burning fossil fuel), item Q18k (We should be taking stronger actions to address climate change), and item Q28_tech_norm (I believe that global warming is a technical issue). Their median coefficient estimates range between 0.25 and 0.35 units on the log-odds scale. A one-unit increase in one of these variables corresponds to a 0.25 to 0.35 unit increase on the log-odds scale (28% to 42% increase in the odds) of a student wanting to address climate change in their careers. Holding a belief that climate change is caused by burning fossil fuels, believing global warming is a technical issue, and believing that we should take stronger actions to address climate change are associated with engineering students being more likely to express an interest in wanting to address climate change in their career.

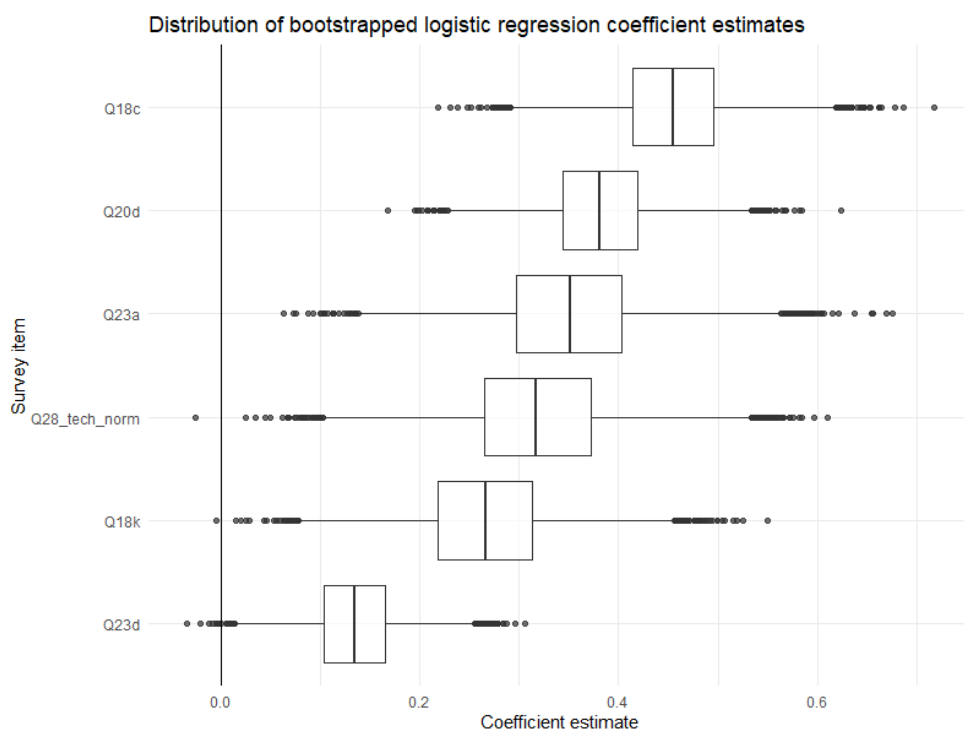

Figure 3: Logistic regression coefficient distributions from 10,000 bootstrap resamples for predictors not including student major.

Figure 4 shows the distribution of the estimates of the logistic regression coefficients from the 10,000 bootstrap resamples for the different majors. Since mechanical engineering was the reference group for the logistic regression model, each of these major coefficients is comparing an increase or decrease among students from different disciplines against mechanical engineering students for wanting to address climate change in their career. The black line at zero corresponds to even odds of expressing an interest in addressing climate change and not expressing an interest in addressing climate change (using mechanical engineering as the reference point).

Most disciplines except environmental, architectural, and general engineering are associated with lower odds of wanting to address climate change when compared with mechanical engineering students. Students in electrical engineering are less likely to want to address climate change in their careers compared to mechanical engineering students. Specifically, the median coefficient estimate for electrical engineering suggests that electrical engineering students were 0.52 units less likely on the log-odds scale, (corresponding to a 40% decrease in the odds) of a student wanting to address climate change compared to mechanical engineering. Even further on the lower end of the estimates, bioengineering/biomedical engineering was associated with a 1.8-unit decrease on the log-odds scale (corresponding to an 83% decrease in the odds of wanting to address climate change compared to mechanical engineering students) according to the median coefficient estimate. On the upper end of the estimates, a student majoring in environmental/ecological engineering was associated with an estimated 0.6-unit increase on the log-odds scale (or 1.82-unit increase in the odds, or 82% higher odds compared to mechanical engineering).

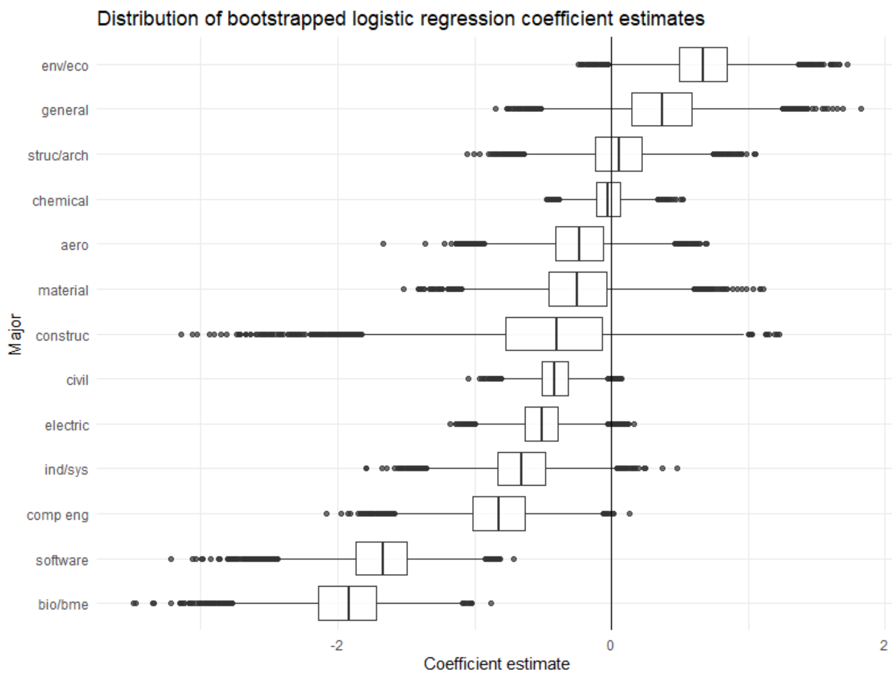

Figure 4: Logistic regression coefficient distributions from 10,000 bootstrap resamples for student major.

Discussion

The greatest predictors for students wanting to address climate change in their career were feeling a responsibility to deal with environmental problems and global warming being an important issue to them personally. These items reflect personal recognition and responsibility to address environmental problems and global warming. This result aligns with prior research that says inspiring climate action requires feeling a personal connection with the information (Wibeck, 2014). When students learn about the personal threats to themselves or their community due to climate change, such as rising sea levels, they are more likely to want to take action to address it (Bofferding & Kloser, 2015). The closer the threat to them personally the more likely they are willing to do something about it (Theobald et al., 2015). This fits with the construal level theory, which explains how people perceive climate change, and how the psychological distance at which people mentally represent objects affects their decisions and actions (Brügger, 2020; Brügger et al., 2016).

Personal relevance is a prerequisite not just for action but also for education (Monroe et al., 2019). It enables learners to link what they already know to the new information (Kaplan & Kaplan, 1989). Personal relevance also helps remove larger barriers associated with not addressing climate change, such as the lack of direct and visible offenders and remoteness of impacts (Moser & Dilling, 2007). Climate change education should focus on building personal relevance (Bofferding & Kloser, 2015; Cone et al., 2012; Lee et al., 2013) to help more engineering students want to address climate change in their careers.

The students in our study who want to address climate change in their careers also recognized, not just themselves but society as a whole should be taking stronger actions to address climate change. These students were more likely to agree that "We should be taking stronger actions to address climate change." In other words, it is not solely students' personal relevance in addressing climate change but also a collective societal responsibility as well. Students who want to take action to address climate change generally assume that the public has a role to play in mitigating it (Flora et al., 2014; Lee et al., 2013; Robelia et al., 2011; Stapleton, 2015). This fits broadly within collective action theory about climate change (Brechin, 2016). Collective action theory is also related to the construal-level theory when measuring the psychological distance of climate change (Wang et al., 2019). Construal-level theory offers a supportive framework for understanding why students who believe in collective action or responsibility could be more motivated to address climate change (Obradovich & Guenther, 2016). Within construal-level theory, distance is defined on several dimensions including, temporal, spatial, social and hypothetical. Social distance is the measure of relational space between people or groups. Appeals to self-interest are small in social distance and appeals to community or society are large in social distance. For example, a gift to self is low in social distance and gift to a charitable organization is high in social distance. Students that see addressing climate change collectively and the need for community level action may hold higher social construal level of climate change and this may help explain their more strongly held motivation to address climate change in their career (Griffioen et al., 2019).

Students in our study who are motivated to address climate change in their careers viewed global warming more as a technical issue rather than a social issue. This finding is counter to previous findings that suggest connections between climate change and understanding the social implications are critical to getting people to care about the issue (Bain et al., 2012). For example, framing climate change about human rights (Howell, 2013), social justice (Howell & Allen, 2019), health (Adlong & Dietsch, 2015), or economic development (Bain et al., 2016) are more likely to lead to action to address climate change among the general public. The difference might be our sample population are engineers, who are trained primarily to solve technical problems. For instance, birdwatchers were not motivated to take action to address climate change when framing it about the dangers for humans but framing the implications for birds was highly effective in changing their future actions (Dickinson et al., 2013). Similarly, engineering students may connect with the technical problems that arise from climate change because they are trained to address these types of issues. This result indicates that different types of engineering instruction may be needed to motivate students to address climate change in their engineering careers.

Additional predictors for students who want to address climate change in their careers were acknowledging that burning fossil fuels and livestock production are causes of climate change. These topics could be related to students' ability to make sense of climate information (Li & Monroe, 2019). Understanding climate science does not always lead to increased motivation to address climate change (Blennow & Persson, 2009; Ungar, 2000) but for this group of students, understanding does increase motivation. This result might be related to their agency to address the issue (Li & Monroe, 2019).

Disciplines within engineering is also a strong predictor of students wanting to address climate change in their careers. This finding aligns with previous literature that says student major is a significant predictor of participation in environmentally responsible behavior (Fusco et al., 2012). Compared to mechanical engineering students, environmental, architectural, and general engineers are more likely to want to address climate change in their careers. Architectural engineers generally work on the design of buildings. Buildings contribute nearly 40 percent of greenhouse gas emissions from humans (*Buildings & Built Infrastructure | EESI*, n.d.). Retrofitting existing buildings and the design and construction of more efficient buildings is necessary to curb greenhouse gas emissions (*Buildings & Built Infrastructure | EESI*, n.d.). These students may recognize this connection and their responses reflect these opportunities through their specific field in engineering.

Environmental engineering generally works to solve problems broadly associated with climate change and implications for sustainability, including waste disposal, public health, and water and air pollution control. These students are necessary to help develop new solutions to deal with the current negative effects of global warming and environmental problems. Their core courses also reflect this responsibility, generally taking more chemistry, biology, and ecology courses compared to other engineering disciplines. An increase in environmental science courses (Monroe et al., 2019) and training to deal with climate problems (Bozdogan, 2011) may contribute to the larger proportion of students in environmental engineering that want to address climate change (Mutlu & Tokcan, 2013; Oluk & Ozalp, 2007; Porter et al., 2012; Reinfried et al., 2012; Theobald et al., 2015). For example, teaching about climate science and human-caused climate change in the humanities (Siegner & Stapert, 2020), film (Walsh & Cordero, 2019), and medicine (Maxwell & Blashki, 2016) led to an increase in climate change belief.

While engineering major was a predictor of climate change motivation, what students learn in their senior design courses was not a strong predictor for whether students want to address climate change in their careers. The course topics in their senior design courses appear less important than how the information is delivered (Holthuis et al., 2014). Previous models suggest in-class coverage of climate change is less predictive than time spent on science homework or science-themed extracurricular activities among first-year college students (Shealy et al., 2017). Pedagogy that engages students (Monroe et al., 2019), for example, through role-play (Karpudewan et al., 2015) and simulations (Dresner, 1990) leads to improved understanding about climate change. Though, neither pedagogy nor course topics were strong predictors among engineering students in our study.

Student co-curricular activities, such as participating in student organizations, undergraduate research experience, and volunteering are not strong predictors among engineering students for wanting to address climate change in their careers. This finding is counter to prior literature that suggests these experiences contribute to changing students' beliefs about climate change (Faria et al., 2015; Lipscombe, 2008). For example, students participating in an informal science education program making a short, place-based film about climate change impacts in their communities led to an increase in climate change belief. Students participating in this informal program reported greater confidence in their understanding of the causes and consequences of climate change and indicated a stronger sense of both collective and personal responsibility to take action (Littrell et al., 2020). Belief in climate change and motivation to take action in their career to address climate change are not the same (Blennow & Persson, 2009). Our results suggest the type of motivation to take action in their career requires more than just co-curricular experiences (Monroe et al., 2019). However, these types of experiences may help develop students to hold a feeling of responsibility to deal with environmental problems, which as our results suggest does lead to wanting to address climate change in their career (Li & Monroe, 2019).

A perceived level of acceptance among family and friends was previously identified as a strong predictor of belief in climate change (Stevenson et al., 2016). Also, family members tend to have more of an influence than friends and girls perceive climate change as a higher risk than boys (Stevenson et al., 2016). However, neither family and friends nor gender were strong predictors in our study for engineering students who want to address climate change in their career.

Political affiliation and religion (Fusco et al., 2012) are known to influence belief in climate change (Dunlap & McCright, 2008). However, neither were strong predictors for whether engineering students are likely to want to address climate change in their careers. The lack of political affiliation or religion as a predictive variable might be a result of the students similar educational training through engineering (Hamilton et al., 2015). Higher education is not necessarily a predictor for increased belief in climate chance (Hamilton, 2011). Rather, the similar training in engineering may be causing the effect. It could also be a result of their millennial generation identity (Ross et al., 2019). Millennials are more likely to believe in human caused climate change than older generations regardless of political party affiliation. Another possible explanation for varying findings between previous studies and our results is that our study measures students interest to address climate change. Interest to address climate change in someone’s career requires considerably more action than just holding a belief in climate change or the amount of motivation to take personal action (e.g., buying an energy efficient car, using publica transportation, or turning down the heat in winter). Previously reported variables that predict belief or personal motivation are likely not the same variables that motivate someone to want to address climate change in their careers.

Limitations and Future Work

A limitation of the research presented in this paper is that students expressing an interest to address climate change in their careers does not mean these students will actually work to address climate change in their careers, which is the ultimate outcome of interest. Future research could include a longitudinal study to understand how students take action in their careers. The findings reported point to the importance of developing students' personal responsibility for climate change as a predictor for wanting to address climate change in their career. These results lead to questions about how educators can foster this type of responsibility in their students. Prior research about developing personal responsibility suggests that education should allow students to discover the information on their own (Kolb, 1983), through experiential learning, and personal connections both in their local community and in time (Dillon, 2003). This roughly fits with the Knowledge Integration Framework (Svihla & Linn, 2012), which suggests educators make content accessible by connecting to personally relevant experiences and make concepts visible by using models, visual data, and analysis.

Learning through seeing and experience can help educators avoid some of the pitfalls about teaching climate science, for instance, how to appropriately frame the information and communicate it to their class in a non-political way (Drewes, 2020; Monroe et al., 2019). Enabling students to discover the information can reduce the chance of incorrect framing. Framing climate change as a social justice issue resonates with some groups of people (Howell

& Allen, 2019), but among engineers, our results suggest viewing climate change as a technical issue is more likely to lead to future action.

Conclusion

We surveyed 4,605 senior engineering students about their desire to address climate change in their careers and compared how factors about their college experience, beliefs about the environment, and demographics predict student interest in wanting to address climate change in their careers. The strongest predictors for students wanting to address climate change in their career are items that reflect personal recognition and responsibility to address global warming and environmental problems. In addition, understanding the causes of climate change, by acknowledging that burning fossil fuels and livestock production produce greenhouse gas emissions, and discipline within engineering are also predictive of a student's career interest to address climate change. Previous variables that influence belief in climate change or increase students' motivation to address it, such as course topics about climate change and co-curricular activities about climate change are not strong predictors for this sample of engineering students. Similarly, acceptance of climate change among family and friends, political affiliation, and religion, are known to have an effect on belief about climate change but these factors are not strong predictors of engineering students wanting to address climate change in their career. The results presented in this paper extend current understanding about what shapes students' motivation to address climate change. The focus on senior engineering students is unique among prior studies that heavily focus on pre-collegiate experiences that shape belief and motivation. The students in our study were months away from entering careers that likely will have a large and longer-term effect on greenhouse gas emissions and climate change for the next century. Given the numerous educational and personal factors associated with a student's belief about climate change and motivation to address it, the research presented in this paper helps focus educational interventions on experiences that shape personal responsibility and recognition for the need for collective action as ways to increase career interest to address climate change.

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Appendix – Student Survey about Career Goals, College Experiences, Climate Change, and Sustainability

***Q1: Rank the top 3 disciples you are MOST likely to enter upon graduation (select one per column)**

Q1a = Aerospace/Ocean/Astro Engineering
Q1b = Agricultural/Biological/Biological Systems Engineering
Q1c = Bioengineering/Biomedical Engineering
Q1d = Civil Engineering (non-structural)
Q1e = Chemical Engineering
Q1f = Construction Engineering/Management
Q1g = Computer Engineering
Q1h = Electrical Engineering
Q1i = Environmental/Ecological Engineering
Q1j = Industrial/Systems Engineering
Q1k = Materials Engineering
Q1l = Mechanical/Manufacturing Engineering
Q1m = Mining Engineering
Q1n = Nuclear Engineering
Q1o = Software Engineering/Computer Science
Q1p = Structural/Architectural Engineering
Q1q = Other engineering
Q1r = Business (non-engineering role)
Q1s = Medical (non-engineering role)
Q1t = Other (non-engineering)
*Note: Question was not included in our analysis because of its similarity to Question 29.

Q2: How likely is it that you will enter one of the following sectors?

Q2a = Private/Corporate
Q2b = Non-profit/NGO
Q2c = Government/Public Policy
Q2d = Education
Q2e = Entrepreneurship/Start-Up
Q2f = Healthcare
Q2g = Other

Q3: Which of the following are you likely to pursue in the next five years? (Mark all that apply)

Q3a = MA/MS (non-engineering)
Q3b = ME/MS (engineering)
Q3c = PhD (engineering)
Q3d = MBA
Q3e = JD (Law)
Q3f = MD
Q3g = Other

Q4: How important are the following factors to your future career satisfaction?
Q4a = Making money
Q4b = Becoming well known
Q4c = Helping others
Q4d = Supervising others
Q4e = Having job security and opportunities
Q4f = Working with people
Q4g = Inventing/designing things
Q4h = Developing new knowledge and skills
Q4i = Having lots of personal and family time
Q4j = Having an easy job
Q4k = Being in an exciting environment
Q4l = Solving societal problems
Q4m = Making use of my talents and abilities
Q4n = Doing hands-on work
Q4o = Applying math and science
Q4p = Volunteering with charity groups

***Q5: Which of these topics, if any, do you hope to directly address in your career? (Mark all that apply)**
Q5a = Energy (supply or demand)
Q5b = Disease
Q5c = Poverty and distribution of wealth
Q5d = Climate change
Q5e = Terrorism and war
Q5f = Water supply (e.g. shortages, pollution)
Q5g = Food availability
Q5h = Opportunities for future generations
Q5i = Opportunities for women and/or minorities
Q5j = Environmental degradation
*All other topics were not included in our analysis because the outcome variable was students who responded that the hope to directly address Q5d: Climate change.

Q6: While an undergraduate, have you don (or are your currently doing) any of the following?
Q6a = Conducted engineering research with a faculty member
Q6b = Participated in study abroad
Q6c = Contributed to a disciplinary-specific society
Q6d = Worked or volunteered in a developing country
Q6e = Worked for an engineering company as an intern/co-op
Q6f = Lived in a residential or dorm-based engineering program/engineering living-learning community
Q6g = Contributed as a member of an organization for women and/or minorities in engineering
Q6h = Acted as a member of an outreach club (e.g. Habitat for Humanity, Big Brothers Big Sisters)

Q6i = Traveled with an international service group (e.g. Engineers Without Boarders, Students Helping Honduras, Bridges to Prosperity)
Q6j = Participated in an organization that focuses on environmental sustainability
Q6k = Work-study or other type of job to pay for college

***Q7: Please indicate whether the following topics were covered in your courses. (Mark all that apply)**
Q7a = Energy supply (e.g. fossil fuels, nuclear, solar, wind)
Q7b = Energy demand (e.g. in buildings, transportation)
Q7c = Climate change
Q7d = Terrorism & war
Q7e = Water supply (e.g. shortages, pollution, conflict)
Q7f = Population growth
Q7g = Food availability
Q7h = Disease
Q7i = Poverty and distribution of wealth and resources
Q7j = Sustainable development
Q7k = Life cycle analysis methods (e.g. cradle-to-grave)
Q7l = Bio-mimicry
Q7m = Environmental degradation
Q7n = Providing opportunities for future generations
Q7o = Female pioneers in engineering
Q7p = Under-representation of females in engineering
Q7q = Under-representation of racial minorities in engineering
Q7r = Engineering careers, stages, or options
Q7s = Benefits of becoming an engineer
Q7t = Students' stories about engineering/science
Q7u = Teachers' stories about their engineering/science experiences
*Note: We used a weighted sum, a student response for discipline specific engineering was scored as 4, engineering elective was scored as 3, non-engineering elective was scored as 2, other course(s) was scored as 1. The total score for each topic ranged from 0-10.

Q8: Please indicate how often the following occurred in your most recent engineering design course.
Q8a = The teacher lectured to the class
Q8b = We spent time doing individual work in class
Q8c = Concepts/ideas were introduced before formulas/equations
Q8d = We spent time doing small group activities
Q8e = We worked on labs or projects
Q8f = Classmates taught each other
Q8g = Whole-class discussions were held
Q8h = The teacher gave demonstrations
Q8i = Topics were relevant to my career goals
Q8j = The teacher related course concepts to contemporary issues in the world
Q8k = You asked questions, answered questions, or made comments
Q8l = Teacher called on students for responses (not voluntary)

Q8m = Other students asked questions, answered questions, or made comments
Q8n = The teacher related course concepts to helping people

Q9: Please answer the following questions:
Q9a = Did you minor in or have a concentration related to sustainability?
Q9b = Did your most recent in-major engineering design project contribute to helping people in need?
Q9c = Did your most recent in-major engineering design course include an international service component?

Q10: Please indicate below the extent to which the following reasons apply to why you chose to major in engineering:
Q10a = I like solving problems
Q10b = Engineers make more money than most other professionals
Q10c = Engineers help people
Q10d = I am good at math and science
Q10e = My parent(s) want me to be an engineer
Q10f = An engineering degree will guarantee me a job when I graduate
Q10g = I think engineering is fun
Q10h = I like to figure out how things work
Q10i = A faculty member, academic advisor, teaching assistant, or other university affiliated person has encouraged and/or inspired me to study engineering

Q11: To what extent do you agree or disagree with the following statements:
Q11a = I see myself as an engineer
Q11b = My professors see me as an engineer
Q11c = My peers see me as an engineer
Q11d = My parents see me as an engineer
Q11e = I have had experiences in which I was recognized as an engineer
Q11f = I am interested in learning more about engineering
Q11g = I find fulfillment in doing engineering
Q11h = I enjoy learning engineering
Q11i = I understand concepts I have studied in engineering
Q11j = I can do well on engineering exams
Q11k = I am confident that I can understand engineering in class
Q11l = I am confident that I can understand engineering outside of class
Q11m = Others ask me for help in my classes
Q11n = I can overcome setbacks in my engineering courses

***Q12: To what extent do you disagree or agree with the following:**
Q12a = Engineering can improve our society
Q12b = I see engineering all around me
Q12c = Engineering can improve quality of life
Q12d = Engineering allows me to think deeply about problems
Q12e = I can make an impact on people's lives through engineering
Q12f = Engineering knowledge is for the advancement of human welfare

Q12g = Engineering can improve societies globally
Q12h = Engineering will give me the tools and resources to make an impact
Q12i = Engineering can help me improve my community
*Note: Q12 included two factors: Factor one included: Q12a, b, and c; Factor two included: Q12 d, e, f, g, h, and i.

Q13: How much do you agree with the following statements:
Q13a = I sometimes find it difficult to see things from another person's point of view
Q13b = I try to look at everybody's side of a disagreement before I make a decision
Q13c = When I am upset at someone, I usually try to "put myself in their shoes" for a while
Q13d = Before criticizing somebody, I try to imagine how I would feel if I were in their place
Q13e = I believe that there are two dies to every question and try to look at them both
Q13f = I sometimes try to understand my friends better by imagining how things look from their perspective
Q13g = If I am sure I am right about something, I don't waste much time listening to other people's arguments

Q14: To what extent do you disagree or agree with the following.
Q14a = I seek input from those with a different perspective from me
Q14b = I identify relationships between topics from different courses
Q14c = I analyze projects broadly to find a solution that will have the greatest impact
Q14d = When problem solving, I focus on the relationship between issues
Q14e = I hope to gain general knowledge across multiple fields
Q14f = I often learn from my classmates
Q14g = I seek feedback and suggestions for personal improvement

Q15: How confident are you in your ability to do the following:
Q15a = Find sources of inspiration not obviously related to a given problem
Q15b = Effectively work on a problem that does not have an obvious solution
Q15c = Change the definition of a problem you are working on
Q15d = Adapt an engineering solution for a culture different from your own
Q15e = Shape or change your external environment to help you be more creative
Q15f = Share your work with other before it is finished
Q15g = Try an approach to a problem that may not be the final or best solution
Q15h = Continue work on a problem after experiencing a significant failure
Q15i = Help others be more creative
Q15j = Identify and implement ways to enhance your own creativity
Q15k = Explicitly define or describe your creative process
Q15l = Solve problems in ways that others would consider creative

***Q16: How interested are you in working on the following solutions in your career?**
Q16a = Redesigning conventional processes in order to minimize energy consumption
Q16b = Developing technologies that improve energy efficiency
Q16c = Creating ways to reduce carbon dioxide emissions
Q16d = Spreading sustainability awareness in my community
Q16e = Working on renewable energy technologies, such as solar and wind power

Q16f = Improving infrastructure to make it more resilient to extreme weather
Q16g = Working alongside your local government to create legislation to mitigate climate change
Q16h = Building computers capable of emulating human intelligence
Q16i = Developing systems that use genetic information to help people (i.e. drugs, vaccines)
Q16j = Countering biological attacks and pandemics through engineering
Q16k = Protecting the nation against cyber-threats
Q16l = Advancing technologies to provide clean drinking water
*Note: This question was removed from our analysis because of its similarity to our outcome variable asking about students' career interests.

Q17: In your opinion, to what extent are the following associated with the field of engineering?
Q17a = Creating economic growth
Q17b = Preserving national security
Q17c = Improving quality of life
Q17d = Saving lives
Q17e = Caring for communities
Q17f = Protecting the environment
Q17g = Including women as participants in the field
Q17h = Including racial and ethnic minorities as participants in the field
Q17i = Addressing societal concerns
Q17j = Feeling a moral obligation to other people

Q18: To what extent do you disagree or agree with the following.
Q18a = We can pursue sustainability without lowering our standard of living
Q18b = Human ingenuity will ensure that we do not make the earth unlivable
Q18c = I feel a responsibility to deal with environmental problems
Q18d = Environmental problems make the future look hopeless
Q18e = I can personally contribute to a sustainable future
Q18f = Nothing I can do will make things better in other places on the planet
Q18g = Pursuit of sustainability will threaten jobs for people like me
Q18h = Sustainable options typically cost more
Q18i = I have the knowledge to understand most sustainability issues
Q18j = I think of myself as part of nature, not separate from it
Q18k = We should be taking stronger actions to address climate change
Q18l = Engineers are responsible for the majority of environmental problems society faces today

Q19: To what extent do you agree with the following:
Q19a = We are approaching the limit of the number of people the earth can support
Q19b = When humans interfere with nature, it often produces disastrous consequences
Q19c = Humans are seriously abusing the environment
Q19d = Plants and animals have as much right as humans to exist
Q19e = Despite our special abilities, humans are still subject to the laws of nature
Q19f = The Earth is like a spaceship with very little room and resources
Q19g = The balance of nature is very delicate and easily upset

Q19h = If things continue on their present course, we will soon experience a major ecological catastrophe

Q20: How much do you agree or disagree with the following statements:
Q20a = I am sure that global warming is happening
Q20b = Global warming is caused by humans
Q20c = I do not believe global warming is happening
Q20d = Global warming is an important issue to me personally
Q20e = My opinions about global warming are not changing

Q21: Which of the following has contributed the most to your understanding of global climate change?
Q21a = College courses (professors, textbooks)
Q21b = Internet, books, newspapers, or magazines I have read on my own
Q21c = Friends or family members (including parents)
Q21d = Scientific/academic publications
Q21e = Climate scientists
Q21f = Mainstream media

Q22: What percentage of climate scientists think that human-caused global warming is happening?
With response options: 0 – 10, 11 –50, 51-89, 90-100%

Q23: I believe that a cause of global climate change is…
Q23a = Burning fossil fuels
Q23b = Nuclear power generation
Q23c = The ozone hole in the upper atmosphere
Q23d = Livestock production
Q23e = Dumping trash into our oceans
Q23f = Waste rotting in our landfills
Q23g = Agricultural use of chemical fertilizers
Q23h = Deforestation
Q23i = Volcanic eruptions
Q23j = Acid rain

Q24: I believe a way to help reduce or slow down climate change is…
Q24a = Building more nuclear power stations instead of coal power stations
Q24b = Planting more trees in the world
Q24c = Making more of our electricity from renewable energy resources
Q24d = Recycling more
Q24e = Not wasting electricity
Q24f = Fertilizing the oceans to make algae grow
Q24g = Reducing air pollution form toxic chemicals
Q24h = Changing lifestyles to reduce consumption
Q24i = Limiting the use of aerosol spray cans
Q24j = Increasing public transportation

Q24k = Eating less meat

Q25: Which of the following… (Mark one per row)
Q25a = is the most abundant greenhouse gas?
Q25b = amplifies the greenhouse gas effect the most?
Q25c = should we be most concerned about when thinking about global warming?

Q26: How much do you agree or disagree with the following statements about Earth's climate?
Q26a = The Earth's climate has remained pretty much the same for millions of years
Q26b = The greenhouse effect and global climate change are likely unrelated
Q26c = Global warming is happening because too many of the sun's rays get to the earth
Q26d = Global climate change is accelerated by the melting of snow and ice-covered surfaces
Q26e = If human civilization had never developed, there would be no greenhouse effect
Q26f = An increase in the greenhouse effect is causing global climate change
Q26g = Climate and weather are basically the same thing
Q26h = There is no definite proof that either the greenhouse effect or global climate change exist

Q27: Global warming will start to have serious impacts on...
Q27a = me personally
Q27b = my family
Q27c = people in my community
Q27d = people in the United States
Q27e = people in other modern industrialized countries
Q27f = people in developing countries
Q27g = plant and animal species
Q27h = the world's poor
Q27i = the natural environment

***Q28: I believe that global warming is a(n)…**
Q28a = environmental issue
Q28b = moral issue
Q28c = religious issue
Q28d = social justice (fairness issue)
Q28e = political issue
Q28f = scientific issue
Q28g = engineering issue
Q28h = health issue
Q28i = economic issue
Q28j = national security issue
Q28k = agricultural (farming, food) issue
Q28l = poverty issue
*Note: Included two factors: The factor about technical issues included a, f, g, h, i, and k; Social issues included a, d, e, j, l. Item b was left out of our analysis because of it loading in both factors.

Q29: What is your current major field of study? Please choose only one of the following. With response options: Aerospace/Ocean/Astro Engineering, Agricultural/Biological/Biological Systems Engineering, Bioengineering/Biomedical Engineering, Civil Engineering (non-structural), Chemical Engineering, Constructional Engineering/Management, Computer Engineering, Electrical Engineering, Engineering Physics, Environmental/Ecological Engineering, Industrial/Systems Engineering, Martials Engineering, Mechanical/Manufacturing Engineering, Mining Engineering, Nuclear Engineering, Software Engineering/Computer Science, Structural/Architectural Engineering, General Engineering

Q30: What year are you in college?
With response options: 1st Year, 2nd Year, 3rd Year, 4th Year, 5th Year, Other

Q31: What have your in-major grades been up to now at this institution?
With response options: A, A-, B+, B, B-, C+, C, C-, D or lower

Q32: Generally speaking, do you usually think of yourself as republican, democrat, independent, or something else?
With response options: Republican, Democrat, Independent, Other

Q33: What is your religious affiliation?
With response options: Protestant (Christian), Jewish, Muslim, Catholic, Latter Day Saints, Buddhist, Hindu, Spiritual, but not committed to particular faith, Atheist, Agnostic

Q34: How active do you consider yourself in the practice of your religious affiliation?
With response options: Very active, Somewhat active, Not very active, Inactive, Not applicable

Q35: Which of the following people have contributed to your selection of a career path? (Mark all the apply) With response options:
Q35a = Mother/female guardian
Q35b = Father/male guardian
Q35c = Siblings
Q35d = Other relative
Q35e = Sports coach
Q35f = Contact with someone in that major/career path
Q35g = High school counselor/teacher
Q35h = University counselor
Q35i = University professor

Q36: What was the highest level of education for your parents/guardians?
Q36a = Male parent/guardian
Q36b = Female parent/guardian
With response options: Less than high school diploma, High school diploma/GED, Some college or associate/trade degree, Bachelor’s degree, Master’s degree or higher, Don’t know

Q37: What is your gender?
With response options: Male, Female, Non-binary

Q38: What is your sexual orientation?

With response options: Straight/Heterosexual, Gay or Lesbian, Bisexual

Q39: With which races/ethnicities do you identify? (Mark all that apply)

With response options:
Q39a = African-American or Black
Q39b = Caucasian or White
Q39c = South Asian (e.g. Indian, Pakistani, Bangladeshi, Sri Lankan, etc.)
Q39d = East Asian (e.g. Chines, Korean, Japanese, etc.)
Q39e = Other Asian
Q39f = Native Hawaiian or Pacific Islander
Q39g = American Indian or Alaskan Native
Q39h = Hispanic/Latino
Q39i = Not Listed

Q40: To help us estimate the size of the community you come from, please provide your home ZIP code.