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Social Responsibility Attitudes of First Year Engineering Students and the Impact of Courses

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Abstract

The goal of this research was to characterize the social responsibility (SR) attitudes of first year engineering students, determine if these attitudes changed during the first year in college, and whether students cited courses and/or volunteer activities as having impacted these views. First year students from four institutions participated in an online survey at the beginning and end of the 2012/2013 academic year. The majority of the 164 respondents were majoring in civil, environmental, or mechanical engineering. Based on the validated Engineering Professional Responsibility Assessment (EPRA), there was little change in the SR attitudes among the cohort as a whole. However, 28 individuals (17%) decreased in SR attitudes and 26 individuals (16%) increased in SR attitudes. Of the students whose SR increased, 58% listed one or more courses that influenced their views of SR, compared to only 38% of the students who did not change in SR and 25% of the students who decreased in SR. Common themes of the courses that were discussed by the students were international, community, ethics, service learning projects, and development. The survey also gathered information about students' participation in volunteer activities. Students who showed a positive change in SR had the highest average volunteer frequency scores of 11.1, compared to average volunteer frequency scores of 9.9 and 9.0 for groups of students with no change or negative changes in SR scores, respectively. The results suggest that courses and volunteer experiences may be effective ways to positively influence students' views of SR. On-going research will explore changes in students as they progress through the engineering curriculum using a longitudinal study.

Background

It has been asserted that the current generation of incoming college students possesses a high degree of civic responsibility. The Higher Education Research Institute has been studying civic responsibility for over 40 years and reported that civic engagement has increased, evidenced by the fact that 72% of first year college students in 2012 said that "help others in difficulty" was an objective that was essential or very important,[1] as compared to 58.7%, in 1987.[2] The Association of American Colleges and Universities (AACU) currently has an initiative to educate students for personal and social responsibility, stating a goal that campuses should "prepare [students] to fulfill their obligations as students in an academic community and as responsible global and local citizens."[3] They conducted a study and found that about half of the students entering college strongly agreed that they were "aware of the importance of contributing to the greater good." Based on these aspirations, one of the messages that engineering is using to attract young adults is a focus on the benefit that engineering can have on society and the world.[4] But to what extent do students view this as more than just a possibility, but as a responsibility for engineers to serve society? Should engineers feel a responsibility to serve society through their profession? Is one of the roles of college to instill this sense of social obligation in students?

Many leading sources seem to indicate that social responsibility is in fact an important goal for both engineering and college graduates. Social responsibility was included among "essential learning outcomes" in *College Learning for the New Global Century*.[5] The American Society of

Civil Engineers (ASCE) "sees civil engineers as being entrusted by society as leaders in creating a sustainable world and enhancing the global quality of life. …the profession's primary concern [is] protecting public safety, health, and welfare."[6] In the American Society of Mechanical Engineers (ASME) Vision for 2028 the guiding theme was "technology serving people" stating that "mechanical engineering will develop engineering solutions that foster a cleaner, healthier, safer and sustainable world".[7] The strategic themes included "creating global, sustainable engineering solutions that meet the basic needs of all people."[7]

Aspirations to educate engineering students to be socially responsible have been realized to some extent via the accreditation criteria for engineering degrees. For example, the EUR-ACE Framework Standards articulate that engineering graduates should be able to "demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice."[8] The ABET accreditation requirements include among students outcomes, an understanding of "professional and ethical responsibility" and "the impact of engineering solutions in a global, economic, environmental, and societal context", as well as the "ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability."[9]

Is an understanding of ethical responsibility a first step toward a larger goal of understanding social responsibility (SR) among engineering students? Engineering training often focuses on micro-ethics, which are "issues related to professionalism such as integrity, honesty and reliability, risk and safety and responsibilities as an employee."[10] But ethics can extend beyond micro-ethics to macro-ethical issues such as the societal context of engineering and sustainability. Conlon and Zandvoort[11] criticize traditional engineering ethics education as being too focused on an individual perspective rather than a broader perspective that may better prepare students for "ethical, professional and social responsibility." An example of a course that has tried to take this broader approach is a sophomore-level mechanical engineering design course that integrated ethics and includes the topic of the "implicit Social Contract between professionals and society".[12] Social responsibility and social justice issues are thus proposed as appropriate training for engineers linked to ethical issues.[10,13-15]

It has been proposed that higher education for social responsibility should begin in the first year.[16-17] Many first year engineering programs are designed to introduce ideas of ethics and societal impact to students.[12, 18-20] Service-learning is also integrated into a number of first year project courses,[21-23] and serves as a hands-on way to demonstrate the social good that can come from engineering. However, the impacts of these learning experiences on students' attitudes toward macro-ethical issues, such as social responsibility, are unclear.

A framework for understanding the development of professional social responsibility attitudes among engineering students has been developed, the Professional Responsibility Social Development Model (PRSDM).[24-25] The PRSDM has three realms: (1) social awareness, (2) professional development, and (3) professional connectedness. The social awareness and professional development realms each have three sub-stages. Personal social awareness parallels Schwartz's model [26-27] for altruistic behavior; including an *awareness* of groups in need and complex social issues, recognition of one's *ability* to help others in need, and finally a feeling of *connectedness*[28] due to a moral obligation to help others. The professional development realm agrees with tenets from Ramsey[29-30] and Vanasupa et al.[31] Professional development starts with *base skills* which encompasses the knowledge to be an effective engineer, progresses to *professional ability* where one recognizes that these professional skills give them the ability to help others, and grows to the ability to *analyze* social issues from a professional perspective. The third realm of the PRSDM, *professional connectedness,* characterizes a sense of moral obligation to help others using one's professional skills. *Professional connectedness* was initially proposed to be a linear progression[25], but is now believed to be cyclical, whereby one considers the *costs and benefits* of engaging in action, and if actions are taken, there may be an increased sense of professional connectedness.[24] The increased sense of professional connectedness associated with engaging in service is characterized through the five stages (exploration, clarification, realization, activation and internalization) of Delve et al.'s Service Learning model.[32] Based on this framework, multiple iterations of a preliminary student survey, and student interviews, evidence of validity and reliability were established. Thus, the Engineering Professional Responsibility Assessment (EPRA) is an appropriate tool for assessing the development of social responsibility in engineering students.[24]

Previous results using EPRA found that female engineering students had more positive SR attitudes than male engineering students.[24] It was also found that students varied in SR based on discipline, with higher SR among environmental engineering students, medium among civil engineering students, and lowest among mechanical engineering students.[24] This research explored the SR attitudes among first year engineering students. The research questions were:

1. Do the SR attitudes of engineering students change from the beginning to the end of the first academic year of college?
2. If the SR attitudes of engineering students changed over the first year, did students cite any courses as impactful to these views?
3. If the SR attitudes of engineering students changed on the first year, did participation in volunteer activities correlate with these changes?

Methods

This research used a mixed-methods approach, and was approved by the institutional review board (IRB) for human subjects research. Students from five institutions were invited to participate in the study, which primarily targeted civil, environmental, and mechanical engineering majors. Responses to the EPRA survey were received from first year students at four institutions: a large Western public research intensive university; a technically-focused research intensive Midwest university; a private Eastern university; and a small public Eastern university. Students were emailed an invitation to participate in the pre survey based on departmental list-serves. Students took the survey online within the first few weeks of the beginning of the semester in fall 2012. They received a $5 gift card to Amazon or Starbucks for taking the survey. The students who took the pre-survey were invited to retake the survey near the end of spring semester 2013; the students received a $10 incentive for the post-survey. Following the informed consent information, the survey defined four terms: community service, social responsibility, social justice, and pro bono. *Social Responsibility* was defined as "an obligation that an individual (or company) has to act with concern and sensitivity, aware of the impacts of their action on others, particularly the disadvantaged." The survey then included 50 Likert questions that "scored" students' sense of personal and professional social responsibility on a 7-point scale. Between 4 to 19 items mapped to each of the eight sub-scales: *awareness, ability, connectedness; base skills, professional ability, analyze; professional connectedness, costs / benefits*. Seven of the eight constructs included one or more items that were negatively worded; the responses to these items were reversed and then averaged with the responses from the other items within the construct. Examples of the survey items are provided in Table 1; the majority of the items were taken from among other surveys.[28,33-38] To identify changes between pre- and post- surveys, paired two-tailed t-tests were conducted, consistent with accepted methods[39-40], where significant differences were inferred when the p values were less than 0.05. To identify differences between groups (such as based on gender or major), two-tailed heteroscedastic t-tests were conducted. Statistically significant differences were similarly inferred when the p values were less than 0.05.

Table 1. Sub Scales of the EPRA Survey

Construct	Definition	Example Items
Personal: awareness	An awareness that others are in need	Community groups need our help.[28]
Personal: ability	A recognition that one has the ability to help others	I can have an impact on solving problems that face my local community.[33]
Personal: connectedness	A feeling of moral obligation, responsibility, or social requirement to help others.	I think I should help people who are less fortunate with their needs and problems.
Professional development: base skills	Students' views of the importance of various technical and professional skills to a professional engineer	How important is ethics to a professional engineer?[34]
Professional development: ability	A recognition that engineers or the engineering profession has the ability to help others and/or contribute to solving social problems	Engineers have contributed greatly to fixing problems in the world.[35]
Professional development: analyze	A recognition of the importance of including social aspects in the engineering process, including community feedback, a broad range of stakeholders, etc.	It is important to incorporate societal constraints into engineering decisions.[36]
Professional connectedness	The responsibility or obligation that an engineer or the engineering profession may have to help solve social problems or help others	It is important to use my engineering abilities to provide a useful service to the community.
Costs/benefits	A recognition of the costs and benefits associated with engaging in socially responsible behavior, such as service	I would be willing to have a career that earns less money if I were serving society.

Other questions on the EPRA survey asked students to indicate their level of participation in volunteer activities before college (pre survey) and during the first year of college (post survey). A total volunteer frequency score (VFS) was calculated by adding the frequency of self-reported participation in 18 different volunteer activities before college (0 = did not participate; 1 = once, 2 = twice, 3 = more than twice but not routinely, 4 = monthly, 5 = weekly). Examples of the volunteer activities were: Habitat for Humanity build, tutoring school children (unpaid), donating blood, food bank volunteer, political campaign volunteer, unpaid coaching, or self-identified "other".

The post survey included the open response question: "Were there any classes in this last year that you found influential to your views of social responsibility? Why/in what ways?" These open responses were coded using a mixture of emergent and *a priori* themes. The survey also included a question that asked the students to evaluate the importance of eight different career attributes. Finally, the survey concluded with demographic questions.

In addition to student input, the required curricula at each institution were explored using the published 2012/2013 catalogs. This included examining the content of the required courses based on the published course description in the university catalog, syllabi for the courses, or online published information on the courses. This approach may be limited due to potential inaccuracies in the public advertising of the courses, but represented an attempt to independently evaluate the curricula for content that relates to SR.

The courses listed by the students were first classified into one of three categories: required engineering courses; non-engineering courses; or elective engineering courses. The required engineering courses were identified based on the published curriculum for that particular major and institution. Next, key attributes of the courses that were identified by students were coded using emergent methods. Commonly occurring key words were identified and then grouped, such as international, world, global, or references to foreign countries coded into "international." The two authors of the paper conducted this coding activity.

Results: Initial Social Responsibility Attitudes

A summary of the demographic characteristics of the survey respondents is provided in Table 2. There were 164 individuals who completed both the pre- and post- survey (a 19% response rate). Compared to the demographics of the institutions, the group was over-represented in females due to their higher response rate (25%). These response rates are typical. For example, there was a 14% response rate of undergraduate engineering students invited to participate in the APPLES2 study with a web-based survey with a similar incentive ($4); at individual institutions the response rates ranged from 5-49%.[41] Most of the respondents were majoring in mechanical engineering. Sixteen percent (n=27) of the students switched their major (or intended major) from the pre to post survey, resulting in a lower percentage of environmental engineering majors and a higher percentage of civil engineering majors. Nearly half of the respondents were attending a technically-focused university in the Midwest.

Table 2. Demographics of the First Year Survey Respondents (valid paired pre/post responses)

	N / %	Major	% pre/post	Institution	%
Total	164 / 100%	Civil	19 / 23	Large Public	23
Male	109 / 66.4%	Environmental	21 / 14	Technical	48
Female	55 / 33.5%	Mechanical	48 / 48	Private	18
		Other	13 / 16	Small Public	12

The pre-survey showed that students started at different levels of SR based on the EPRA evaluation (Table 3). The overall average across the 50 Likert questions per individual ranged from 3.22 to 6.88, with an average among the 164 respondents of 5.52, standard deviation of 0.68. Female versus male students were significantly different on seven of the eight constructs (all except *base skills*). The female students had average scores that were 0.2 to 0.8 Likert points higher. Due to these gender differences, majors were compared within gender. There were not significant differences based on pre-survey major among the male students (data not shown). There were a few differences between the female students of different engineering majors (see Table 3). Across the four institutions the scores for the EPRA SR constructs were not statistically significantly different (data not shown). The results indicate that first year engineering students did have some differences based upon demographic characteristics such as gender and major, which were consistent with previous findings that included seniors and graduate students.[24]

Table 3. Summary of SR Attitudes of Incoming First Year Students

Social Responsibility Aspect	Range Pre n=164	Avg Pre n=164	Female Avg n=55	Male Avg n=109	Female ME n=16	Female CE n=13	Female EnvE n=16
EPRA all question average	3.2-6.8	5.5	**5.9**	5.3	5.9	6.1	6.1
Personal: awareness	3.4-7.0	5.9	**6.3**	5.7	6.3	6.4	6.3
Personal: ability	3.0-7.0	5.6	**6.0**	5.4	5.9	6.3	6.0
Personal: connectedness	1.5-7.0	5.3	**5.8**	5.1	5.6	6.0	6.0
Professional development: base skills	1.0-7.0	6.2	6.3	6.1	**6.6**	5.8	6.3
Professional development: ability	3.0-7.0	6.4	**6.5**	6.3	6.7	6.6	6.5
Professional development: analyze	2.8-7.0	5.5	**5.8**	5.4	5.5	5.9	5.9
Professional connectedness	2.6-6.8	5.1	**5.6**	4.9	**5.1**	5.8	5.8
Costs/benefits	1.8-7.0	5.3	**5.8**	5.1	**5.5**	6.1	5.8

Bold = statistically significant difference in two-tailed t-test compared within demographic groups or sub-groups ($p < 0.05$)

Results: Changes in Social Responsibility Attitudes over the Academic Year

There was little change during the academic year in the SR attitudes among the cohort as a whole (Table 4). The individual post SR attitudes still included significant variability, ranging from 3.5 to 6.9, with an average across the 164 students of 5.51 and standard deviation of 0.70. On the entire group of first year students (n=164), a paired two-tailed pre-post t-test using all of the items within each construct only found differences in the EPRA *professional ability* sub-scale (p=0.001) and *engineering base skills* (p=0.001).

Table 4. Summary of EPRA scores for the First Year Students

Social Responsibility Aspect	Avg Pre	Avg Post	Female Avg Pre	Female Avg Post
EPRA all question average	5.5	5.5	5.9	5.8
Personal: awareness	5.9	5.9	6.3	6.3
Personal: ability	5.6	5.5	6.0	**5.8**
Personal: connectedness	5.3	5.4	5.8	5.8
Professional development: base skills	6.2	**6.3**	6.3	6.4
Professional development: ability	6.4	**6.2**	6.5	**6.3**
Professional development: analyze	5.5	5.5	5.8	5.7
Professional connectedness	5.1	5.1	5.6	5.5
Costs/benefits	5.3	5.3	5.8	5.7

Bold = statistically significant difference in two-tailed t-test compared pre survey responses ($p < 0.05$)

Of the 50 Likert-items on the survey, only eight were significantly different for the whole cohort between the pre and post survey. The single item with the largest difference in the pre vs. post survey was "how important are ethics for a professional engineer" which increased from an average of 6.0 (important) to 6.4 (where 7 = very important). Two questions from the *professional ability* sub-scale were also significantly different (p=0.02), but the average only decreased by 0.1. Both items were highly saturated on the pre-survey, averaging 6.5. The questions were "engineers have contributed greatly to fixing problems in the world"[42] and "engineers can have a positive impact on society."

Within demographic sub-groups, differences in the pre vs. post EPRA scores were evident among female students and female mechanical engineering students for the *personal ability* and *professional ability* scores, which decreased; and the female environmental engineering students for the *professional analyze* scores, which decreased. Within majors the only significant differences in the pre and post scores were lower *professional ability* among mechanical engineering majors (0.07 lower) and lower *professional analyze* among environmental engineering majors (0.05 lower). Within institutions the only significant difference in the pre and post scores was at the technical university where the *professional ability* score was 0.21 Likert-points lower. These decreases are somewhat troubling, as they indicate that some groups of first year students decreased in both their recognition of the ability of engineers to help others and in recognizing the importance of including social aspects in the engineering process. This might be a result of an over-emphasis on purely fundamental or technical issues in first year students' courses.

Paired t-tests among the pre- and post- responses on the full suite of 50 Likert questions within individuals identified 54 individuals with significant difference; 28 decreased in SR attitudes and 26 increased in SR attitudes (Table 5). Within the decreased group, there were significant decreases from the pre to post survey in all constructs ($p<0.003$). This cohort of students that decreased in SR had pre-scores that were not significantly different than students who did not change. But their final scores were lower than the no change cohort, except for the *professional ability* sub-scale. Within the increased group, all constructs significantly increased from the pre to post survey except the *professional ability* construct. This group that increased in SR had lower pre SR scores on 3 sub-constructs and overall SR compared to the no change cohort. The group that increased in SR also had significantly higher post SR scores on three sub-constructs and overall SR compared to the no change group. What characteristics of the students who increased and decreased might be different?

Table 5. Average EPRA Scores for individuals with change in pre vs. post (paired t <0.05)

Social Responsibility Aspect	Negative Change (n=28)		Positive Change (n=26)		No change (n=110)	
	Avg Pre	Avg Post	Avg Pre	Avg Post	Avg Pre	Avg Post
EPRA total	5.6	*5.0*	**5.2**	*5.9*	5.6	5.6
Personal: awareness	6.2	*5.5*	**5.6**	6.1	6.0	6.0
Personal: ability	5.7	*5.1*	5.5	*6.0*	5.6	5.5
Personal: connectedness	5.4	*4.7*	5.0	*5.9*	5.4	5.4
Professional development: base skills	6.4	*6.1*	**5.5**	6.4	6.3	6.4
Professional development: ability	6.3	6.0	6.4	6.4	6.4	6.2
Professional development: analyze	5.7	*5.0*	5.1	5.9	5.5	5.6
Professional connectedness	5.2	*4.5*	**4.7**	*5.5*	5.2	5.1
Costs/benefits	5.4	*4.9*	5.1	5.6	5.4	5.4

Bold = significant difference vs. no change pre; Italics = significant difference vs. no change post

First, the groups were explored for demographic characteristics (Table 6). Female students were more likely to decrease and less likely to increase in SR. This is troubling given previous research showing that women are more motivated by an ability to help people in their careers than men[43-44]; if female students decrease in attributing socially responsible behavior to engineers, they may be more inclined to leave engineering. Mechanical engineering students were more likely to change their SR, either positively or negatively. Fewer civil engineering students changed SR. Students at the large public university were more likely to change their SR attitudes, either positively or negatively. Students at the private institution were less likely to change their SR attitudes. Changes in SR that differ by major and/or institution may be due to differences in the first year courses and/or extracurricular experiences of the students.

Table 6. Demographics of Students Who Changed SR Attitude Pre vs. Post First Year

	Decrease in SR	Increase in SR	No change in SR
% of 164 (n)	17% (28)	16% (26)	67% (110)
% of the females (n)	20% (11)	7% (4)	73% (40)
% of the males (n)	16% (17)	20% (22)	64% (70)
% of CEs (n)	13% (4)	10% (3)	77% (24)
% of EnvE (n)	21% (7)	15% (5)	65% (22)
% of MEs (n)	19% (15)	19% (15)	62% (49)
% of Large Public (n)	22% (8)	22% (8)	57% (21)
% of Technical (n)	18% (15)	17% (13)	65% (51)
% of Private (n)	10% (3)	10% (3)	80% (24)
% Small Public (n)	16% (3)	11% (2)	74% (14)

n = number of students

Results: Course Impacts

The next element that was explored with respect to students' attitudes about SR were their responses to the open-ended question on the post survey that asked which courses had impacted their views of SR (summarized in Table 7). Of the 164 respondents, 19% left the question blank, 42% explicitly stated "no courses", and 39% included a response. Of those with a course response, 59% listed a required engineering course (typically a first year introductory engineering or engineering projects course), 41% listed a non-engineering course (typically a humanities or social science elective), and 9% listed an engineering elective [the total does not sum to 100% because some students listed more than one course and these courses fell into multiple categories]. Engineering elective courses were only evident among students from the private university; the curricula at the other institutions does not recommend that students take an engineering elective in the first year. At the large public, small public, and technical universities, students first year courses are constrained to math, science, required engineering courses (including general introduction, first year projects, computer aided design, etc.), and humanities-social science electives.

Table 7. Codes to Describe the Open Student Responses of Courses that Impact SR

Codes	**"Quotes", key words, and/or *example courses***	**N**	**%**
Blank	**Nothing was written into the open box**	31	19
None	"No, none that I can think of"; "No classes have changed my views of social responsibility this past year."	69	42
Required engineering course	*Introduction to Engineering, Introduction to Civil Engineering, First Year Projects*	*38*	*23*
Elective engineering course	*Music & Art of Engineering; Structural Art*	*6*	*4*
Non engineering course	*Philosophy; Environmental Sociology; Comparative Religion*	*26*	*16*
Course Themes			
International	World, global;	19	
Ethics	*Introduction to Engineering,*	13	
Project	*Engineering Projects*	12	
Design	*First year projects;*	10	
Environment	*Introduction to Environmental Engineering;*	9	
Service Learning (SL)	*First Year Engineering Projects*	8	
Development	"community development and applied economics really helped my understanding of what sort of opportunities are available for engineers in the developing world"	6	
Economics	*Economics of globalization*	4	
Sustainability	*World Food, Population & Sustainable Development*	2	

Of the students whose SR scores decreased, 50% indicated that no courses contributed to their SR, 25% listed one or more courses, and 25% left the question blank. In contrast, of the students whose SR increased, 58% listed one or more courses that contributed to their views of SR (more than twice the percentage of the decreased SR students), 31% indicated that no courses contributed to their SR, and 12% left the question blank. This seems to indicate that courses may have a positive impact on SR.

Within the cohort of 26 students with an increase in SR, a more detailed exploration of the content of the course responses was conducted. Of the 15 students who indicated that a course had an impact, 47% were required engineering courses, 40% were non-engineering courses, and 13% were elective engineering courses. Key themes in these courses described by the 15 students with increased SR were: international (40%), community (33%), ethics (27%), service learning projects (20%), and development (20%). An example quote for SL is: "Engineering Projects. Our professor had us work with disabled children and it has made me thankful for what I can do. It also has shown me how we can help others." An example quote for ethics is: "We learned about ethics. We learned that we need to always do what is best for the community or company even if we can get away with doing something bad that will benefit only us."

Differences in the percentage of students who indicated that no courses influenced their views of SR varied significantly between institutions and majors (Table 8). Overall, students from civil engineering and students at the private institution were most likely to report that no courses influenced their views of SR, while environmental engineering majors and students from the small public institution were more likely to report that courses impacted their views of SR.

Table 8. Number of first year students who indicated that NONE of their courses over the past year influenced their views of SR (number and percentage of the students of that demographic)

Engineering Major in Pre Survey	Institution: Large Public	Technical	Private	Small Public	TOTAL %
Civil	3/6 = 50%	11/15 = 73%	2/3 = 67%	2/7 = 29%	18/31 = 58%
Environmental	2/12 = 17%	0/11 = 0%	N/A	2/11 = 18%	4/34 = 12%
Mechanical	7/19 = 37%	27/52= 52%	4 / 7 = 57%	N/A	38/78 = 49%
Other	N/A	N/A	10/20 = 50%	0/1 = 0%	10/21 = 48%
Total %	12/37 = 32%	38/78 = 49%	16/30 = 53%	4/19 = 21%	70/164 = 43%

N/A = no responses from students in this group

It was of interest to review the required curriculum at the various institutions to see if the student responses seemed to agree with the intent of the curriculum. Despite the fact that all students at the large public university were taught about ethics in required introductory courses and would also be aware of SL projects via the "design expo" for the first year projects course (even if their own section did not work on SL projects), 32% of the students indicated that none of their courses contributed to their views of SR. At the small public university all of the civil and environmental engineering students worked on SL projects, but 21% still indicated that none of their courses contributed to their understanding of SR. These results seem to indicate that the impacts of courses on the SR of students may be more limited than instructors intend. This may reflect a typical dichotomy between "what is taught" versus "what is learned". It may also indicate that instructors should use reflective essays or in-class discussions to encourage metacognition and thinking around how engineering can and should try to positively impact society and help underserved populations.[26]

Ethics provides a counter example to the minimal impact of courses as influential to student views of SR. The single question with the largest difference in the pre vs. post survey was "how important are ethics for a professional engineer" which increased from an average of 6.0 (important) to 6.4 (where 7 = very important). On the pre-survey students rated the importance of ethics below the importance of technical skills, fundamental skills, and professional skills, but above the importance of business skills. On the post survey ethics was rated equally as important, on average, as fundamental and professional skills. This increase in the perceived importance of ethics was perhaps linked to course content that the students encountered. Most of the students were enrolled in a major that required a course that included ethics, based on published university catalogs. So perhaps the coverage of ethics was limited to micro-ethical issues (such as safety and professional codes of ethics) rather than including broader macro-ethical issues that may have a greater impact on students' sense of social responsibility.

Results: Volunteer Activities

The next point of interest was to explore potential correlations between volunteer service activities and SR scores. Recall that, though it is believed that engaging in service positively affects views of social responsibility, the 50 Likert-items from EPRA assess core beliefs and attitudes with respect to views of social responsibility. Therefore, by examining those scores and volunteer activities, we can examine if the two are in fact related. Correlation coefficients were calculated between the pre survey Likert SR scores (total and the 8 sub-constructs) and the students' pre total volunteer frequency score (VFS). The pre VFS was based on pre-college activities. The VFS of the first year students ranged from zero to 49 (average 9.9, median 8). There was a weak positive correlation between the VFS and SR total score*, professional connectedness, cost/benefits*, and *ability* (correlation coefficients 0.20, 0.27, 0.18, 0.18); a very weak positive correlation with *awareness, connectedness*, and *analyze* (correlation coefficients 0.16, 0.16, and 0.09); and very weak negative correlations with *professional ability* and *base skills* (correlation coefficients -0.12 and -0.05). The activities with the highest total VFS were (listed from highest to lower total scores summed across all 164 first year students): tutoring school children, food bank volunteer, soup kitchen volunteer, big brother/big sister/boys club/girls club, in-class SL project, and donating blood. Although not significantly different, the average VFS based on activities before coming to college were the highest for the students who significantly decreased in SR compared to no change in SR and positive increase in SR; volunteer frequency scores were 10.5, 9.9, and 9.2, respectively.

The VFS during the academic year (as reported on the post-survey) were similar to pre-college, and ranged from 0 to 37 (average 9.9, median 8). The post VFS were strongly correlated with the pre VFS (correlation coefficient 0.50). The activities with highest total volunteer scores had changed somewhat from pre-college activities; these were (listed from highest to lower total VFS across all first year students): tutoring school children (unpaid), tutoring college students (unpaid), sports camp/coaching (unpaid), food bank volunteer, in-class SL, donating blood, and professional society. Students who increased in SR score also had the highest post VFS (11.1), compared to students with no change in SR score having a medium average post VFS (9.9), and students who decreased in SR score had the lowest average post VFS (9.0). Although the differences were not statistically significant, the students' with a positive change in SR also increased somewhat in volunteer frequency score (+1.9; $p=0.18$), students' with no change in SR score had a similar average VFS (-0.1; $p=0.91$), and students' with a decrease in SR score also decreased slightly in VFS (-1.5; $p=0.23$). These data indicate potential interactions between students' SR attitudes and volunteer frequency, which aligns with the theoretical grounding of the PSRDM.

Two specific volunteer activities were explored in more detail: course-based SL and EWB (Table 9). SL in a course is the only item on the list that may not consist of fully voluntary participation. Perhaps all of the students in the course are required to work on a SL project as the basis for the coursework. The percentage of students with negative, positive, or no change in SR who had participated in course-based SL was nearly the same. So SL itself didn't appear to result in increased SR. This might be due to the context of the project, a lack of structured reflection, or other factors. Interestingly, there did appear to be a higher percentage of students with initially high SR who participated in SL courses. So perhaps some self-selection into SL courses occurred. Participation in EWB is fully voluntary. There seemed to be a correlation between a higher pre SR score and participation in EWB. This could be expected that a higher sense of SR might impact the decision to participate in EWB. There was a statistically higher pre SR score for EWB participants (average 5.8) vs. non participants (average 5.5) ($p < 0.01$); the same was also true for post SR scores (EWB participants average 5.7 vs. EWB non-participants average 5.5; $p<0.01$). Among the 31 first year students who reported participating in EWB during their first year of college (on the post survey), the pre SR and post SR were not significantly different (based on a paired two-tailed t-test, $p=0.21$).

Table 9. Exploration of correlations between SL or EWB participation during the first year of college and SR scores

	Negative change in SR (n=28)	No change in SR (n=110)	Positive change in SR (n=26)	Low pre SR (<4.8) (n=25)	Medium pre SR (n=114)	High pre SR (>6.2) (n=25)
Pre SR avg	5.6	5.6	5.2	4.4	5.6	6.5
Post SR avg	5.0	5.6	5.9	4.6	5.5	6.4
In class SL	36%	37%	35%	28%	33%	52%
EWB	18%	21%	12%	12%	16%	40%

Discussion and Conclusions

Of the first year engineering students who participated in this study, 67% did not change in their attitudes toward personal and professional social responsibility over the course of the academic year. It is unclear if first year engineering curricula have been designed with an intent to change the SR attitudes of students. Thirty-nine percent of the students listed one or more courses that they believed had impacted their views of SR. Many of the students listed an *introduction to engineering* or project-based design course. However, based on the required first year engineering curricula at the four institutions in the study, it seemed that many of the students who had taken these same types of courses did not indicate that these courses impacted their views of SR. This suggests that what is taught may impact students differently, based on their predispositions, incoming knowledge, or incoming attitudes. More in-depth studies, such as focus groups or interviews with students in these courses, may reveal particular instances within the courses that students found meaningful to their views of SR. In addition, a course with an intentional SR focus (such as a course with project-based service learning) may want to use the EPRA tool at the beginning and end of the semester to evaluate potential impacts.

Due to the fact that students with increases in SR started with lower SR than the other students, it might be inferred that the first year engineering curriculum somehow homogenized the students.

But this did not seem to be true, given the range and standard deviation in the pre and post survey SR scores.

Some of the key outstanding questions from the research relate to moving from correlative to causative relationships, which will likely require more in-depth qualitative methods. For example, does a higher sense of SR lead a student to engage in more volunteer activity? How does engagement in volunteer activities change students' sense of SR? The reasons for engaging in volunteer activities, or not, may provide some evidence of these interactions. For example, a student with high SR may want to volunteer but is unable to devote time to these activities due to time demands for studying, working to earn money, etc. Intrinsic motivations may be more common among students who volunteer due to a strong sense of personal SR. Extrinsic motivations for engagement in volunteer activities may result in a greater change in a students' sense of SR. Service-learning projects embedded within required courses remove this issue of self-selection. Among the 164 first year students, 37% reported participating in an in-class SL activity. But this percentage was evenly distributed among students who decreased in SR score (36% SL participants), increased in SR score (35% SL participants), or did not change in SR score (37% SL participants). The specific execution of each in-class SL experience may explain this variance, including if reflection was present, the type of project, and depth of student engagement.

A further issue of concern revolves around first year female students' SR perceptions. It is unclear if SR attitudes relate to students' motivation toward engineering. Previous research has found that a large percentage of female students are motivated by helping people, and if attributing this characteristic to engineering decreases, what is the impact on retention? A longitudinal study combining the EPRA survey and qualitative interviews is underway to explore the SR attitudes in female students through college and how this relates to their motivation toward or away from engineering. If it is found that engineering students motivated to help people leave engineering because they don't believe that they can fulfill this desire through engineering, more programs may be motivated to change the content in their courses to focus on the immense history and potential for engineers to contribute positively to society. As significant attrition out of engineering typically occurs in the first year, it may be particularly important to emphasize the capacity for social good from engineering in required first year courses.

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