Humanitarian Aspirations of Engineering Students: Differences between Disciplines and Institutions

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ABSTRACT: *This study explored the aspirations of undergraduate engineering students in regard to helping others, examining potential differences between disciplines and institutions. Over 1,900 undergraduate students from 17 U.S. universities responded to a survey in spring 2014. In open-ended responses, 15.5 % of the students included some form of helping people and/or the world as one of the factors that motivated them to select their engineering major; for 6.7 % of the students this was the primary or only motivating factor listed. Helping as a motivation was not equally prevalent among different engineering disciplines, being much more common among students majoring in biomedical, environmental, materials, and civil and less common in computer and aerospace. Different disciplines also varied in the priority for helping people relative to other future job factors – highest in chemical/biological, moderate in civil and related majors, and lowest among electrical/computer and mechanical. Institutional differences were found in the extent to which students indicated an importance that their career would help people and the extent to which an ability to help others was a central message in their major. The results indicate the percentages of engineering students who are most likely to embrace humanitarian engineering; fostering these aspirations in students could help with attraction and retention.*

KEYWORDS: Professional goals, helping people, motivation for engineering

1 INTRODUCTION

The current "Generation Z" students have been characterised as "motivated to serve, particularly through volunteerism" and they "believe they will be the generation that will help Americans realise better futures through their civic-mindedness" (Teammates 2011, p. 1). The American Freshman survey found that helping others who are in difficulty was an essential or very important objective for 72.2 % of 153,015 students entering college for the first time (Eagan et al. 2014). Students in this generation often have goals to realise their helping and service motivations through their jobs and profession, with 60 % indicating that "having an impact on the world" will be important in their job (Beltramini & Buckley 2014). Studies in the UK and Denmark also found that many students were motivated toward engineering due to social good and a desire to make a difference in the world (Alpay et al. 2008; Kolmos et al. 2013). Therefore, the service-related elements of engineering are likely to be motivating and attractive to these students.

Humanitarian engineering has been defined as "the artful drawing on science to direct the resources of nature with active compassion to meet the basic needs of all – especially the economically poor, or otherwise marginalised, always seeking a balance of listening and learning from the traditional people whilst humbly sharing appropriate engineering knowledge" (Colledge 2012, pg. 3). Lucena et al. (2010) termed the period since 2000 as an "explosion of 'engineering to help' activities". Well-known groups that promote humanitarian engineering include the Peace Corps (Manser et al. 2015), Engineers Without Borders (EWB) (Sacco & Knight 2014), Engineers for a Sustainable World (ESW) (Dale et al. 2014), Engineering World Health (EWH) (Malkin & Calman 2014), Bridges to Prosperity (B2P) (Reichle et al. 2009), and Habitat for Humanity (Leach 2014). A number of curricular programs also promote humanitarian engineering including Engineering Projects in Community Service (EPICS) (Zoltowski & Oakes 2014) and programs at 28 individual institutions including the University of Colorado Boulder, Ohio State University, and Pennsylvania State University (International Journal for Service Learning in Education 2014).

While the engineering community appears to have increasing interest in humanitarian goals (Munoz &

Mitcham 2012), it is unclear the extent to which this is common among all engineering students or rather represents the aspirations of a limited sub-group. Previous research at a single institution found that 75 % of incoming first year engineering students agreed that "service should be an expected part of the engineering profession" (Duffy et al. 2011a); female and minority students agreed more strongly with the statement "It is important to me personally to have a career that involves helping people" than males and non-minority students, respectively (Duffy et al. 2011b). This specific institution advertises and promotes service-learning that is integrated into numerous courses through all four years of the curriculum for all engineering disciplines. A study based on a 2012/2013 survey found that a desire to have an impact on society and help others in their career was a more common motivation for female than male students (Canney and Bielefeldt 2015a), was more common among environmental engineering students over civil engineering students over mechanical engineering students (Canney and Bielefeldt 2015b), and that learning through service involvement correlated with these attitudes (Bielefeldt and Canney 2014). However, previous studies have not determined how these attitudes vary across a wider range of engineering disciplines, nor if these attitudes vary at different institutions. The research questions explored in this paper are:

RQ1. Are there differences between engineering disciplines and institutions in the extent to which helping others a motivation for students selecting their engineering major?

RQ2. Are there differences between engineering disciplines and institutions in the extent that helping others is a priority for future engineering job?

RQ3. To what extent do engineering students in different majors and attending different institutions believe that the ability to help others is a central message in their major?

2 METHODS

2.1 Overview

This study presents a sub-set of the results from a larger study to explore the professional social responsibility attitudes of engineering students. A previous phase of the research in 2012/2013 included students from five institutions and three engineering disciplines. This follow-up study in 2014 was a broader national study at 17 U.S. institutions encompassing all majors. The study utilised a large online survey instrument, the Engineering Professional Responsibility Assessment (EPRA), described in detail in Canney & Bielefeldt (2015c). This paper focuses on a sub-set of the survey questions; for other results, see Bielefeldt & Canney (2016), Canney & Bielefeldt (2015d), and Canney et al. (2015).

Data collection. In spring 2014, about 26,200 undergraduate engineering students at 17 universities in the USA were emailed an invitation to participate in the online survey. The institutions and majors invited to participate in the survey are shown in Appendix Table A1. All solicitation emails, forms and the survey were approved by the lead author's Institutional Review Board (IRB) in compliance with human subjects testing procedures. As an incentive, student participants who completed at least 90 % of the survey were entered into a drawing for two $50 USD gift cards from among other participants at their institution.

The survey was administered via Qualtrics and began with the informed consent statement. The first question asked students to rate the importance of eight different skills to a professional engineer. The second question was used to evaluate RQ1 and asked "what factors led you to choose your current major?" The next portion of the survey was used to answer RQ2; students were asked to indicate the future job qualities that were most important to them by distributing 10 "stones" into 8 bins. Students could allocate from 0 to 10 stones into each of the bins. The bin labels were: salary, helping people, working on industrial/commercial projects, working on community development projects, living domestically, living internationally in a developed country, living internationally in a developing country, own your own business (be self-employed). These bin labels were developed from previous open-ended student responses on their views of their future careers (Canney 2013).

The next large section of the survey was comprised of fifty Likert items on a 7-point agreement metric to measure students' attitudes toward social responsibility (SR); this resulted in an average SR score (those results are explored in Bielefeldt & Canney 2016). To further explore RQ2, student responses to three items that reflect a desire to help/serve others through engineering are explored in this paper. To answer RQ3, responses to an additional Likert-item that stated "An ability to help others is a central message in my major" were examined. The next large section of the survey asked students to characterise the typical frequency that they had engaged in community service activities since beginning college; responses to this question were explored in a previous study (Canney & Bielefeldt 2015b).

The survey concluded with items to gather demographic information about the respondents including institution, major, and academic rank. When indicating their engineering major, students were allowed to "check all that apply" from among 23 options; students earning dual degrees could indicate both disciplines. Students who indicated "other" or "open" could write-in their major/intended major.

2.2 Data Analysis

Response rates from the 17 institutions (Table A1) were highly variable, ranging from 30 % at a small, Christian institution to 3 % at a large public Master's institution.

Low response rates can bias the results and threaten the ability to draw valid conclusions. A calculation of the confidence interval for each institution was conducted, using a 95 % confidence level and entering the population and sample size (Creative Research Systems 2012). Institutions with a response rate under 20 % and a confidence interval over 10 % were not included in institutional comparisons (italicised in Table A1), leaving 11 institutions for evaluation of potential institutional differences.

Open-ended responses to the second survey question about factors that led students to select their current major were used to answer RQ1. There were 1,906 individuals who wrote a response to the question (50 left it blank). These open-ended responses varied from 1 to 242 words, with a median of 16 words. To provide an initial overview of the responses, a word cloud was generated (Appendix Figure A1). Then the open-ended responses were coded using emergent methods (Creswell 2007) and responses related to "helping people" were analysed in this study. The first author coded all of the responses, and the second-author coded a randomly selected sub-set of 50 of the responses as a check for inter-rater reliability (IRR). Cohen's Kappa was calculated using IBM SPSS Statistics version 22; Kappa above 0.6 indicates a good level of inter-rater agreement (Landis & Koch 1977).

Differences in responses between undergraduate students in different engineering disciplines and from different institutions were evaluated using independent samples non-parametric tests conducted via IBM SPSS Statistics version 22. Non-parametric tests were needed because the data was interval (number of stones) or ordinal (Likert responses). Kruskal-Wallis and median tests were conducted with post-hoc tests to explore pairwise differences when the null hypothesis was rejected; asymptotic significances (2-sided tests) at less than 0.05 were considered significant.

2.3 Participants

Over 1,900 undergraduate students from a broad array of majors completed the survey. At some institutions this also included students from non-engineering majors still within the College of Engineering, such as computer science and math. Some students likely included minors or concentrations among their responses, as a few indicated options that were not available as majors at their institution. Of the 1,937 students who indicated a major, 86.5 % indicated a single major, 11.2 % indicated two majors, and 2.4 % indicated 3 or more majors. Students were "counted" for all of the majors they indicated (Table 1). Write-ins that were similar to the provided choices were counted with those. For example, software engineering is similar to computer engineering, and was counted as such. Less than 30 individuals indicated the following disciplines: agricultural, architectural, biological, construction management, industrial, mining, nuclear, open, petroleum, applied math, and engineering physics.

For some analyses, similar majors were grouped into clusters because these majors are often offered from the same department and a number of students indicated more than one of these majors. The Civil+ cluster included civil, environmental, construction, and architectural. The ChBio cluster included chemical, biological, chemical/biological, and biomedical. The Electrical and Computer Engineering (ECE) cluster included electrical, computer science or engineering, electrical and computer, and software engineering.

Table 1. Engineering disciplines of survey respondents

Major	# students	# students inc. write-ins	# institutions	% students with additional disciplines
Aerospace	78	78	8	21
Biomedical	92	95	11	39
Chemical	70	72	6	13
Chemical/Biological	62	62	4	21
Civil	305	307	15	17
Computer	251	260	13	22
Electrical or Electrical and Computer	217	217	15	23
Environmental	151	154	14	27
Materials	42	42	5	36
Mechanical	684	695	15	11
Other	84	84	13	99
Clusters:				
Civil+		444	15	
ChBio		224	12	
ECE		444	15	

Table 2. Factors that led students to select their current engineering major related to humanitarianism

Code	n	Kappa	Example student response
Help people	134	0.841	Interest in solving problems and an interest in helping others and designing.
Help community	21	1.000	My interest in math and chemistry, as well as the potential to end up in a career where I feel like I can make a contribution to my community.
Help society and/or public	48	0.922	Interest in civil works projects: their scale, scope, and effect on public welfare. Civil engineering also seems to be a stable career with better-than-average pay, and many directions to take (from project managing, to design, to financial oversight).
Help world, environment, and/or humanity	88	0.831	Having a strong base in math and science and being interested in advancements in the world and wanting to solve world problems.
Help disadvantaged (e.g. poor, those with disabilities)	14	0.648	I enjoy science and math, I like the idea of solving problems instead of only studying them, and I think I can do a lot of good for less fortunate people than myself with my engineering degree.
International development	19	0.790	I've always wanted to work in international development, and believed that this would be the best way to achieve that goal.
Make a difference	38	1.000	Job Market, Creative Skillset, Solving World Problems, Making a difference.
Help people / world (HPW) sole or greatest motivation	126	0.601	The ability to improve society and help other people was the main one. I also really enjoyed math, science, and problem solving.

The number of respondents from each of the 17 institutions are provided in Table A1. Other demographics of the respondents (not explored in this study) included: female 35 %, male 65 %; white (not Hispanic) 74 %, Asian 12 %, Hispanic 6 %, multiracial 6 %, Native-American 2 %, African-American 1 %; first-year 14 %, sophomore 28 %, junior 29 %, senior 29 %; grew up primarily outside the U.S. 7 %.

3 RESULTS AND DISCUSSION

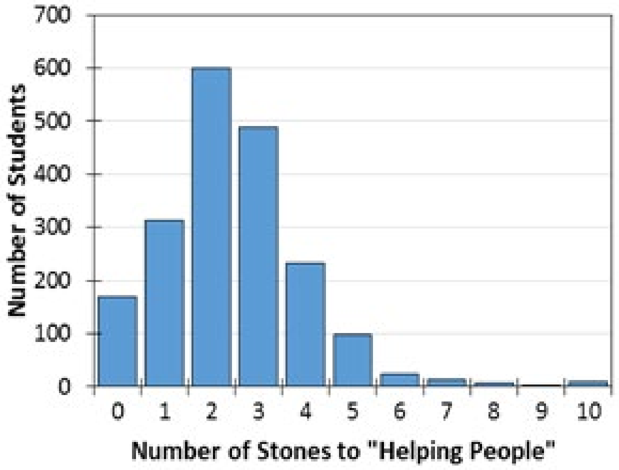
3.1 Helping as a motivation for selecting major

In response to the open-ended question "what factors led you to choose your current major", many students included multiple factors. The most common responses revolved around an interest and/or aptitude in math and science, personal interest, and working with things). Elements related to humanitarian engineering appeared with less frequency. The themes around these responses that were identified from emergent coding are shown in Table 2.

Of the 1,906 responses, 18.4 % (n=351) included some form of helping people and/or the world as one of the factors that motivated them to select their major in engineering. Among those individuals, for 36 % (n=126) it was the primary or only motivating factor listed. Helping people was most commonly cited, followed by helping the world/environment/humanity, then society, and community. Some students also just said "make a difference" without specifying a target (i.e. in my community, in the world, etc.).

Helping as a motivation was not equally prevalent among all of the engineering disciplines (chi test $p<0.001$). A higher-than-average percentage of students majoring in biomedical (36 %), environmental (31 %), materials (24 %), and civil (21 %) cited helping people/world as a factor that motivated them to select their major. Students majoring in computer and aerospace cited these helping people goals less frequently (6 % and 8 %, respectively). Helping was the primary motivating factor for 18-19 % of the biomedical and environmental engineering students, versus only 7 % of the materials and 11 % of the civil engineering students. This supports and expands results seen previously among only environmental, civil and mechanical engineering students at five institutions (Canney & Bielefeldt, 2015b).

Institutional differences of helping people as a factor in selecting their engineering major were also identified; 32 % of the students attending PublicM3 cited helping people/world reasons, compared to 20 % at Christian2, 18 % at Christian4, 17 % at Christian1 and PublicDoc3, and 9-12 %



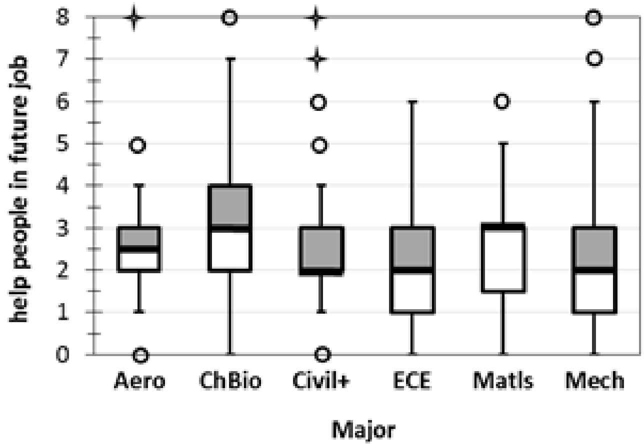


Figure 1. Distribution of importance of helping people in future job – all students (left) and box-and-whisker plots for different disciplines (right)

at PublicM1, PublicDoc4, PublicB1, PrivateDoc1, and Christian3. There were not significant differences in the percentages of students at different academic ranks who cited helping people and/or the world as factors in their choice of major (16 % first year, 17 % sophomores, 14 % juniors, 15 % seniors). Therefore, it seems that the institutional characteristics might differentially attract students with these helping goals, which then persist over time. Further longitudinal research would be needed to verify this assertion.

3.2 Helping as a goal for engineering career

The number of the ten stones that the students used to indicate the importance of "helping people" in their future engineering job ranged from 0 to 10 among the 1,956 responses, with two being most common (2 = mode and median; 2.45 = average) (Figure 1). The average was higher (3.2) among students who were motivated to choose engineering based helping others according to their open ended question responses discussed earlier (median and mode = 3).

There were significant differences between engineering disciplines in the extent to which "helping people" was an important quality of their future engineering job. The box-and-whiskers plot shows the median (line in box), first quartile (bottom of box), third quartile (top of box; shaded), the maximum and minimum values within 1.5 times the interquartile range (the whiskers), and any statistical outliers (circles = out values; star = extreme values). The importance of helping people tended to be the greatest motivator among students majoring in ChBio disciplines, moderate for Civil+ and aerospace, and the lowest for students majoring in ECE and mechanical. There were also differences between related disciplines. For example, within the Civil+ cluster, the environmental students were significantly higher (median 3) than architectural students (median 2); independent samples median test p=0.011.

3.3 Helping attitudes of students

Three of the 7-point Likert-items were examined to determine if there were differences between the attitudes toward helping people through engineering among students in different majors and/or institutions (Table 3; Figure 2). Most students agreed that it was important to help others through engineering, indicated by first quartile scores of 5 (somewhat agree) or higher. There were differences between majors in attitudes toward using engineering to help or serve others; most positive for ChBio and Civil+ and lowest for ECE and mechanical. Paired tests between majors for "use my engineering to serve others" found differences between ChBio and

Table 3. Results of statistical tests for differences between majors and/or institutions

Survey Item Statement	Major		Institution	
	Median sig.	**Kruskal-Wallis sig.**	**Median sig.**	**Kruskal-Wallis sig.**
I think it is important to use my engineering to serve others	0.000	0.000	0.087	0.007
It is important to me personally to have a career that involves helping people	0.000	0.000	0.011	0.002
I will use engineering to help others	0.000	0.000	0.311	0.140

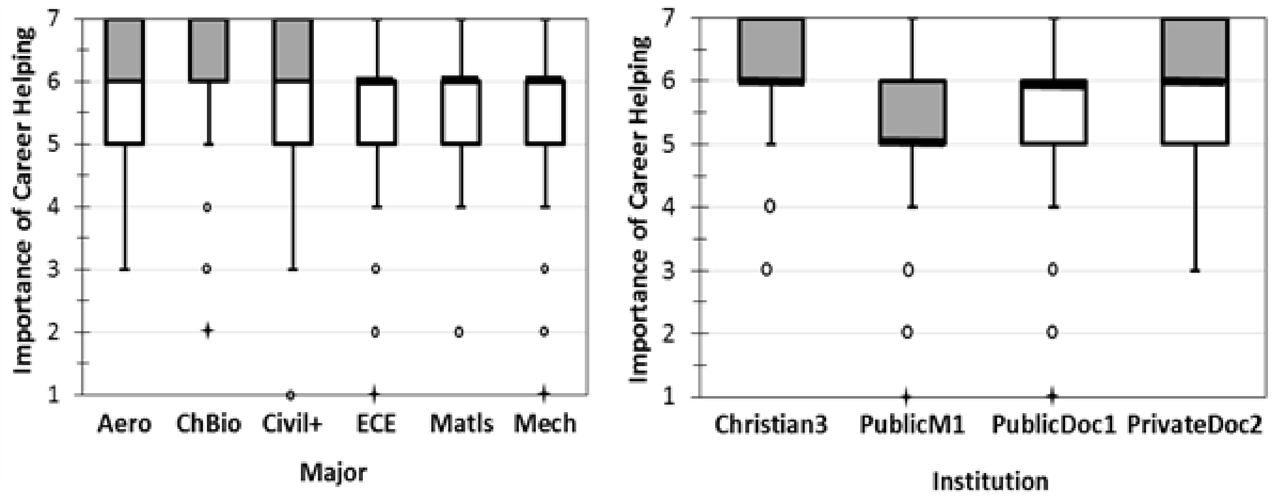


Figure 2. Box-and-whisker plots of Likert-responses to the importance of having a career helping people for different majors (left) and institutions (right)

ECE, Civil+ and mechanical, Civil+ and ECE. For the importance of a career helping people (Figure 3), there were significant differences between ChBio and ECE, ChBio and mechanical, Civil+ and ECE, Civil+ and mechanical. Paired tests for using engineering to help others found differences between ChBio and ECE and Civil+ and ECE.

For institutional differences, examples are highlighted in Figure 2. Most of the institutions had student response distributions similar to PublicDoc1, with a median and third quartile of 6. Based on paired post-hoc tests from the median test, the Christian3 institution was different than three other institutions, PublicM1 was different than two institutions, and PrivateDoc2 was different than three other institutions.

3.4 An ability to help others is a central message in my major

The extent to which students felt that an ability to help others was a central message in their major ranged from "strongly disagree" to "strongly agree". This distribution was significantly different between majors. Example results are shown in Figure 3, where Civil+ engineering students were the most likely to agree with this statement (73 % on the agreement side of the scale), in contrast to 45 % of the ECE students saying the same.

The responses to this question gauge how students feel about the messages being communicated about their major, likely through courses and perhaps also via co-curricular activities. These messages are not intrinsic to particular majors, but vary between institutions; Table 4 shows the averages for institutions where the major had 10 or more respondents; grey highlights the highest and pink the lowest. The Christian institutions were often among the highest across multiple disciplines. Perhaps courses common across all engineering majors, such as required ethics and/or religion-related courses, emphasise the message of helping others through your career. In addition, perhaps the engineering instructors at these institutions emphasise this message in their courses. In contrast, PublicDoc1 had the lowest scores for ECE and mechanical majors, but was among the highest for Civil+; this indicates

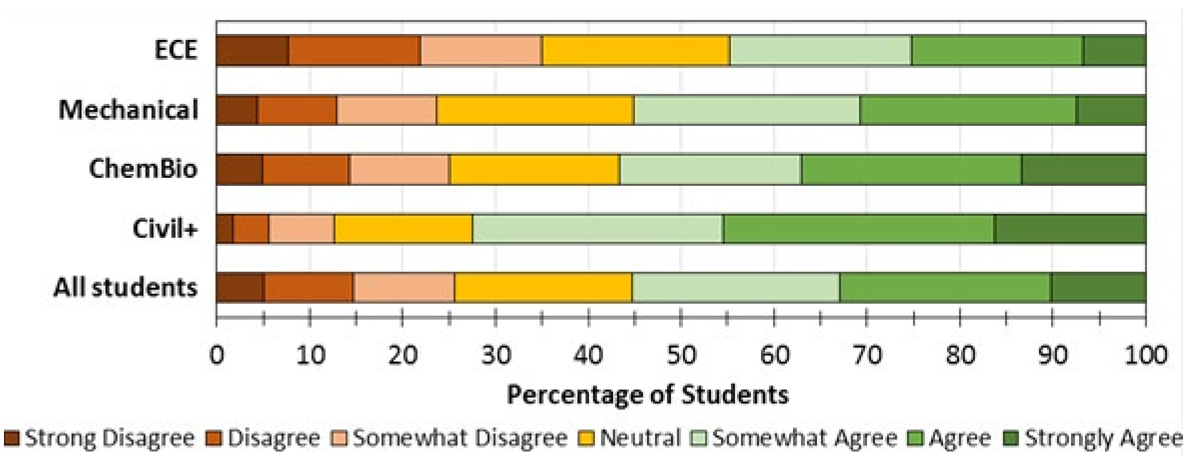


Figure 3. Likert-responses from different majors to "an ability to help others is a central message in my major"

Table 4. Average response at different institutions for "ability to help others is a central message in my major"

	Christian				PublicM		PublicDoc			PrivateDoc	
Major	**1**	**2**	**3**	**4**	**1**	**2**	**1**	**3**	**4**	**1**	**2**
ChBio	6.2			5.2		5.4	4.3			4.7	3.7
Civil+				5.4	5.2	5.4	5.2	5.4	5.1	4.1	4.7
ECE	5.0	4.6	5.2	4.6	4.3	4.0	3.5		4.0	4.2	3.6
Mech	4.8	5.0	5.6	5.0	4.3	4.0	3.8	4.7	4.9	4.5	4.3

that helping others is not consistently high or low across an institution but rather departments can set this tone.

4 CONCLUSIONS AND RECOMMENDATIONS

The current study adds to the body of literature that has explored factors related to engineering students' motivation toward humanitarian engineering. While previous work has focused on differences between female and male engineering students, this work found that elements of humanitarian engineering, namely a desire to help others, varied in frequency and importance across engineering disciplines and higher education institutions with respect to students' views and goals. Helping others as a motivation for students selecting their engineering major was most common among students in biomedical, environmental, materials, and civil engineering; and the least common among students in aerospace and computer engineering. Helping others as a motivation for selecting an engineering major was quite common (32 %) among students attending a Public institution offering Master's degrees as the highest degree; this was much less common (9-12 %) among students attending the majority of institutions. Students majoring in chemical/biological engineering placed a greater importance on helping others in their future engineering careers than students majoring in ECE or mechanical engineering; students attending a Christian-affiliated private institution also placed more importance on helping others than students attending other institutions. The extent to which students believed that helping others was a central message in their major was the highest among students majoring in civil engineering and related disciplines, moderate in ChBio and mechanical engineering, and the lowest among students majoring in ECE. This message varied between institutions, being the highest at Christian-affiliated private institutions and the lowest at two private, research-intensive doctoral institutions.

These results provide evidence for what many faculty who have engaged in humanitarian engineering projects have already anecdotally known, that, for some students (32 % in this study), a desire to help others is a driving motivation for their studying engineering. This sets the stage for further discussion about the ways in which current engineering education does and does not acknowledge, support, and expand upon these motivations. Toward catering to this variety in motivations, especially for those who desire to help others, it seems clear that a "one size fits all" educational approach may not be adequate for all engineering majors. Disciplines with higher percentages of students who are motivated with humanitarian engineering ideals may benefit from adjusting course offerings, course content, or even just adding humanitarian engineering context to traditional engineering problems, as a way of acknowledging and supporting those motivations. Disciplines with lower percentages of students may wish to look at messaging that attract students to see if an ability to help others may reach a broader range of potential students.

The study indicated that the culture at particular institutions may differentially attract students with humanitarian goals, while courses and community service opportunities at the institution and within the local community may also foster these ideals. Institutions should work to make students aware of service opportunities that match their goals and interests. Incorporating service-learning into required courses may be particularly effective, given that students often have busy schedules and financial constraints that may limit their ability to engage in co-curricular and/or volunteer activities on their own time. Asking students to reflect on their responsibilities toward community service and helping people as professional engineers may also help to foster these goals. Future work should focus on measuring how the humanitarian goals and aspirations of engineering students change over time, and potential links to persistence and retention in engineering through college and into the workplace. It is also important to establish the extent to which these findings are generalisable outside the U.S.

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7 APPENDICES

Table A1. Institutions Participating in the Study

Institution Abbrev[1]	Carnegie Basic, Community Engagement, Geographic Region, Enrollment[2]	Engineering Majors[3]	N student responses	Population Response rate, %	Confidence Interval, %[4]	Humanitarian programs
Christian1	Master's L, NC, Southeast, 6000	Bm C E M P	53	30	11.3	Eng global SL class
Christian2	DRU, CEOP, Plains, 11,000	C E M	157	28	6.6	SL senior design; Peace Engineering
Christian3	Bac/Diverse, NC, Southeast, 2000	EC M O	34	22	15.0	Global community development projects
Christian4	*Master's L, CEOP, Far West, 8000*	*C Ci E M*	*56*	*13*	*12.3*	*Sr. Design; EWB/ESW*
Christian5	Master's L, CEOP, Far West, 9000	B C Ci E G M	104	11	9.1	EWB; frugal innovation center
PublicB1	*Bac/A&S, NC, US service sch, 5000*	*C Ch Ci E En M Os*	*67*	*6*	*11.6*	*EWB*
PublicM1	Master's L, CEOP, Rocky Mtns, 19,000	Ci C Co E Ma M	108	5	9.2	SL sections first year design, global humanitarian SL course
PublicM2	Master's L, NC, Far West, 19,000	A Bm C Ci E En Ma M	193	3	7.0	EWB
PublicM3	*Master's L, CEOP, Southeast, 19,000*	*G*	*34*	*8*	*16*	*Project-based learning*
PublicDoc1	RU/VH, NC, Rocky Mountains, 33,000	A C Ch ChB Ci En E EC G M P O	435	12	4.4	EWB, B2P; SL sections of first year design
PublicDoc2	*RU/H, CEOP, New England, 13,000*	*Ci E En G M*	*80*	*11*	*10.4*	*EWB; SL through CiEn curriculum infusion*
PublicDoc3	RU/H, NC, Great Lakes, 7000	Bm C Ch Ci E En G M Ma Os	251	7	6.0	EWB, H4H, D80, Peace Corps
PublicDoc4	RU/H, CEOP, Far West, 28,000	C Ci E En M	109	5	9.2	Institute for Sustainable Solutions; EWB
PublicDoc5	*RU/VH, NC, Plains, 29,000*	*Ci* En**	*16*	*6*	*24*	*B2P, EWB*
PrivateDoc1	RU/VH, CEOP, New England, 10,000	Bm Ch, Ci En C E G M P	101	12	9.1	EWB; K12 outreach
PrivateDoc2	RU/VH, NC, Far West, 18,000	C Ch Ci E En G I M Ma	116	4	8.9	ESW; frugal innovation center
PrivateDoc3	*RU/VH, CEOP, Southwest, 6000*	*Ci* En**	*17*	*31*	*20*	*EWB, Beyond Traditional Borders*

[1] Institutions were assigned pseudonyms based on control (public or private or private Christian) and top level of degrees of available (B= Bachelor's, M = Master's; Doc = doctoral); italics indicates a response rate below 20 % and confidence interval over 10 %, therefore data may not be representative and these institutions were not included when conducting statistical tests for institutional differences

[2] Carnegie classifications – Basic: Bac/A&S = Baccalaureate Colleges – Arts & Sciences, Master's L = Master's College and Universities (larger programs), RU/H = research universities (high research activity), RU/VH = research universities (very high research activity). Voluntary Community Engagement classification either not classified (NC) or Curricular Engagement and Outreach & Partnerships (CEOP). Geographic Region. Enrollment (fall headcount all levels) rounded to the nearest thousand.

[3] Engineering Majors: A = aerospace; B = bioengineering, biological engineering; Bm = biomedical; C = computer science, computer engineering, or software engineering; Ch = chemical; Ci = civil; Co = construction; E = electrical; En = environmental; G = general (many of these also have set focus areas available such as aerospace, industrial, etc.); I = industrial, management, manufacturing, systems; M = mechanical; Ma = materials; O or Os = other specialty degree(s); P = physics, engineering physics

[4] Confidence interval calculated based on the population surveyed, number of responses, and a 95% confidence level; a smaller confidence interval is better (http://www.surveysystem.com/sscalc.htm)

* only students from these majors were invited to participate in the survey, based on contacts that were made at the institution