

A Longitudinal Study of Social and Ethical Responsibility Among Undergraduate Engineering Students: Preliminary Results

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Abstract

For students pursuing engineering degrees, training in ethics, social responsibility, and allied topics is advocated by a variety of stakeholders, mandated in ABET accreditation requirements, and largely presumed by professional associations and licensing bodies. As a consequence, almost all engineering students have at least some exposure to engineering ethics training. Additionally, many formal courses and programs have been created to promote ethical integrity and professional responsibility among engineering graduates, while a variety of other interventions (e.g., service learning programs) have been developed to more broadly challenge engineering students to see themselves as socially engaged citizens and professionals.

Nonetheless, there has been a surprising lack of research on development of social and ethical responsibility among undergraduate engineering students. Few studies have systematically examined levels of ethical knowledge, decision-making capabilities, and commitments to social responsibility among large numbers of engineering students, much less examined how such indicators change over time and are impacted (or not) by specific kinds of learning experiences. As a result, faculty, administrators, and other stakeholders have little evidence to guide creation of high-impact courses and programs. Still other recent research suggests that such impacts may be blunted by a “culture of disengagement” that pervades many engineering schools.

This paper reports on an National Science Foundation (NSF) supported CCE STEM research project that aims to address some of these gaps. Our study addresses two main questions:

- RQ1: What do engineering students perceive as responsible (and irresponsible) professional conduct, and what do they perceive as socially just (and unjust) technical practices?, and
- RQ2: How do foundational measures and understandings of social and ethical responsibility change during a four-year engineering degree program, both in general and in relation to specific kinds of learning experiences?

This paper offers an overview of the longitudinal mixed-methods study design we are using to collect and analyze quantitative and qualitative data from undergraduate engineering students at four universities. These schools represent a variety of institution types, and each has students in programs of particular interest, e.g., those involving service-learning or intensified ethics instruction. Our data collection efforts were initiated in early Fall 2015, with survey responses collected from 757 first-semester engineering students at four schools. The survey includes items and measures related to engineering ethics knowledge, justice beliefs, political and social involvement, macro-ethical considerations, moral attentiveness, moral disengagement, ethical climate, and extensive demographics. Repeat measures will be collected from as many of the original respondents as possible during their fifth and eighth academic semesters. To more deeply probe constructs and themes of interest, we will also conduct semi-structured interviews with more than 10% of survey respondents during their first and eighth academic semesters.

In addition to describing our study design, this paper reports preliminary insights from the first phase of our study. We especially focus on some highlights from our initial analysis of the survey data, as well as how select survey results are being used to stratify the interview sample and tune the interview protocol to focus on some observed patterns in the survey data. We expect this paper will be of interest to scholars involved with teaching and/or conducting research on ethics, social responsibility, and related topics.

Introduction

As suggested by one recent headline, engineers are a “last line of defense” between disasters and the public.¹ Such statements take on additional gravity given recent engineering catastrophes such as the levee failures after Hurricane Katrina, the Deepwater Horizon oil spill, GM’s automotive recall for faulty ignition switches, and Volkswagen’s “dieselgate” emissions scandal. As technological advances lead to exponential increases in the complexity of the human-built world and interactions of the natural and built environments, the stakes associated with engineering success – and failure – grow ever larger. At the same time, engineers are being called on to more proactively and collaboratively address complex, large-scale problems, as reflected in the National Academy of Engineering’s (NAE) fourteen global grand challenges for engineering.²

At the same time, debates about the social and ethical responsibilities of engineers persist. What roles do professional codes of conduct play in engineering practice?³ To what extent should engineers concern themselves with micro-ethical vs. macro-ethical issues?⁴ How might engineers negotiate cross-national/cultural differences in professional ethics and integrity?^{5,6} And how should engineers navigate emerging ethical issues related to bioengineering, robotics and artificial intelligence, privacy and security, and defense and surveillance technologies, to name just a few prominent examples?^{7,8}

Many leading stakeholders acknowledge that engineering degree programs play critical roles in preparing future engineers for such realities. For instance, the NAE’s *Educating the Engineer of 2020* summarizes a contemporary mandate to “educate technically proficient engineers who are broadly educated, see themselves as global citizens, can be leaders in business and public service, and who are ethically grounded”.² Other recent reports likewise call on engineering programs to intensify their focus on ethics, professional responsibility, citizenship, and allied themes.^{9,10} And in a March 2015 letter to President Barack Obama, Deans representing more than 120 U.S. engineering schools noted the importance of exposing students to ethics and various other “interdisciplinary fields,” while providing them with service-learning experiences to develop their “social consciousness”.¹¹

Yet often overlooked in much current commentary and research on engineering ethics are the perspectives and capabilities of engineering students themselves. We know little about how students perceive social and ethical responsibility, much less how these perceptions change during a typical four-year degree program. As a further complication, many models and strategies have been proposed to bring such themes into the curriculum, ranging from formal coursework and seminars to project-based learning, service learning, and other experiential interventions.¹² However, empirical evidence regarding the effectiveness and impacts of these

different approaches remains sparse and largely inconclusive. Other research has described a pervasive “culture of disengagement” in many engineering degree programs, which may in turn lead to decreasing student interest in social welfare, public engagement, and other broader considerations.¹³ Still other studies tentatively suggest that many common approaches to ethics instruction may blind students to the “everyday” ethical issues that frequently arise in engineering practice.^{14,15}

Research is sorely needed to investigate how engineering students understand ethics, social responsibility, and allied topics, as well as how these perceptions change over time and in relation to specific kinds of learning environments and experiences. Without such empirical evidence, faculty and administrators are often left with little more than anecdotal insights to guide development curricula and programs. To address these gaps, this paper reports initial results from a larger project with three major objectives:

- O1) Characterize patterns of ethical development among undergraduate engineering students,
- O2) Identify specific context variables (e.g., climate and culture of programs and institutions) and types of interventions (e.g., formal ethics instruction, service learning programs, etc.) that have positive (or negative) impacts on foundational measures and understandings of social and ethical responsibility, and
- O3) Identify specific student characteristics that can be leveraged to grow programs oriented toward social and/or ethical responsibility, while increasing program alignment with – and impacts on – participating individuals.

Synergistic with these objectives, this project utilizes a longitudinal mixed-methods study design to collect and analyze quantitative and qualitative data from undergraduate engineering students at four universities. In addition to expanding our current knowledge base on engineering, ethics, and social responsibility, the findings from this project are intended to help university faculty, staff, and administrators develop and scale up highly effective interventions that cultivate a more socially and ethically responsible corps of future engineering leaders and change agents.

This paper reports on the first phase of data collection for the larger project, including extensive demographic information and a variety of baseline measures collected from a diverse sample of first-semester engineering students at four universities. As further context and background for our initial results, the sections that follow provide a brief literature review, overview of our larger study design, and discussion of our survey data collection methods.

Literature Review

Much prior literature on social and ethical responsibility in engineering education has focused on content and pedagogy.^{7,16} Nonetheless, a small but growing body of studies has investigated other foundational considerations, such as student perceptions of, and attitudes toward, social and ethical responsibility, as well as their levels of moral development. Beginning with broad perceptual considerations, a handful of studies have found that students often have rather narrow understandings of what counts as ethics,¹⁷ while research by Zoltowski et al. looking at views of

ethics among members of project-based engineering teams revealed that students often had difficulties identifying “everyday” ethical considerations and issues, particularly in terms of design considerations, and issues to consider in their individual and group work processes.^{18,20}

The wider literature on ethical climate in organizations has additionally highlighted how social norms and culture can influence the behavior of individuals. Rudnicka, for instance, has shown how students’ ethical reasoning and decision-making are affected by “contextual/environmental factors” such as team learning dynamics, work experience, the culture of the engineering field, and the moral intensity of a given dilemma or situation.¹⁹ Studies by Feister et al. and Zhu et al. additionally found evidence that students working in teams conceptualized ethics and made ethical decisions differently based in part on programmatic orientations (e.g., entrepreneurship, business, and community engagement).^{18,20,21} Sunderland has also pointed to curricular approaches and constraints as important factors contributing to narrow perceptions of ethics among students.²² For example, educational reforms aiming to introduce more social and ethical requirements into curricula can be perceived by students as “constraints” and “discrete requirements” rather than integral to both their education and future professional practice.

Related research has additionally questioned whether engineering education has measurable impacts on the ethical capabilities and moral development of engineering students. For instance, Shuman et al. coded student responses to an open-ended ethical dilemma, and found little evidence of growth in ethical reasoning from the freshman year to senior year, although relatively few of these students had taken formal ethics courses.²³ Similarly, Wu et al. used the Defining Issues Test, Version 2 (DIT-2) to assess moral development of engineering students across classes from freshmen to seniors and found no statistically significant differences.²⁴

Still other studies have more broadly looked at social responsibility and related commitments among engineering students. For instance, one early and influential study by Astin found that engineering graduates were more likely to have pessimistic views about their ability to change society and cultivate a meaningful philosophy of life as compared to individuals in other fields.²⁵ Along similar lines, Sax reported that engineering students on average had lower commitments to social action as compared to their counterparts in other disciplines.²⁶ And more recently, Cech identified a pervasive “culture of disengagement” in her pioneering study of four engineering degree programs, with student concerns and commitments related to public welfare declining considerably during their years of undergraduate education.¹³

Another strand of the literature has reported on efforts to measure how educational interventions focused on social and ethical responsibility specifically impact students. As Colby and Sullivan note, formal coursework/curricula and community-based learning are among the leading strategies used to teach engineering ethics and related topics.¹⁶ Regarding the former, a study by Loui reported modest increases in DIT-2 scores after engineering students were exposed to a video-based case study of an engineering ethics dilemma.²⁷ And in a related study, Loui used interview data to show how formal instructional interventions can help reinforce and expand student awareness of, and commitments to, social and ethical responsibility.²⁸ Clancy, Quinn, & Miller similarly used focus groups and surveys to assess their “case study laboratory” approach, finding significant improvements in students’ awareness of ethical issues.²⁹

However, very different results emerged from Drake et al.'s comparison of two kinds of ethics instruction, namely a full semester ethics course and an engineering course that included an ethics module.³⁰ Their results, based on DIT-2 scores, showed that neither approach resulted in significant improvement in students' moral development. A survey conducted by Carpenter et al. also found that the effectiveness of co-curricular experiences for students' ethical development was conditional on the quality of instruction, but such instruction was also rarely satisfactory for students who already had higher levels of ethical reasoning capabilities.³¹

Regarding how community-based learning impacts students' ethical development, Prichard cites three approaches that have been verified as successful: 1) a specific design project within a senior design course, 2) engineering course with a service-learning component, and 3) student initiated organization for students across the engineering curriculum.³² Even more specifically, other studies have shown that students engaging in core undergraduate engineering courses with community service learning components have significant increases in their sensitivity to the social, cultural, and environmental consequences of engineering decision-making.³³ On the other hand, research by Jesiek et al. suggests strong self-selection factors may be a major factor in such interventions, based on evidence that students who opt into global service learning experiences tend to have much stronger orientations toward political and social involvement as compared to their peers who do not participate.⁶ Further, a study by Harding et al. documented increases in student participation in community-based projects and pro-social behavior (e.g., volunteering) over a two-year period, but this was paradoxically paralleled by evidence pointing to an increased likelihood of cheating among these same subjects.³⁴

As this overview suggests, the current body of literature on social and ethical responsibility in engineering education offers many intriguing insights, but taken together provides only glimpses of what is a much larger and more complex story. Studies focused on students and practitioners in other professional fields offer other complementary insights worth noting. For instance, research investigating perceptions of ethics among business students have identified gender and age as significant predictors, with women and older students tending to have stronger ethical attitudes.³⁵ Other studies have reported that orientation toward ethical conduct is stronger among business people as compared to business students, as well as among those reporting higher levels of religiousness.^{36,37} Some of these associations also appear to hold when broader issues of social responsibility are studied, as in one study reporting positive correlation between religiousness and student orientation toward aspects of corporate social responsibility.³⁸

Other research from the business field raises questions about the relative effectiveness and impacts of formal coursework focused on ethics, social responsibility, and allied topics. While some studies argue that such coursework can enhance ethical judgment^{39,40} and improve awareness of social issues,⁴¹ other reviews of the literature have noted that much research in this area has been plagued by study design shortcomings, or has actually shown that the impacts of such interventions are short-lived.⁴² Indeed, one study from the medical education field found that a course designed to enhance social and cultural awareness among medical students had little in the way of lasting, measurable impacts.⁴³ Still other research has found tentative differences across professional fields, as in McCabe et al.'s study showing that formal ethics courses seemed to positively impact law students but had no measurable effect on business

students.⁴⁴ Finally, a study by Pauli et al. found that the enforcement of an institutional honor code can significantly improve an institution’s ethical work climate.⁴⁵

This overview of the literature reveals many important themes that have received relatively little systematic attention in the engineering education literature. More comprehensive research is needed to understand how individual differences (e.g., age, gender, ethnicity, class, religion, nationality, etc.) and specific kinds of educational experiences (e.g., formal instruction, teamwork, service learning, interactions with fellow students and faculty, etc.) affect students’ perceptions of, and commitments toward, ethics and social responsibility. Starting to address these gaps is critically important, not least to: help identify specific interventions that have the biggest impacts on students, explore how these efforts are inflected by individual characteristics, and enable meaningful comparisons and cross-pollination both within and beyond engineering.

Study Design

The proposed project supports the aforementioned project objectives and responds to gaps in the extant literature by investigating two main research questions:

- RQ1) What do engineering students perceive as responsible (and irresponsible) professional conduct, and what do they perceive as just (and unjust) professional work practices?, and
- RQ2) How do foundational measures and understandings of social and ethical responsibility change during a four-year engineering degree program, both in general and in relation to specific learning environments and experiences?

To address these questions, we are utilizing a longitudinal mixed-method study design⁴⁶ to collect quantitative and qualitative data from undergraduate engineering students at four universities, as summarized in Figure 1 and described in more detail below. The focus of this paper is on the first phase of quantitative data collection, indicated by the red box.

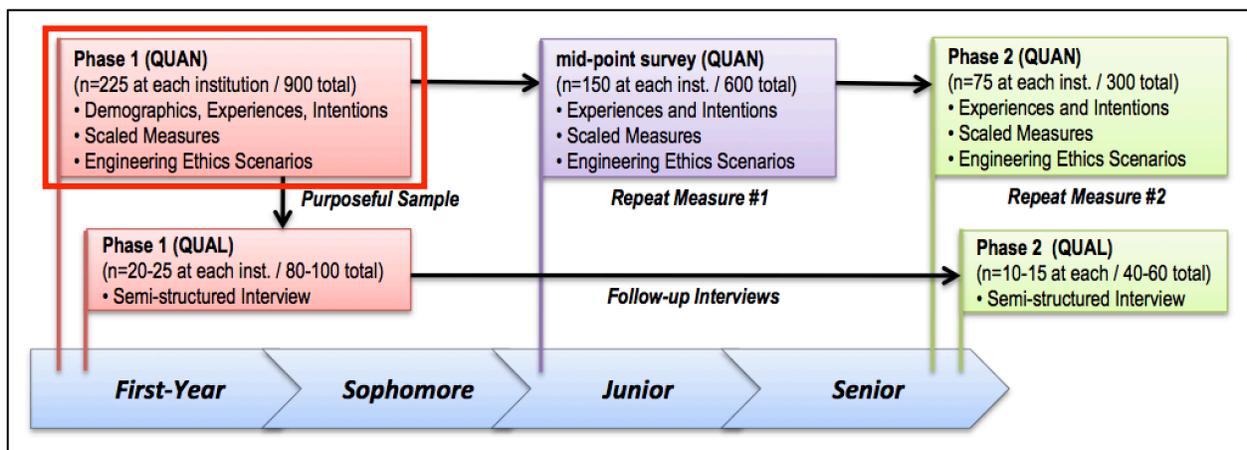


Figure 1. Study Design Overview – Phase 1 (QUAN) is the Focus of this Paper

The first phase of data collection involved large-scale surveys of first-year engineering students at four institutions to collect demographic information and a number of other measures related to the core aims of this study. Data collection consisted of direct measures from students via validated scales of engineering ethics in survey form and semi-structured interviews. Follow-up interviews were administered in an attempt to further expand upon survey results and enhance understanding of student ethical perceptions at baseline. The participating institutions were strategically selected to represent a variety of institution types: Purdue University and Arizona State University (ASU) as large, public, “highest research activity” institutions; Brigham Young University (BYU) as a large, private, “highest research activity”, religious-affiliated institution; and Colorado School of Mines (CSM) as a somewhat smaller, public, “higher research activity” institution with an engineering and science emphasis. In order to be eligible to participate in the study, students must be: age 18 or older, enrolled full time, true first-time university students, and likely to pursue an engineering or technology major. Special efforts have also been made to collect samples at each school that are gender- and ethnic-diverse, as well as stratified to include large numbers of students who are and are not likely to receive intensified exposure to considerations of social and ethical responsibility during their degree programs (e.g., through service-learning programs, required coursework, etc.). Our initial targets for data collection were about 225 responses at each school, or 900 responses in total.

The first phase of our study also involved conducting semi-structured interviews with more than 10% of the survey respondents, or about 25-30 students at each institution and more than 100 in total. As discussed below, recruitment of interviewees at each school is again purposeful, with each school stratifying the sample based on specific variables of interest. Development of the protocol for these 30-60 minute interviews was also in part informed by the quantitative survey measures and initial analysis of the survey data.

The second phase of the study involves repeat administration of the original survey measures with as many of the original participants as possible during the start of their junior year, fifth semester. Based on an estimated response rate of two-thirds of the original participants, we project 150 survey responses at each institution or 600 total. The study’s third and final phase involves a third repeat survey measure in the senior year, eighth semester of study. Based on an expected response rate of 75 students at each institution, we project having complete longitudinal survey data from 300 students. During this same semester we will also carry out semi-structured interviews with as many of the original interviewees as possible. We aim to recruit half of the original interview group, yielding ~50 complete sets of pre/post interview data for our analysis.

The sections that follow are primarily focused on the first phase of quantitative data collection, including detailed information about our survey measures, respondent characteristics, and some highlights from a large but incomplete set of survey responses. We also discuss how some key early insights from our survey data analysis has informed our approach to recruiting interviewees and developing an interview protocol focused on particular variables and themes of interest.

Survey Research Design

Data collection for the initial phase of this study involved administering a comprehensive survey and semi-structured follow-up interviews at each of the four universities. The survey was given

in an online format and data was kept confidential and aggregated at each university, in accord with and under appropriate Institutional Review Board (IRB) approvals for human subjects research. Stratification of participants for interviews and modification to the interview protocol was determined based on very general, initial analysis of the survey results, including consideration of items with the greatest variance. The more detailed analysis of results found in the Preliminary Results section of this document took place after the interviews were underway.

Survey Instrument

The survey was administered via *Qualtrics*⁴⁷ to freshman (first-semester) engineering students at each school. It consisted of 93 items regarding ethics, social responsibility, and related constructs, along with 34 additional demographic questions. The ethics and social responsibility measures were as follows, each listed with the corresponding number of items per subscale:

- Ethics knowledge and situations (8 items)
- Ethical Climate Index (19)
- Justice Beliefs (8)
- Political and Social Involvement Scale (PSIS) (12)
- Engineering work/practice considerations (7)
- Macro-ethics (8)
- Moral Attentiveness (7)
- Moral Disengagement (24)
- Experiences and Demographics (34)

Each of the subscales is described in further detail below. Participation in the survey was solicited via e-mail to declared engineering majors. On some occasions, mention was also made in beginning engineering classes encouraging students to participate, without consequence to the class. Participants who qualified for the study and completed the survey were sent a \$5 Amazon gift card.

The survey instrument was developed by compiling and adapting various instruments previously utilized and validated in ethics literature, including some specific to engineering, and from such studies as the Wabash National Study of Liberal Arts Education,⁴⁸ the Student Engineering Ethical Development (SEED) study,⁴⁹ a global engineering service learning study,⁶ and prior scenario-based research by two of the investigators.^{50,51} Many of the parent measures have been tested for reliability with published results ranging between 0.60 to 0.90, and with the majority of the measures in the 0.70 to 0.89 range. However, a lack of established measures specific to engineering demanded use of some survey items for which validity evidence is not yet available.

Ethics Knowledge and Situations: These nine items were adapted from two main sources: a set of five ethics knowledge questions utilized in the SEED study,⁴⁹ and four situational assessment questions adapted from a parallel study concerned with ethics as an aspect of global engineering work.⁵⁰ For each multiple-choice scenario or question, participants were asked to select the response he or she thought was best. The presence of strong distractors in some of the questions and scenarios helped increase the variance in student responses. As part of the follow-up

interviews, participants were also asked to describe the factors that influenced their choices in two of the scenarios that had the highest variance in terms of responses.

Ethical Climate Index (ECI): This 36-item inventory is designed to measure the ethical climate of organizations.⁵² The instrument consists of four dimensions: collective moral sensitivity, collective moral judgment, collective moral motivation, and collective moral character. The items present statements about ethical climate that participants respond to on a six-point Likert scale ranging from “Completely False” to “Completely True.” To help reduce the overall length of our survey we adopted the validated 19-item short form version of the ECI, and also made minor revisions to some items to more explicitly situate them in a university context (e.g., “People at my university are very sensitive to ethical problems.”) For purposes of initial data analysis, ECI was analyzed as a composite score for the entire subscale.

Justice Beliefs: The Justice Beliefs subscale was based on the Procedural and Distributive Justice Beliefs measure as a way to gauge students’ perceptions of justice.⁵³ Our study used the eight survey items concerned with distributive justice beliefs, as the procedural questions were deemed not sufficiently relevant to our research questions. Four questions each were posed regarding student beliefs about: (1) fairness with respect to *other people*, and (2) fairness with respect to *oneself*. Participants were asked to respond to these statements based on a seven-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.”

Political and Social Involvement Scale (PSIS): Students were also asked to complete the Political and Social Involvement Scale (PSIS), adapted near verbatim from the Wabash National Study of Liberal Arts Education.⁴⁸ Respondents were asked to rate twelve statements of political and social involvement (e.g., “Becoming a community leader”, “Helping others who are in difficulty”, and “Volunteering in my community”) in terms of “how important [each is] to you personally”, with response options ranging from “Not Important” and “Somewhat Important” to “Very Important” and “Essential.”

Engineering Practice Considerations: Building on a parallel study of engineering students’ social and technical perceptions, participants were asked to rate the importance of seven considerations in relation to the field of engineering work (or the practice of engineering), namely: technical, environmental, social, economic, health and safety, manufacturability, and ethical. While these items only partially capture the complex realities of engineering work, they were developed as a representation of some key themes appearing in the student outcomes (criterion 3.a-k) mandated in current ABET accreditation requirements.⁵⁴ The four-point Likert scale for each of these items ranged from “Not at all important” to “Extremely Important.”

Macro-Ethics: The first section of the macro-ethics subscale was comprised of four items in which respondents were asked a variety of questions about the general social responsibilities of engineers and scientists. A second set of four items solicited the degree to which respondents agreed with various statements about the duties and social responsibilities of engineers based on a five-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.”

Moral Attentiveness: The Moral Attentiveness scale is designed to measure the extent to which individuals perceive and consider morality and moral issues in his or her day-to-day

experiences.⁵⁵ Respondents were presented with seven statements (e.g., “I regularly think about the ethical implications of my decisions”) and asked to rate each using a seven-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.”

Moral Disengagement: Respondents were presented with statements drawn from prior research on mechanisms of moral disengagement.⁵⁶ We specifically used a set of 24 items validated through prior research, with three items assigned to each of eight distinct dimensions of moral disengagement: moral justification, euphemistic labeling, advantageous comparison, displacement of responsibility, diffusion of responsibility, distortion of consequences, attribution of blame, and dehumanization.⁵⁷ Students were asked to respond to these items (e.g., “It is alright to protect your friends” as an example of an item measuring moral justification) using a five-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.”

Experiences and Demographics: Seventeen experiences were listed, with respondents asked to acknowledge participation within the last five years, as well as their plans to participate in the future. These items were used in stratification of participants for interviews as well as items of further probing during the interviews themselves. The experiences listed include topics of interest to the researchers of this study in determining effects longitudinally, such as service-learning courses, missions or volunteering trips, and participation in a Grand Challenge Scholars Program, among others. Other demographic information was collected including intended major of study, age, gender, international student status, and importance of religion in respondents’ life. These characteristics served for stratification purposes, as well as features to distinguish between groups of respondents as data is disaggregated.

Preliminary Results

An analysis of the survey results produced a number of findings. For the most part these were intended to provide a baseline for subsequent longitudinal analysis. However, some particularly noteworthy results may be worthy of further investigation, in addition to providing criteria for potential stratification of interview sampling. The results presented in this paper represent those findings that represent statistically significant differences in participants’ ethical dispositions and understandings based on gender, international student status, and students’ specific attitudes regarding the importance of religion, or “religious importance” for simplicity.

The scoring for each of the subscales varies based on the number of items within each subscale. The data represented in this section represent the results of ANOVA analyses of the composite scores for each subscale within the survey. Although the scores, and therefore the scales represented in each figure, are unique to each subscale, responses varied significantly in regards to ethical considerations based on gender, international status, and religious importance. Only results that were determined to be statistically significant are reported here.

Basic Demographics

Table 1 presents the basic demographic distribution of participating students disaggregated by school. Demographic attributes for students who completed the survey differed by the percentage of international students, gender, and students who indicated that they felt religion was very

important to them. Purdue had a larger number of international students who completed the survey compared to the other schools participating in this study (the others had similar proportions). ASU had a smaller number of female students (percentage wise) who responded to the survey. And as would be expected, BYU as a private religious school had a much larger proportion of students indicating they felt religion was very important in their lives. As a result, comparisons of the various ethical scales often differed by schools largely because these constructs tended to confound with the importance students placed on religion. Still, when asked about engineering considerations (EC), no significant statistical differences were found in the proportion of students who self-reported their perceptions of the importance of ethics and social considerations when it came to engineering practice. Approximately 87% of students overall felt ethics was an important consideration and 65% indicated they felt social considerations were important.

Table 1. Demographic distribution of survey participants by school

School	% International *	% Female *	% with Strong Religious Feelings *	% high Ethics EC	% high Social EC
ASU	5%	20%	22%	91%	72%
BYU	2%	24%	92%	88%	66%
CSM	3%	33%	22%	84%	60%
Purdue	12%	38%	29%	86%	68%
Overall	6%	30%	43%	87%	65%

* Statistical difference between schools based on Chi Squared analysis of independence

Ethics Knowledge and Situations

Students' understanding of engineering ethics was explored through the use of eight questions which asked respondents to choose the most appropriate action or answer given a specific ethical statement, situation, dilemma they might encounter as an engineer. Correct answers came from prior research studies or input from engineering ethics experts who were presented with the questions. Responses were scored dichotomously as correct or incorrect for a total possible score of 8.0 points. On average, students scored 5.23 total points. A higher score indicates greater ethics knowledge, including an ability to apply that knowledge in a realistic ethical situation.

In general, student scores shown in Table 2 from BYU and Purdue were similar on average and slightly higher than students at ASU and CSM. Of special interest is the fact that international students tended to score lower on these items. Female students, with the exception of those at ASU, tended to score higher on these items.

Further analysis of specific items seems to suggest that differences based on international student status may originate in a tendency by international students to ignore a situation in order to comply with their supervisor, i.e., international students may indicate less willingness to confront a supervisor. Additionally, female students seemed unwilling to ignore a situation, and like international students, were less likely to confront a supervisor directly. They seemed more likely to indicate a willingness to go over the head of supervisors or decline further work.

Table 2. Ethics Knowledge and Situations Scores by Gender, International Student Status

School *	Avg. total score (of 8)	International Student Status *		Gender *	
		Yes	No	Male	Female
ASU	5.3	4.5	5.4	5.4	5.3
BYU	5.6	5.3	5.6	5.5	5.9
CSM	5.2	4.7	5.2	5.0	5.5
Purdue	5.8	4.8	5.9	5.6	6.1
Overall	5.5	4.8	5.6	5.4	5.8

* Statistical difference between groups based on ANOVA

In Figure 2 an analysis of these items also showed a statistical difference in scores based on the importance individual students placed on religion. An ANOVA calculation with post-hoc analysis indicates that students who felt religion was very important to them tended to score higher on these items as compared to students who indicated “not too much” or “not at all” to the question of religious importance ($F(3,753) = 1.3, p = .005$). However, most students scored fairly high on these items and the difference in terms of practical significance was low ($\eta^2 = .02$) suggesting that only about 1% of the variance is explained by the importance students place on religion.

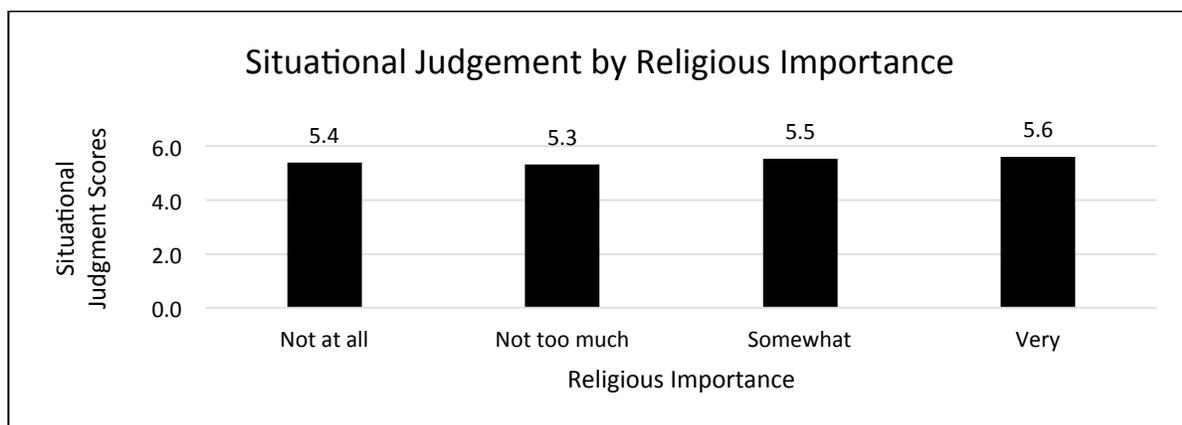


Figure 2. Ethics Knowledge and Situations Scores by Importance of Religion

Distributive Justice Beliefs for Others and Self

Distributive justice for others and self were measured using four questions each. Given that each item was based on a seven-point Likert scale, a maximum score of 28 could be obtained for this subscale. Higher scores indicate an individual perception regarding the importance of justice for others and justice for self. Figure 3 shows only minor differences in justice-for-others and justice-for-self scores based on gender and religious importance. However, domestic students tended to have higher justice-for-self scores than international students ($F(1,755) = 4.1, p = .045$). International students seemed to rate these two aspects of justice similarly, while the domestic student respondents seem to value justice-for-self much higher than justice-for-others.



Figure 3. Justice Scores by International Status

Ethical Climate

The students were asked their perceptions of the ethical climate at their university via 19 items on a 6-point Likert scale for a total possible score of 114. The average score for this subscale was 76.5. Higher scores indicate a positive perception of the ethical climate at a student’s university. This subscale was divided into the following sections with three to four items per section:

- Collective moral sensitivity – norms of moral awareness
- Collective moral sensitivity – norms of empathetic concern
- Collective moral judgment – focus on self
- Collective moral judgment – focus on others
- Collective moral motivation
- Collective moral character

There were no significant differences between ethical climate scores by gender or international status. However, overall ethical climate scores differed by the importance of religion ($F(3,753) = 22.4, p < .001$) as observed in Figure 4. Students who indicated religion was very important also tended to have higher ethical climate scores than those who indicated religion was not too much or not at all important. When looking at individual subscale scores, international students tended to score slightly lower on the moral motivation section of the scale ($F(1,755) = 4.8, p = .028$). Compared to domestic students, International students seemed slightly more likely to believe that other individuals would compromise their ethical standards.

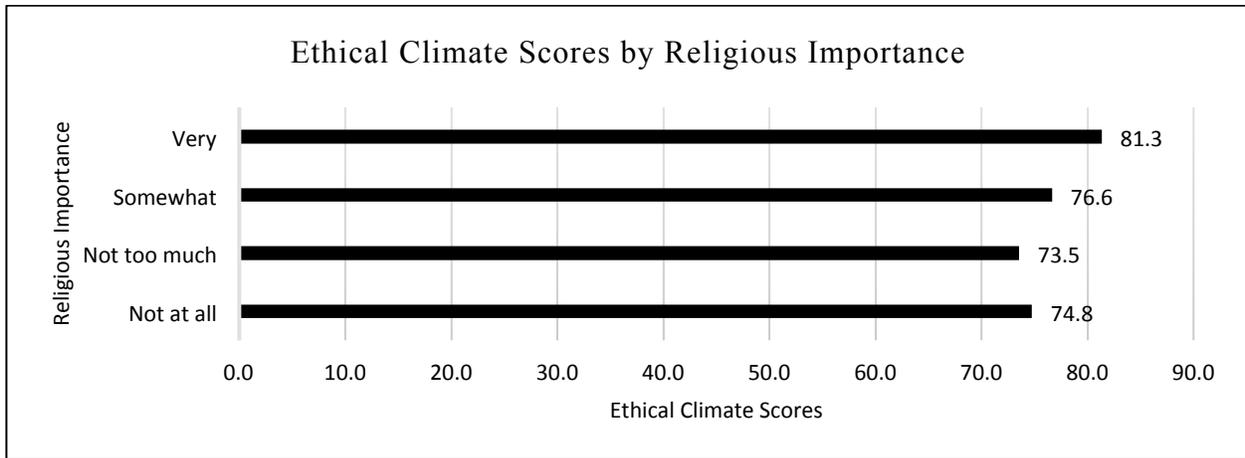


Figure 4. Ethical Climate Scores by Religious Importance

Political and Social Involvement Scale (PSIS)

The PSIS items are designed to measure the importance students place on various kinds of political and social involvement, including volunteering, influencing political structures, and promoting racial understanding.⁴⁸ There were 12 items administered on a four-point Likert scale for a possible total score of 48. A higher score indicates that an individual is more oriented toward involving themselves in a variety of political and social issues and activities. The average student score for this subscale was 33.4.

There was also a strong relationship between PSIS scores and the degree to which students valued religion as shown in Figure 5. Students who felt religion was very important tended to have much higher scores than students who indicated that religion was not at all important ($F(3,733) = 35.6, p < .001$). A smaller but still statistically significant difference was found between male and female students ($F(1,753) = 9.1, p = .003$) with females expressing greater importance on political and social involvement than males as shown in Figure 6. No difference was determined based on students' international status.

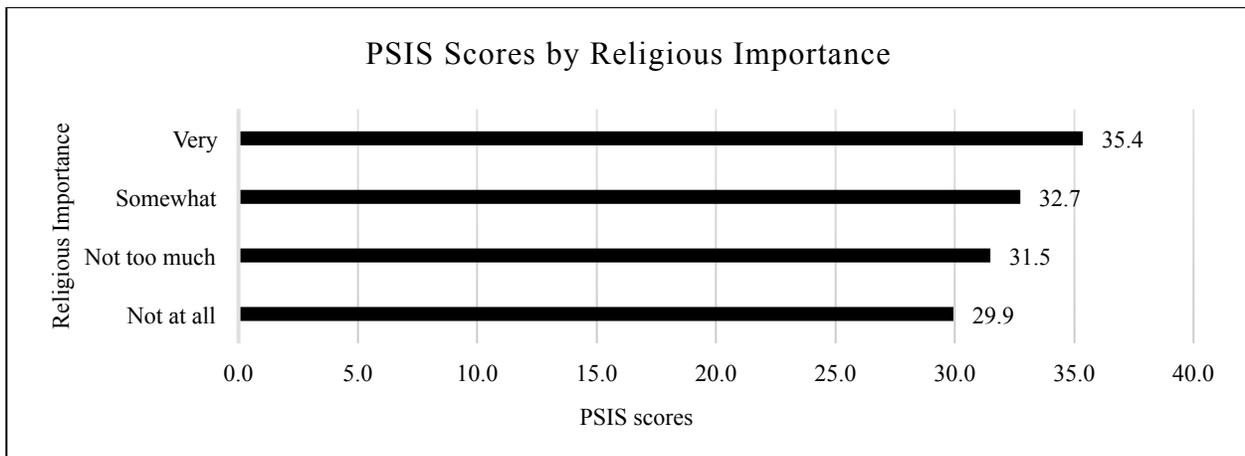


Figure 5. PSIS Scores by Religious Importance

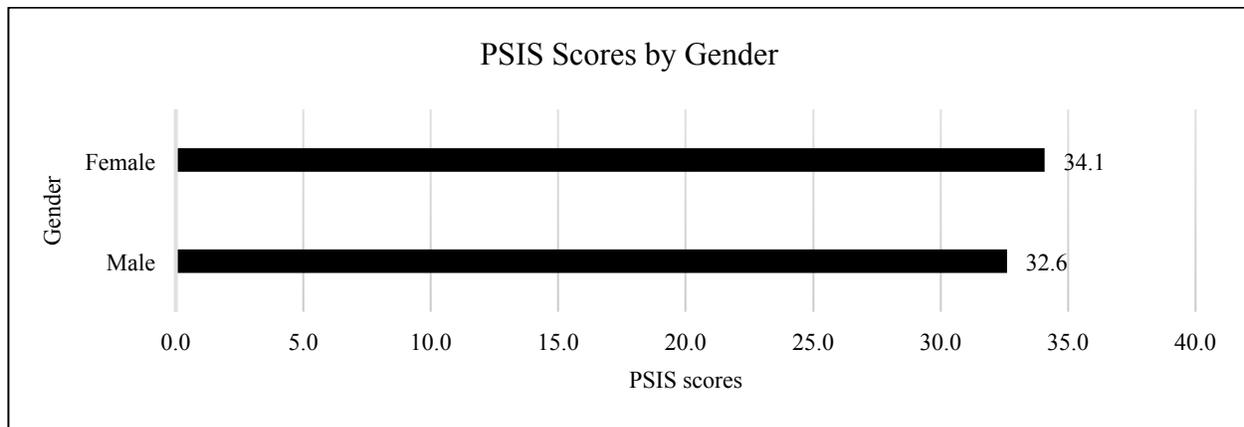


Figure 6. PSIS Scores by Gender

Moral Disengagement

The moral disengagement subscale attends to students' tendency to morally disengage given certain circumstances. It was measured by providing 24 statements for students to rate on a five-point Likert scale from "strongly disagree" to "strongly agree" for a total possible score of 95. This subscale was divided into the following eight sections with three items per section:

- Moral justification
- Euphemistic labeling
- Advantageous comparison
- Displacement of responsibility
- Diffusion of responsibility
- Distortion of consequences
- Attribution of blame
- Dehumanization

A higher moral disengagement score indicates greater tendency to morally disengage, which is likely why the average score for students in this study was 48.4. Students generally reported overall moral engagement.

Moral disengagement scores differed considerably by how important religion was to students ($F(3,752) = 12.6, p < .001$). Individual students who felt religion was important in their lives tended to have much lower moral disengagement scores compared to other students as shown in Figure 7. Males tended to have higher moral disengagement scores than females ($F(1,752) = 18.1, p < .001, M_{\text{female}} = 44.9, M_{\text{male}} = 48.7$). International students also had higher disengagement scores than domestic students ($F(1,754) = 6.6, p < .001, M_{\text{international}} = 51.1, M_{\text{domestic}} = 47.3$).

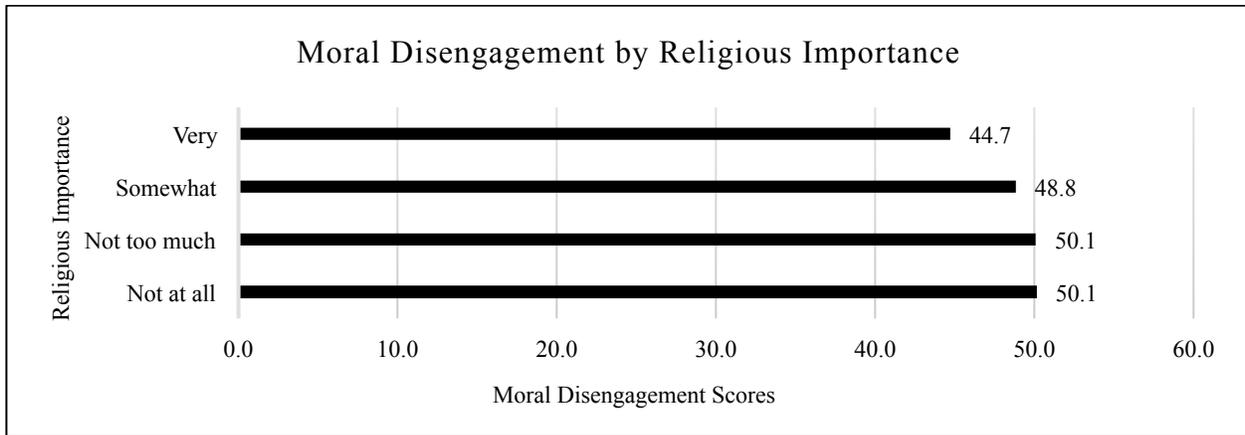


Figure 7 - Moral Disengagement by Religious Importance

Moral Attentiveness

Moral attentiveness included both reflective and perceptual moral attentiveness, with four statements each measured on a seven-point Likert scale for a total possible score of 56. The average student score was 34.6. A higher moral attentiveness score indicates greater awareness of moral and ethical dilemmas and decisions in a student’s everyday life.

As has been seen with other subscales, moral attentiveness scores also differed by how important religion was to students ($F(3,752) = 12.6, p < .001$). Students who felt religion was somewhat or very important tended to have higher moral attentiveness scores as compared to other students as shown in Figure 8, indicating greater awareness of moral and ethical impact in their lives. Scores of males and females did not differ much ($M_{\text{female}} = 34.9, M_{\text{male}} = 34.4$), and no statistical difference was found between scores of international students and domestic students ($M_{\text{international}} = 34.8, M_{\text{domestic}} = 34.9$).

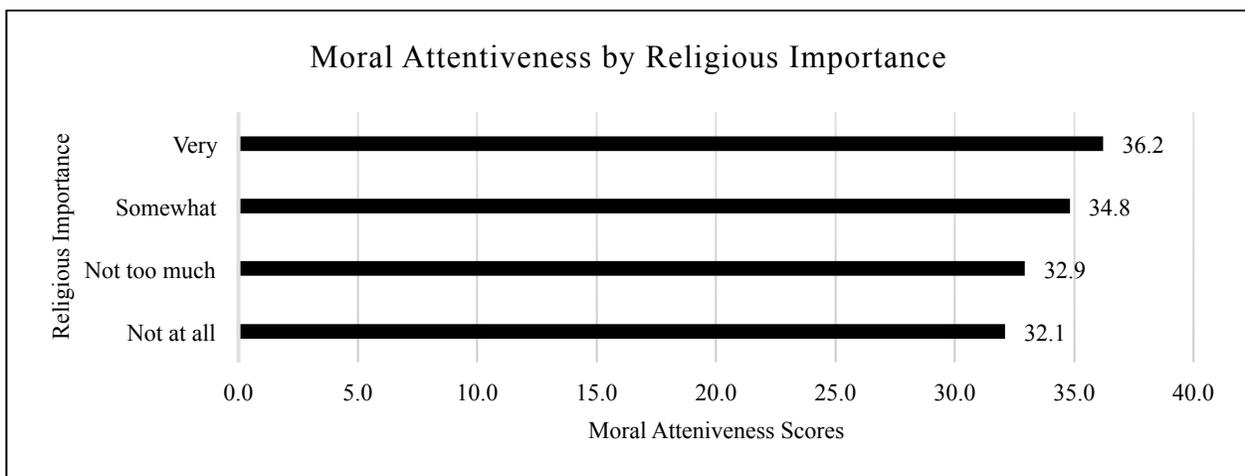


Figure 8. Moral Attentiveness by Religious Importance

Concluding Discussion

Most students (87%) indicated that ethics, as a consideration related to engineering work or practice, was important; while over half (54%) said ethics was extremely important. This did not vary much between schools and there was a moderate correlation between this measure and each of the other scales used in this study. However, saying ethics is important did not always transfer directly into high ethics scores for other measures.

Further analysis of our data suggests that cultural norms may affect ethics perceptions. More specifically, international students' situational judgment, justice-for-self, and perceptions of ethical climate may have been affected by differences in acceptable cultural norms and contexts.

While there were some differences in ethics measures by gender for moral disengagement and situational judgment, as well as feelings about political and social involvement, by far the most influential predictor of ethics attitudes and beliefs seems to be students' feelings regarding the importance of religion in their lives. There appears to be a persistent and constant relationship between this factor and most of the measures. The value students placed on the importance of religion tended to correlate with, and perhaps shape, ethics perceptions, beliefs, and attitudes.

Semi-Structured Interview Development

Stratification

As the baseline survey administration did not yield greatly varying results on particular items, it made more sense to stratify our interview recruitment according to demographic characteristics rather than responses to specific questions. However, as mentioned in the preliminary results section, observations were made according to variations in results related to demographic variables such as gender and international status. Therefore, interview participants were purposefully recruited in part based on the following demographic criteria: (1) gender, (2) international student status, (3) participation in service learning programs (such as EPICS at Purdue) or religious mission (BYU), and (4) declared major, as civil engineers were oversampled at baseline. Due to the longitudinal nature of the study, it is the desire of the researchers to retain sufficient civil engineers to be able to compare variance in responses in future phases. It is hypothesized that civil engineers may respond differently or demonstrate varying change over time that may possibly be due to increased quantities of ethics courses civil engineers are required to take as compared to other engineering fields, including to prepare for the Fundamentals in Engineering exam as a first step toward professional licensure. Similar trends are hypothesized for biomedical engineering students given that they often receive intensified ethics instruction due to the human health and safety issues they may encounter professionally.

Interview Protocol Development and Administration

After reviewing the initial survey responses and prior to complete survey data collection, the interview protocol went through several revisions to arrive at the one utilized. This included an interview protocol committee with members from each university offering input and feedback. For example, the original protocol was determined to be too lengthy. The committee decided

upon which items could be removed or which would provide sufficient information by combining items. Once an initial protocol was decided upon, approximately three pilot interviews at each university were conducted to determine any further changes that needed to be made. Based on feedback, the protocol was modified to flow more smoothly, including the reordering of some sections, and improving clarification of items that students considered confusing. The revised protocol was then administered to approximately 20-30 students per university.

The final interview protocol consists of the following sections: (1) general definitions of ethics including macro-ethics, (2) experiences (past, present, and future) that may shape students' ethical perspectives and sense of social responsibility, (3) ethical climate, and (4) ethical situations. The committee determined that an appropriate amount of time per interview was approximately 30-60 minutes. Some items were deemed optional depending on time constraints.

Within the interview protocol, several questions that demonstrated some variance of responses in the survey were included to further highlight reasoning behind the variance. For example, the two ethical situations with the greatest variance in responses from the survey were included, with respondents asked to discuss the factors that influenced their choices. An optional third scenario was also added, time permitting. This was done to support understanding of responses to the survey, as well as obtain an overall sense of students' ethical perspectives. Based upon survey results, responses that showed variance were probed further as time allowed. This allows student to further describe their reasoning regarding certain responses as part of the interview protocol in a way that will help researchers further understand varying response patterns in the survey data.

Next Steps

Analysis of the qualitative data obtained from student interviews is underway. Each audio file has been de-identified to protect identity of participants and allow for cross-university analysis. A sub-committee of researchers is now working collaboratively to select a subsample of interview transcripts from each university, to be coded using both inductive and deductive approaches to thematic analysis of qualitative data. This group's goal is to establish an appropriate coding framework for the interview data, which will in turn facilitate analysis of all remaining interviews from each university. Appropriate software will be used to allow for sharing of the subsample transcripts as well as collaboration as needed on the remaining interview data. Our intent is to use a web-based coding platform to facilitate multi-university collaboration. The interview analysis subcommittee will also consider the possibility of other approaches to analyzing the interviews (e.g., phenomenographic analysis) to provide additional and perhaps richer insights about the perceptions and experiences of these students. As noted above, survey data collection will be repeated with these same students during their fifth semesters, while repeat survey measures and interviews will be conducted in their eighth semesters. As this overview suggests, we anticipate ample opportunities for further exploration and investigation of the intriguing preliminary survey results presented in this paper.

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