Disengaging or Disappearing? Losing the most Socially Motivated Students from Engineering?

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Abstract

Engineering has been marketing itself to high school students as a discipline that helps people. As more socially motivated students enter into engineering, an outstanding question is whether or not these students are retained to graduate in engineering or leave to other disciplines at higher rates as compared to less socially motivated peers. A previous study that characterized students' motivations toward engineering using interview methods found that female students whose primary motivation toward engineering was to help underserved populations left engineering at a higher rate than female students with other primary motivations toward engineering. The students participating in that study were initially enrolled at four different institutions, but the study population was quite small (n~30). The current research used quantitative methods to characterize the social responsibility (SR) attitudes of a larger population of incoming engineering students at a single institution. A high SR score was defined as an average score across nine 7-point Likert-type items at the third quartile or higher. Among 122 students who entered engineering at the institution in fall 2011, 45% of those with high initial SR scores left engineering, compared to only 28% among students with lower SR scores. Among 57 students initially majoring in mechanical, civil, or environmental engineering in fall 2012, 44% of the students with high SR scores left engineering, compared to only 34% leaving who did not possess high SR scores. Both gender and major appeared to play a role in the results. The curricular context of engineering majors at this institution are discussed in terms of social context, technical/non-technical balance and course flexibility, as compared to the most common destination majors of the students who left engineering. The preliminary results suggest that engineering programs that wish to retain highly socially motivated students should explore the infusion of social context into engineering courses beyond the first year, as well as the required balance of technical and non-technical coursework in their curriculum and opportunities for course choice.

Background

Engineering has an important role to play in addressing a number of important challenges facing society and the world.[1-3] These challenges embrace the interface between humans and technology, and addressing these issues will require creative, systems-level thinking. A diversity of engineering students with a range of talents and attributes will be needed to meet the demands of society.[4] This includes students who are motivated toward engineering due to a desire to help people and the planet.

Previous research has explored the attitudes of engineering students toward helping society. Across three institutions, Cech[5] found that the public service motivations of engineering students decreased during college. She termed this a "culture of disengagement." Canney and Bielefeldt[6-7] found that the social responsibility attitudes of engineering students differed between genders, among ranks, engineering disciplines, and among those attending religiously-affiliated, secular private, and public institutions. Their work also found that among female students at four institutions, a higher percentage decreased in social responsibility attitudes over time than increased. Differences in the social responsibility of engineering students at different ranks could be partially attributed to decreases longitudinally in individual students. However, it was unclear if some of the lower social responsibility scores among seniors might be attributable to higher attrition of students with highly positive social responsibility attitudes out of engineering.[6]

A primarily qualitative study on the social responsibility attitudes of engineering students tracked changes in student majors over time. [8-9] There were initially 34 first-year engineering students interviewed (21 women, 13 men), who were attending four institutions and majoring primarily in mechanical, environmental, and civil engineering. Based on the interview responses during spring of their first year of college, the students were generally found to cluster into four groups with respect to the extent to which the ability to help others was a motivation for choosing to major in engineering in college.[8] For ten students, the choice to major in engineering was strongly related to their sense of social responsibility and a desire to help disadvantaged and marginalized individuals in the world. Among these students, 70% left engineering within the first three years of college (75% of the women, 50% of the men). [9] Among the other 24 students, only 17% left engineering (8% of the women, 27% of the men). [9] Interviews with nine of the students who left engineering found that for one, her concern with an inability to realize her social responsibility goals through engineering was a primary reason to change majors. For three other female students, social responsibility was among their main reasons to change majors out of engineering. Three students left engineering primarily due to other reasons, but social responsibility concerns were partially present. In no cases did students indicate that they left engineering solely due to concerns of insufficient opportunity to help others; rather, for many social context was one among an array of concerns (lack of interest in courses, few course choices, struggling in core courses, unsupportive faculty, dislike type of work during internship). Perhaps a lack of social context in the engineering courses that they were experiencing helped tip the balance to deciding to change their major out of engineering. The findings from this earlier work leads to the question of whether students with greater social motivation might be leaving engineering at a higher rate than others.

Why would the social relevance of engineering (or perceived lack thereof) impact whether or not some students leave engineering? A few underlying issues are likely at work. First, if helping others is a primary goal for students in their engineering careers and they lose confidence that these goals can be realized, their motivation toward engineering would clearly suffer. Intrinsic motivation, interest congruence, and values alignment have been linked to retention in engineering in college and likelihood of persistence to engineering careers.[10-13] Seeing a more clear path to helping others through different, non-engineering careers would draw those students away from engineering. Another effect may relate to identity. Identity is also among the diversity of factors shown to be relevant to student retention within engineering.[14-15] If students feel that engineering can help others but the general culture of engineering does not embrace this identity, students may feel that they don't "fit" within engineering. This feeling could result if students don't see social context in their core engineering courses. While they realize the helping potential is there in the future, they feel somewhat misfit if the culture of engineering that they are experiencing evidences little empathy or caring.[16-17]

This research aimed to determine if students' with strong aspirations to help others through engineering might be leaving engineering at higher rates than students with lower motivations in this regard. These retention differences might be related to the decontextualized engineering education that has been reported.[5,18]

Research Questions

Four primary questions were explored in this study.

RQ1. Is there differential retention of students in engineering who possess strong and weaker attitudes toward professional social responsibility?

RQ2. Is there a differential retention of students in engineering between genders with respect to their professional social responsibility attitudes?

RQ3. Is there a difference among majors in the retention in engineering with respect to professional social responsibility attitudes?

RQ4. Is there evidence that curricular factors such as topics in required courses, curricular balance, and/or choice might influence the retention of socially motivated students in the engineering majors of interest at this institution?

Methods

This was an exploratory study among a convenience sample of students at a single large public institution classified as having very high research activity.[19] In this study, the professional social responsibility attitudes of incoming first-year students were measured using items from the Engineering Professional Responsibility Assessment (EPRA) survey instrument.[20] The full EPRA survey evaluates the eight dimensions of the Professional Social Responsibility Development Model (PSRDM).[20] Two of the eight dimensions were selected as the focus of the current study: *analyze* and *professional connectedness*. *Analyze* reflects the attitudes of individuals about the importance of including social and human dimensions in engineering, going beyond solely technical factors. All five EPRA items to assess the *analyze* dimension were used (Table 1). *Professional connectedness* gauges attitudes toward applying one's technical skills to help people and society. Four items from among the larger number of 19 items in EPRA were selected to assess professional connectedness (Table 1). Students responded to the items using a 1 to 7 scale from strongly disagree to strongly agree. One of the items for each dimension was negatively worded, and therefore reverse scored. The average score across the nine survey items (SR9) was computed, and for each student could range from 1 to 7.

Four cohorts of students were examined. In fall 2011, students enrolled in introductory courses for entering first-year students majoring in civil engineering, environmental engineering, and a general engineering introductory course, were invited to participate in the survey. These students took a pilot version of the EPRA survey.[21] In fall 2012, first-year students majoring in civil, environmental, and mechanical engineering at five institutions (including the institution in this study) were invited to participate in a larger research study; the survey recruitment methods have been described in detail elsewhere.[20] These students took the full ERPA survey in an online format, including 50 Likert-type items to evaluate SR attitudes. Survey participation rates among the students at the target institution in these three majors were relatively low (Table 2).

Table 1. Statements used to Assess the Social Responsibility Attitudes of Engineering Students

Dimension	Survey Item
Analyze	Rate the importance of different knowledge and skills for professional engineers: cultural awareness
	Rate the importance of different knowledge and skills for professional engineers: societal context
	I would not change my engineering design because it conflicted with community feedback [reverse scored]
	It is important for engineers to consider the potential broader impacts of technical solutions to problems
	It is important to incorporate societal constraints into engineering decisions.
Professional Connectedness	Rate the importance of different knowledge and skills for professional engineers: volunteerism
	It is important to me personally to have a career that involves helping people
	Service should not be an expected part of the engineering profession [reverse scored]
	I feel called by the needs of society to pursue a career in engineering

The third and fourth cohorts of students were enrolled in first-year introductory courses for architectural, civil, and/or environmental engineering in fall 2014 and fall 2015. These courses were required for entering first-year students in these majors. A paper survey that included the nine SR items of interest among a larger group of 38 survey items (largely focused on sustainability attitudes[22]) was distributed in-class on the first or second day, and participating students were awarded extra credit points for participation. Response rates were higher for this in-class paper survey method (Table 2).

Table 2. Cohorts of incoming first year students examined for retention

Cohort (year)	Initial Discipline	% participation	n with SR score	% female
1 (2011)	Civil	94	45	20
	Environmental	30	21	38
	Various	*	62	29
2 (2012)	Civil	34	11	27
	Environmental	28	13	62
	Mechanical	28	32	16
3 (2014)	Architectural	97	37	41
	Civil	94	50	36
	Environmental	95	70	50
4 (2015)	Architectural	71	20	50
	Civil	91	52	31
	Environmental	83	53	42

* a number of students took the survey without providing their identity, and thus unable to determine whether or not they stayed in engineering

Among the student respondents in the cohorts, females were over-represented relative to their percentage of the students in each group invited to participate in the survey; this phenomenon has been commonly reported in survey research.[23]

On September 15-16, 2016, the majors of the students were determined (upon graduation for the majority of the students in cohorts 1 and 2, current majors for students who had not yet graduated). Individuals affiliated with any engineering major were counted as “retained” or “stayers”, while individuals in other disciplines or who left the institution were counted as “leavers”. Cohort 4 student majors were re-examined in January 2017; however, this still only represents retention after 3 semesters. Additional students in cohorts 3 and 4 would be expected to change majors out of engineering prior to graduation based on typical retention patterns at the institution. For example, among the 2012 cohort that entered the College of Engineering & Applied Science, the percentage of students still enrolled in the College in the 2nd fall, 3rd fall, and 4th fall were 86%, 73%, and 68%. The retention of female students among the 2012 cohort was 2%, 5%, and 7% lower than the retention of male students in each of those terms, respectively. The 4th fall retention within engineering for specific initial majors were: 65% architectural, 70% civil, 62% environmental, and 73% mechanical. It is also important to note that some non-engineering majors exist within the college (such as computer science, applied math); thus the retention numbers presented for the College would be somewhat higher than the engineering retention values calculated in this research.

Responses that did not include answers to all nine Likert-items of interest were removed from the data set; response rates shown in Table 2 are only based on completed responses. Among each cohort and sub-group of interest, the third quartile (Q3) among the SR9 scores were determined, with results shown in Table 3. For RQ1, the overall cohort in each year was examined, with similar Q3 SR9 scores among cohorts 1, 3, and 4. For RQ2, the students were separated by gender to determine the Q3 SR9 scores; within each cohort it was found that female students had higher Q3 SR9 scores than the male students. For RQ3, the students were separated by major to determine the Q3 SR9 scores. Students whose SR9 score fell at or above the Q3 level were identified as the high SR sub-group, and the remaining students placed in the other classification. Counts were conducted of students who remained in engineering or left engineering. Then Fisher’s exact tests were conducted, with two-tailed p-values calculated to identify statistically significant differences ($p < 0.05$).

Table 3. Third quartile SR9 scores for various cohorts and sub-groups

Cohort	All	Female	Male	Architectural	Civil	Environmtl	Mechanical
1	6.22	6.53	6.00	NA	6.22	6.56	6.00
2	5.89	6.08	5.67	NA	6.17	5.89	5.58
3	6.22	6.44	5.89	6.00	6.33	6.31	NA
4	6.11	6.33	5.89	5.81	6.25	6.11	NA

To explore the characteristics of the curricula of interest relative to RQ4, a variety of methods were used. The university catalog described the requirements for each degree. Earlier work quantified choice metrics and technical/non-technical balance in engineering degrees.[24-25] These same methods were used to characterize the common “destination” majors for the students who left the targeted engineering majors at this institution. Choice was defined as opportunities for students to choose a course to count toward graduation requirements; these could be small menus of options (such as choose one of three laboratory courses), offer choice within a single discipline (such as a civil engineering elective among about 30 junior/senior level courses), or wide choices (such as technical electives or humanities &/or social science electives from among 100 to 300 courses across an array of majors, or completely free electives). Technical/non-technical balance separated the curriculum requirements into these two general pools. Engineering, math, computing, and natural science courses were considered technical; social science and humanities courses were considered non-technical. Further, the three engineering majors for cohorts 3 and 4 were participating in ABET assessment that included student ratings of the extent to which they believed that required engineering courses in these disciplines contributed to the ABET Criterion 3 A to K outcomes. This was done anonymously in surveys at the end of the semester. These data give a sense from students as to whether societal context was a significant element in required engineering courses in their curriculum.

Results and Discussion

RQ1. Differences in Attrition Based on SR Attitudes

The percentage of students who left engineering was compared based on students' SR9 scores when they entered college; the results are summarized in Table 4. For the first cohort, after five years 17% more of the students with high SR had left engineering; the difference was only marginally statistically significant. Among cohort 2 over 4 years, 10% more of the high SR students had left engineering compared to the percentage of students with lower SR scores. However, this was not found to be a statistically significant difference. Among the third cohort, 5% more of the students with high SR had left engineering by the second year; the difference was not statistically significant. Among the fourth cohort, after 3 semesters a similar percentage of students from both SR9 groups had left engineering. If the 2014 and 2015 cohorts were tracked longer, additional attrition would be expected; it is unclear if more of the students who leave in the later years might be those with initially more positive social responsibility attitudes.

Table 4. Percentage of students who left engineering from groups with different SR attitudes

Cohort (year entered college)	SR group	n	% students left engineering	Fisher's exact 2-tailed p
1 (2011)	High SR	33	45	.0841
	Other SR	89	28	
2 (2012)	High SR	16	44	.4981
	Other SR	41	34	
3 (2014)	High SR	44	39	.5799
	Other SR	113	34	
4 (2015)	High SR	35	23	.6559
	Other SR	90	28	

RQ2. Gender, SR Attitudes, and Attrition

To explore the second research question, the data were disaggregated by gender within each cohort (Table 5). In the 2011 and 2012 cohorts, there were not differences in the percentage of male students who left engineering majors based on their SR scores. Among the 2014 and 2015 cohorts, somewhat fewer of the male students with high SR scores left engineering compared to male students with lower SR scores; differences were not statistically significant. In contrast, there was somewhat higher loss among females with high SR scores within cohorts 2 and 3, but the difference was not statistically significant. The loss rate of female students overall was higher than male students; this agrees with institution-level data from the College of Engineering & Applied Science.

Table 5. Percentage of students by gender and SR attitude who left engineering

Cohort (year)	Gender	n High SR / Other SR	% loss high SR	% loss other SR	Fisher's exact two-tailed p
1 (2011)	Female	6/10	50	60	1.000
	Male	13/31	38	38	1.000
2 (2012)	Female	4 / 12	75	42	.5692
	Male	12 / 29	33	31	1.000
3 (2014)	Female	20/48	50	35	.2885
	Male	29/60	21	37	.1505
4 (2015)	Female	17 / 44	24	27	1.000
	Male	21 / 43	24	28	1.000

RQ3. Disciplines

The data were disaggregated by discipline to explore retention (Table 6). Across all four years of cohorts, civil engineering students with high SR scores left engineering at a higher rate than their peers with lower SR scores; however, none of the differences were statistically significant. A similar result was found for architectural engineering students. Results for environmental engineering students were mixed among the cohorts, with greater loss of students with high SR scores among the 2011 cohort, but lower loss of high SR students among 2012 and 2015 cohorts; differences were not statistically significant. For mechanical engineering students, there was a somewhat higher loss of students with high SR scores among the 2012 cohort; the attrition rate was similar in the 2011 cohort regardless of SR score. Although none of the results were statistically significant, it appears that initial student major may be an important factor. While the majority of the students who stayed in engineering remained in their initial major, 18% had changed majors within engineering. In the future, larger data sets could allow multi-level models for retention that include factors of incoming SR score, incoming student major, and gender. Then interactive effects could be elucidated.

Table 6. Percentage of students by discipline and SR attitude who left engineering

Cohort (year)	Discipline	n High SR / Other SR	% Loss High SR	% Loss Other SR	Fisher's exact 2-tailed p
1	Civil	19 / 39	42	28	.3742
(2011)	Environmental	5 / 10	60	30	0.3287
	Mechanical	4 / 9	25	22	1.000
2	Civil	3 / 8	67	25	.4909
(2012)	Environmental	5 / 8	20	38	1.000
	Mechanical	8 / 24	50	38	.6838
3	Architectural	11 / 26	55	31	.2679
(2014)	Civil	14 / 36	36	20	.2777
	Environmental	18 / 52	44	40	.7874
4	Architectural	5 / 15	20	7	.4474
(2015)	Civil	13 / 39	23	21	1.000
	Environmental	18 / 35	28	43	.3745

RQ4. Curriculum Factors

Given the apparent increasing attrition of students with high SR out of engineering over time (given that the highest percentage loss from engineering was in cohort 1 and lowest loss from engineering in cohort 4), curricular factors that could influence students to change their major out of engineering were explored.

The required courses that were primarily indicated by students to impact their understanding of the 'impact of engineering on society' (for ABET outcomes assessment) and 'social responsibility'[18] are highlighted in Table 7. All four majors at this institution require students to take a first-year projects course; across the many sections of the course, some of these projects may be service-learning (S-L), others are community contextualized, and some are purely technical exercises (like a Rube Goldberg machine).[26] Additional introductory courses to the major required in the first semester for architectural, civil, and environmental engineering students contain an emphasis on societal factors. Overall, the environmental engineering curriculum appears to include the most courses that emphasize societal impacts, followed by civil, architectural, and then mechanical engineering. Across all of the required courses in the curriculum with student rating data, the average societal impacts ratings were 3.7, 4.0, and 4.2 (scale 0 to 6) for architectural, civil, and environmental engineering, respectively (comparative data is not available for mechanical). This gives a sense that students with strong desire to impact society via their work are likely to find these aspirations congruent with environmental engineering but perhaps unsure if they fit well into mechanical or architectural engineering.

Table 7. Required courses in the curriculum with social context

	Architectural	Civil	Environmental	Mechanical
First year	First-year projects: some sections S-L, some community context, some little/no social context AR/CV Intro (2-cr)		EV Intro (1-cr)	
Second year		Engineering Geology*	Fund Environmental Eng Sustainability Principles	Professional Issues
Third year	Intro to Construction	Fund Environmental Eng Intro to Construction	Env Microbiology Air Pollution Control	
Fourth year	Capstone design	Capstone Design	Env Organic Chemistry Capstone Design	Capstone design

** Variable with instructor*

Another consideration is the fact that students with interests in helping people and society may be more likely to value the opportunity for a balanced education that includes humanities and social science courses as well as their technical engineering coursework. Previous research determined that in general engineering curricula offer students less balance between technical (math, natural science, and engineering) and non-technical (humanities, social science) coursework.[25] At the institution in this study, students in engineering do not participate in the "common core" that is required in the College of Arts & Sciences and the College of Business. The common core requires courses related to topics including human diversity, contemporary society, and ideals & values. In contrast, the engineering majors only allow a small number of humanities &/or social science electives, without any restriction on topics.

The most common non-engineering majors into which students in the four cohorts transferred were: environmental studies (15), biology (11), environmental design/architecture (10), integrated physiology (9), computer science (7), math (6), economics (6), various majors in the College of Business (6), physics (3), geology (3), sociology (3), international affairs (3), and other majors in humanities and social science (e.g. geography, psychology, anthropology, film, Spanish; 9). The balance of required technical, non-technical, and free electives (either) courses in the four engineering majors in this study and six non-engineering comparators is summarized in Table 8. For the architecture and business students, the majority of the architecture and business courses were counted as "technical" (with exceptions such as "History of Architecture" and "Business Law, ethics, and social responsibility"). Adding required non-technical courses and free electives together, engineering majors can take up to 16-19% non-technical coursework, compared to 28%-62% in the other "comparator" majors.

Self-determination theory indicates that choice is a powerful ingredient in motivation.[27] The extent of any choice among the courses taken to earn a Bachelor's degree varied substantially between engineering disciplines, being lowest in mechanical engineering at 25% and highest in environmental engineering at 46%. However, these choices range from very small (select among two engineering economics courses) to large (a free elective, any technical or non-technical course eligible). Choice was much higher in the non-engineering degrees into which the students transferred, with the exception of Architecture that had a similar level of choice. An example of a particularly stark contrast is environmental engineering (BS) versus environmental studies (BA), where the environmental studies degree includes only 13 credits of required courses (89% choice) and all other requirements are menus of courses to fulfill various requirements or free choice; the environmental engineering degree has 69 credits of required courses without choice.

Table 8. Curricular balance and choice in the degree programs of interest

Major	Total credits	% required technical	% required non-technical	% free or either tech/non-tech electives	Total choice, %
Architectural Engrg	128	84	14	2	31
Civil Engrg	128	81	14	5	38
Environmental Engrg	128	84	14	2	46
Mechanical Engrg	128	84	14	2	25
Environmental Studies (science/policy tracks)	120	68/38	28/45	4/17	89
Biology	120	67	28	6	81
Architecture	120	70	15	15	45
Integrated Physiology	120	63	28	9	70
Computer science (eng)	128	72	19	9	70
Business majors	120	62	24	14	60

Choice opportunities may allow students to select electives, either technical or non-technical, that embrace human and societal dimensions and interests. For example, among mechanical engineering students at this institution, some identified an elective mechanical engineering course in sustainability as influential to their views of social responsibility.[18] The timing of choice opportunities is also important. Many students leave engineering within the first few semesters, so the commonly observed model at the institution of allowing students choices at the end of the curriculum (such as specialization courses within their major) are too late to impact students' decision whether or not to remain in engineering.

Compounding issues of curricular balance and choice may be considerations of time to degree. The engineering and computer science degrees required 128 total semester credits to graduate, compared to only 120 credits in the other non-engineering majors. Navigating to on-time graduation is also facilitated by more choice and/or fewer pre-requisite "chains". In addition, many engineering students enter college with a number of AP credits and only a fraction of those could be applied to the degree requirements in engineering while a much larger number could be applied toward the graduation requirements in the non-engineering degrees. Thus, it is possible that a number of factors combine to make engineering less attractive to students than other degree options.

Limitations

The results of this exploratory study have a number of limitations. First and foremost, the ability of the Likert-items to characterize the social responsibility attitudes of students is rather limited. Social desirability bias in the responses is a concern. In particular, the extent to which students were drawn to an engineering major due to their aspirations to help others through engineering in comparison to other factors was previously found to be associated with retention,[10] but this was not measured with the SR9 survey items. Looking at the previously established SR types that were based on interviews, it is evident that the SR9 scores are only a rough proxy (Table 9). There were students whose primary motivations toward selecting engineering as a major related to their aspirations to use engineering to help disadvantaged populations (Type 1), but still had somewhat low SR9 scores. This may explain the differences in the mixed retention results in the current study versus the previous research where the evidence was more compelling.

Table 9. Correlations between social motivations for selecting engineering as a major and average Likert scores on the professional social responsibility items

SR Type: Description[9]	n	% left engineering	Mean SR9 score	Min SR9 score	Max SR9 score
1: chose engineering largely due to desire to help marginalized and disadvantaged through engineering	10	70	5.8	4.4	6.7
2: chose engineering to help society or the environment in general	10	30	5.5	3.8	6.9
3: believed helping others was important, but did not associate this social responsibility with their personal vision of engineering in their future	10	0	5.1	3.8	6.4
4: thought little about social responsibility in the context of engineering	4	25	4.4	2.8	5.1

Another limitation of the current study is that the results are confined to a single institution. The characteristics of students admitted to this institution may differ from other institutions. This large, public institution tends to have a reputation for sustainability, social engagement (a high number of graduates entering the Peace Corps), and strong co-curricular engineering service engagement through K-12 outreach, a large Engineers Without Borders-USA student chapter, and a Bridges To Prosperity chapter. This may mean that students who enter engineering majors at the institution differ from students nationally in their expectations toward helping people and serving society. However, a recent study among primarily environmental and civil engineering students across four institutions (including the one in this study) did not find significant differences in the social responsibility and sustainability attitudes of entering first-year students.[22]

The results should not be considered generalizable to engineering disciplines beyond the four in this study. Previous work found that the social responsibility attitudes of engineering students vary across disciplines.[7] The students in this study primarily were initially majoring in civil and environmental engineering.

Further, the cohort 2 students may not have been fully representative of their disciplines at large, given the email message recruiting their participation and informed consent statements that were included as part of the study. Students with a stronger interest in social responsibility may have decided to participate in the study that year; the participation rates among the three targeted disciplines were about 30%. In contrast, the other cohorts had much larger participation rates among the targeted majors (>70%).

A final note regards the complex range of factors that have been demonstrated in other studies influence retention in engineering. Across all disciplines, college graduation rates have been found to differ among institution types, by gender, first generation status, race/ethnicity, high school grade average upon college entry, and Scholastic Aptitude Test (SAT) composite scores.[28] A similar range of factors have also been found to be important in engineering retention and graduation, with specific institution, discipline, socioeconomic status, and math placement found to be additional factors of importance.[29-33] This current, exploratory study did not control for or account for these factors. Clearly, a range of complex issues impact students' very personal choices of selecting and persisting in engineering majors.

Implications

Should engineering educators be concerned if the most socially motivated students are leaving engineering at disproportionately higher rates? Given differences in the social and helping motivations that have been observed by gender, this could make it more difficult to achieve gender representativeness in engineering. Also, the engineering profession as a whole may fail to reach its full potential to yield beneficial societal and environmental benefits without individuals who are primarily motivated by these goals. A related ethical issue for engineering educators is a sense of "bait-and-switch". At our own institution, recruiters took to heart the marketing messages found to resonate with the public in "Changing the Conversation", promoting that "engineers make a world of difference".[34] However, the recruiters failed to inform faculty members in engineering that they were promoting our programs with these messages. Thus, it was unclear that the engineering vision that students were attracted to would be realized within the engineering programs at our institution. And perhaps students saw these ideals to a somewhat high degree in two first-year courses (the introduction to engineering and engineering projects courses), but later failed to see societal context in their sophomore or junior year. It seems that engineering education needs to "walk the walk" versus just "talk the talk" in regards to the importance of serving society through our work. Others may argue that it is better for students to develop realistic expectations of the workforce in college and that if they have overly idealized views they will just leave the engineering profession after graduation. However, if engineering is to live up to its potential for serving humanity and contributing to the solution of the most pressing global problems, individuals with helpful aspirations must enter the engineering workforce and promote this vision.

It appears that a range of curriculum design and course content issues might be effective in helping students to see the potential for social good through engineering. Choice is a powerful instrument, allowing students with these aspirations to select courses that meet their goals. Increasingly, institutions have a range of minors and certificates available for students at the interface between society and technology. This approach, however, may allow students with virtually no interest or awareness of societal context to avoid becoming educated on these issues. The proposed changes in the ABET EAC accreditation requirements appear to lower the minimum bar for engineering educational outcomes in this regard.[35-36] Increasing the social science and humanities (SSH) requirements for students may help achieve these aims. Many institutions have a common core, which requires that students take SSH electives with particular topics. At the institution in this study, students in the College of Arts & Sciences must fulfill a core that includes a balanced range of topics (human diversity, ideals and values, contemporary societies, historical context, literature and the arts, etc.). However, engineering students are exempt from these core requirements and must only take a minimum number of courses at different levels (upper division); these can be a potpourri of courses including the ever-popular "History of Jazz" that appear to contribute little to engineering students' understanding of social context relevant to their work as engineers. Alternatively, this gives students the freedom to find courses that match their interests and could be clustered into a minor or certificate, such as "Engineering, Science, and Society". But the small number of total credits allocated to electives limits these options. There are also concerns that relegating social context to SSH electives devalues their importance, moving them to the periphery rather than the core of engineering skills. On the whole, engineering programs should think carefully about the implications of curriculum decisions and how infusing social context (or not) may be a contributing factor for some students to leave engineering.

There are a number of strategies that might be effective in helping socially motivated students to understand how they can realize their goals through engineering. Service-learning (SL) is a powerful pedagogy to connect students to communities. Exemplar programs include the Engineering Projects in Community Service (EPICS) program that originated at Purdue University[37] and the Service-Learning Integrated throughout a College of Engineering (SLICE) at the University of Massachusetts-Lowell.[38] The SLICE program aims to include SL in required engineering courses in each of the four years of the curriculum. This persistent and integrated approach will reach all students. But it requires a significant investment to develop and maintain relationships with community partners, and get buy-in from a number of faculty. A less resource intensive approach is to integrate projects and problems that are contextualized in real-world issues into engineering courses. These types of course experiences were noted by students to impact their ideas of social responsibility, and included core courses such as thermodynamics.[18] Engineering courses could alternatively highlight relevant current events and contemporary issues, which could take just a few minutes in a lecture each week. These approaches do not require significant resources or redesign of curriculum, but would serve to role model that engineering faculty care about the impacts of their work. This could help students to integrate concern for others within their understanding of what it means to be an engineer, and this could help students motivated by helping others to more readily identify with engineers and the engineering profession. This sense of identity has been shown to be related to persistence.[39]

Future Work

Retention of students from cohorts 3 and 4 within engineering will continue to be monitored; additional students from these cohorts are likely to leave engineering by year 4. Permission could potentially be acquired from the institutional review board for human subjects research that would allow us to explore additional factors that may be relevant to persistence for these cohorts, such as math placement at the institution and entering high school GPA. Students who leave engineering can be contacted in an attempt to identify factors that contributed to their decision to leave. The current exit survey includes reasons typically identified in the literature but does not query specifically about helping people goals, limited course choice opportunity, interests in non-technical coursework, etc. However, there were a small number of students in this study from a limited number of engineering disciplines at a single institution. Future work might measure SR attitudes among all incoming first-year students and partner with additional institutions, in order to conduct a rigorous study of the potential impacts of incoming professional social responsibility attitudes on the retention of engineering students. However, the survey may wish to directly query factors that led the student to select an engineering major, ranking a variety of factors that could include helping disadvantaged people, impact on society, etc.

Summary and Conclusions

This small, exploratory study found that engineering students with higher professional social responsibility (SR) attitudes, as measured by Likert-type items, had left engineering at a higher rate after 4 to 5 years than students with less positive SR attitudes. Retention differences in engineering were not found between groups with different SR scores in two more recent cohorts after 3 and 4 semesters. When the students were separated by gender, there were not statistical differences found in the retention of female engineering students with initial differences in professional social responsibility attitudes. Among male students, differences in retention in engineering for students with different SR attitudes were not found. Disaggregating students into different incoming engineering majors, some differences in retention based on SR attitudes occurred, but these differences were not found to be statistically significant. Throughout the study, the small number of students was likely a limitation in identifying statistically significant differences. Differences in the technical/non-technical balance of required courses and course choice opportunities were found between the engineering majors and common destination majors of the students who left engineering. However, the extent to which social context in courses, technical/non-technical balance, and/or course choice opportunities impacted students' decisions to leave engineering, and perhaps differentially impacted students with high social responsibility, is uncertain. This exploratory study raises some interesting questions, and poses another potential factor to be considered in student retention.

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