Spring 1-1-2013

# Assessing Engineering Students' Understanding of Personal and Professional Social Responsibility

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# ASSESSING ENGINEERING STUDENTS' UNDERSTANDING OF PERSONAL AND PROFESSIONAL SOCIAL RESPONSIBILITY

by

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A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado in partial fulfillment

of the requirement for the degree of

Doctor of Philosophy

College of Engineering and Applied Science

2013

Adviser: Dr. Angela R. Bielefeldt, P.E.

This thesis entitled:
Assessing Engineering Students' Understanding of Personal and Professional Social Responsibility
written by Nathan E. Canney
has been approved for the Department of Civil, Environmental, and Architectural Engineering

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IRB protocol # ______11-0414______

Canney, Nathan E. (Ph.D., Civil, Environmental, and Architectural Engineering)

Assessing Engineering Students' Understanding of Personal and Professional Social Responsibility

Thesis directed by Professor Angela R. Bielefeldt

Many groups within the engineering community have recognized the need for more diversity in the engineering profession and for more holistic engineers to develop responsible, equitable, and sustainable technology for the future. New educational approaches, such as Service-Learning, are being used to teach technical skills as well as professional skills including ethics and an understanding of the social context of engineering solutions. There is a need, however, for frameworks and instruments to assess the effectiveness of these programs and others towards developing these skills. This study uses the lens of social responsibility to view the development of underlying dispositions, foundational to many of the professional skills that are needed for a more holistic profession.

This thesis presents a new framework describing the development of social responsibility in engineering students. The iterative process between theory development and data is discussed, leading to a finalized model from which future instruments and studies can be designed. Next, the development of an instrument to assess beliefs of social responsibility, the Engineering Professional Responsibility Assessment (EPRA) tool, is presented, which was developed iteratively with both quantitative and qualitative data. Evidence of both reliability and validity are presented.

Finally, results from a multi-institutional administration of the EPRA tool are analyzed for differences in beliefs of social responsibility between genders, academic ranks, and engineering disciplines (specifically Civil, Environmental, and Mechanical). Results showed that women had higher degrees of social responsibility than men, correlating with higher degrees of participation in volunteer activities. First-year students also tended to have higher degrees of social responsibility than senior and graduate students; predominately for female students. Finally, Environmental Engineering students had higher degrees of social responsibility than Civil Engineering students, who were higher than Mechanical Engineering students. Students in Environmental Engineering, over Civil or Mechanical, most often cited a desire to have a positive impact on society and to help others as motivation for their

choice of major. These results form a foundation from which future studies regarding the development and effects of social responsibility in engineers can be conducted.

# ACKNOWLEDGEMENTS

First and foremost, I would like to thank my loving wife for her support, encouragement, and flexibility throughout this educational journey. Most of all, I would like to thank her for her willingness to follow me around the country, living in family housing for the first five years of our marriage, and journeying with me through all the ups and downs that we have endured. Also, I send love to my two beautiful children, Mia and George, whose fun and laughter always gave me the best reason to leave the office and come home at the end of each day.

In endless gratitude to my adviser, Angie Bielefeldt, who engaged in this research with me as a collaborator, helping to guide my process of discovery from the very beginning in a challenging and respectful way. Throughout my doctoral path, Angie was both a research adviser and a life mentor in the best way, constantly exemplifying the relationship which I hope to develop with my future students.

Thank you to my parents, siblings and many other family members who have been listening ears and encouraging voices along the way. Specifically, I am excited to be following in the footsteps of my father, George, as a passionate educator and I am thankful for his advice throughout this doctoral process.

I am grateful for my committee members who were willing to provide guidance throughout my research process. It has been crucial for me in this interdisciplinary research area to have professors across multiple fields of study that were willing to meet with me, give feedback, read papers, and help me interpret results. In addition to my committee members, I would like to thank Dr. Andy Maul, Dr. Ray Littlejohn, Dr. Daniel Knight, and Steven Ouellette for help with survey development and statistical analysis related to the EPRA tool.

I would like to thank the greater community of engineering education researchers at the University of Colorado Boulder. To Mindy Zarske, Marissa Forbes, Kaitlin Litchfield, Greg Rulifson, and Janet Tsai who were graduate students with me, negotiating the budding territories around doing engineering education research while remaining viable in traditional engineering fields. To the Discipline Based Education Research and Engineering Education Research Groups at the University of Colorado Boulder for providing important forums for discussion and to share ideas about different research studies.

Finally, I would like to acknowledge the significant financial opportunities afforded by the 2011-2012 CU Chancellor's Award for Excellence in STEM Education and the NSF Grant No. 1158863 which allowed me to conduct this research and will continue to fund this area of study for the next few years.

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# CHAPTER I

# INTRODUCTION

## STUDY PURPOSE

The ways in which the engineering profession impacts society are innumerable. From infrastructure and transportation, to energy, food and water production, engineering is present in nearly every aspect of life. Engineers work in complex systems where there may be both social pros and cons as a result of their work. They must work within very real and demanding constraint, striving to balance the needs for resources and development with the needs for environmental protection and human health. New ways of thinking such as “triple bottom line” sustainability or systems thinking have been brought into engineering in order to inform the engineering design process to include these complex elements. There remains, however, an unclear vision of what the role of the engineer is towards working on these complex social issues. Is the engineer merely technical, applying physics and math to solve whichever problem they are presented with? Is the engineer there to discover, develop and share impartial, unbiased and scientific knowledge so that others can make the key decisions in an informed manner? Should the engineer participate in the conversation, share opinions, and be a part of the deciding body, sometimes saying ‘no’ to development or technical progress because of the potential consequences? How should personal values play into the professional work of an engineer, and where should those values and that interaction be developed, taught, or promoted? These are just a few of the key questions that loom over a changing engineering profession, which recognizes its capability to have profound impacts on many of the toughest issues facing our global society, but is unclear as to what the role of the engineer in society is or how to teach it.

Beliefs of personal and professional social responsibility are one avenue through which these issues can be examined. Social responsibility incorporates both values and actions rooted in feelings of desire or obligation to help others. With respect to engineering, views of social responsibility address what the role of the engineer is in society, specifically related to the incorporation of social issues into the engineering design process, issues of professional service or pro bono work, and how one’s personal values and beliefs should play into her/his professional life. Social responsibility in engineers and the engineering profession are important to examine because these form the foundation for the attitudinal dispositions of the individuals and the collective, informing how the technical and professional skills that they possess are used in society. Many professional organizations have highlighted the need for more holistic engineers and a more diverse engineering profession (National Academy of Engineering, 2005; ABET, 2008; American Society for Civil Engineering, 2008; Engineers for Social Responsibility, n.d.nz). This work assumes that at the root of changing the profession to better address complex social issues, are the views of social responsibility which inform why and how engineers act towards those issues. Therefore, before the engineering educational system adjusts towards creating the new 'renaissance engineers', they must first examine the foundational beliefs at the core of the engineer and of the engineering profession.

Central in the calling to re-envisioning the profession is the National Academy of Engineering's (NAE) report, *Educating the Engineer of 2020* (National Academy of Engineering, 2005), which lays out a vision for how the educational system can aid in the development of a more diverse profession and of more holistic engineers. They call for new forms of teaching using active learning pedagogies, such as service-learning, a focus on professional skills in addition to technical skills, and placing social context as a key component of engineering design. The U.S. engineering accreditation body, ABET, also highlights the need for a wider range of skills in Criterion 3 (a-k), including an understanding of professional and ethical responsibility, and the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (ABET, 2008).

The American Society of Civil Engineering's (ASCE) Body of Knowledge (BOK2) goes even further and incorporates a discussion of attitudinal dispositions which are needed in order to be an effective engineer (American Society for Civil Engineering, 2008). In their list of critical attitudes they include the consideration of others, fairness, positiveness, respect, sensitivity, thoughtfulness, and tolerance. These qualities, while universally held up as good attributes of any person, are not often associated so directly with the engineering profession. But, as engineering pushes beyond traditional boundaries to work across cultural and social divides, engineers need to develop a wider range of skills and perspectives to remain effective. Social responsibility provides a useful lens through which these attitudes can be examined.

How to develop holistic engineers is a difficult problem to solve. Many of the values and attitudes highlighted by the NAE, ABET, and ASCE BOK2 develop throughout one's life, therefore students don't enter the engineering educational system as blank slates. Learning Through Service (LTS) is one approach which has been suggested to tie these values into engineering learning objectives (Bielefeldt, Paterson, & Swan, 2009). LTS is a term used to encompass Service-Learning (SL), which is curricular based and directly tied to academic goals, and extracurricular activities which use engineering service such as Engineers Without Borders (EWB) or Bridges to Prosperity (B2P).

Research on the effects of SL have shown that students across disciplines who engage in SL have an increased understanding of civic and social responsibility, awareness of the world, and increased academic, personal and professional advancement (Ariely, Banzaert, & Wallace, 2005; Ejiwale & Posey, 2008; Bielefeldt, 2006; Astin, Vogelgesang, Ikeda, & Yee, 2000; Eyler, Giles, Stenson, & Gray, 2001; O'Neill, 2012). In a review of studies on the effects of service learning, Kezar (2002) noted that service learning has been associated with increased cultural awareness, acceptance of diversity, altruistic attitudes and social development (self-esteem, social self-confidence, public speaking and meeting people) in students. The reflection inherent in SL also helps students to understand the role of engineering in the context of larger social issues (Oakes, 2009) which is a critical component in the development of an engineers' social responsibility. Additionally, there are myriad anecdotal stories among faculty and students of increased social awareness after engaging in SL experiences. Other benefits of LTS in engineering, which may also be associated with an increased focus on social responsibility, include greater attraction of women to engineering and higher retention of underrepresented students (Carberry, 2010; Romkey, 2007; Duffy, Barrington, & Heredia Munoz, 2011).

Few tools have been developed toward gauging the effectiveness of LTS activities on the development of social responsibility values in engineers. The Community Service Attitudes Scale (CSAS) was developed to measure student attitudes based upon models of altruistic behavior development (Shiarella, McCarthy, & Tucker, 2000) and has been used to examine these views in engineering students (Bauer, Moskal, Gosink, Lucena, & Munoz, 2007; Bielefeldt, Amadei, & Sandekian, 2007). Similarly, the Service Learning Model (Delve, Mintz, & Stewart, 1990) inspired the creation of the Scale of Service Learning Involvement (Olney & Grande, 1995) which focuses on attitudinal development associated with service experiences. The Personal and Social Responsibility

Inventory (Association of American Colleges and Universities, n.d.) focuses more broadly on institutional characteristics which may influence the development of social responsibility in students, but no study was found that used this instrument to focus on engineering students, nor does it address ideas of professional social responsibility. Other tools have focused specifically on the development of ethical skills in engineering (Rest, 1979; Shuman, et al., 2003; Wu, Troboy, Cole, Cochran, & Roach, 2008). None of these tools, however, focus specifically on the development of personal and professional social responsibility within the context of the engineering profession as a method to measure the effects of LTS involvement.

## Scope of the Problem

The purpose of this study is to investigate the development of personal and professional social responsibility in engineering students. Social responsibility is believed to be a foundational disposition which informs many of the other professional skills and attitudes needed for engineers to effectively address social issues. Toward this goal, the Professional Social Responsibility Development Model (PSRDM) was created to explain the development of both personal and professional social responsibility, how the two belief systems might be related, and how service may be linked to advancing social responsibility. This framework formed the foundation for the creation of a survey instrument, the Engineering Professional Responsibility Assessment (EPRA), which was piloted during its development and later distributed more widely to engineering programs at a diverse set of institutions. More detail about the selection of majors and schools for this work is given in the following chapter. Results from these distributions helped to inform the development of the survey, including validity and reliability, which are detailed in this study. Additionally, these results provided useful information about what student beliefs of personal and professional social responsibility are and shed insight on some potential causes of those beliefs.

The final EPRA tool consists of 50 Likert-items which address the eight dimensions of the PSRDM. There is also a question which asks students to prioritize between different job attributes based upon the personal importance of those attributes in their future engineering careers. EPRA asks about previous volunteer experiences, including type and frequency, and about motivations and limitations to volunteering. There is an open-ended question which asks students about other life experiences which may have influenced their views of community service and social responsibility. Finally, EPRA contains demographic questions including gender, major, academic year, grade point average, race/ethnicity, work experience, and religious preference.

Based upon the results from the multi-institution distribution of EPRA, it was found that female students had stronger beliefs of social responsibility than male students did, potentially resulting in or a result of female students having engaged in more volunteer activities and more frequently. It was also found that Environmental Engineering students had stronger beliefs of social responsibility than Civil and Mechanical Engineering students. When asked why they chose their major, Environmental Engineering students more often cited socially focused motivations, such as having a positive impact on society or helping others, whereas Mechanical Engineering students more often cited inwardly focused motivations, such as an affinity toward math and science, or a personal interest in building things. These results suggest that students with differing degrees of social responsibility self-selected into these majors based upon motivations related to social responsibility. These initial study results point toward many more avenues for discussion and exploration into the views and development of social responsibility in engineers, including how these may affect the attraction and retention of a more diverse body to the engineering profession.

## Arrangement of the Thesis

This thesis is developed such that the main chapters are four separate articles, intended to be stand-alone pieces for publication in peer-reviewed journals in engineering education. Chapter II provides the overarching research questions and hypotheses for this study, as well as detailing the data collection methods used to gather evidence for the chapters that follow. Chapters III through VI present discrete journal articles, each containing an introduction, research questions, review of relevant literature, methods, results and conclusion sections. The individual bibliographies for each paper have been combined into one bibliography for this entire thesis, given at the end. Also, because each chapter contains a literature review directed specifically at the topic of that article, there is not an independent literature review chapter in this thesis. Chapter III focuses on the development of the PSRDM framework[1] and presents the theoretical foundation for this research. Chapter IV presents the development of the EPRA tool, including evidence for reliability and validity. Chapter V is a discussion of differences in views of social responsibility by gender and Chapter VI is a discussion of differences by major. The final chapter is a conclusion of the entire thesis, including a discussion of future research questions that were identified through the process. Finally, the appendices include the final version of the EPRA tool, a chronology of the development of

[1] This article is currently under review for a special issue of the International Journal of Engineering Education focusing on professional skills in engineering.

EPRA, including items which were removed or added through the Pilot and primary distributions, the Institutional Review Board (IRB) approval document, a more detailed discussion of the Multidimensional Item Response Theory approach used as evidence of validity, and a discussion on EPRA results regarding student volunteer frequencies.

# CHAPTER II

# RESEARCH OBJECTIVES AND HYPOTHESES

## RESEARCH OBJECTIVES

The research objectives were to create a framework and tool to explain and measure the development of social responsibility in engineering students. The purpose of the framework and tool are to better understand what students believe regarding their personal and professional social responsibility, and to assess the effectiveness of educational interventions designed to increase views of social responsibility. Additionally, the purpose of this research was to examine some of the results obtained from the EPRA tool, contributing to the narrow existing body of knowledge pertaining to student views of social responsibility in engineering. These results also contribute to the more extensive body of literature surrounding the gender gap in engineering and possible ways to increase the attraction and retention of a more diverse body into the engineering profession. Finally, these results shed light on the differences between the engineering sub-disciplines, which have been largely overlooked. The majority of the literature treats engineering as a homogenous body, but from within, there are very clear distinctions between the disciplines which may illuminate new strategies for incorporating social issues into engineering education toward developing more holistic engineers. Specifically, the following research questions are asked:

1. What are student's beliefs and attitudes towards ideas of social responsibility in engineering?
2. What are key experiences that are related to those views of social responsibility?
3. Are there differences between female and male engineering students with respect to beliefs of personal and professional social responsibility?
4. If there are gender differences in views of social responsibility, what factors could help explain those differences?
5. Are there differences in students' degrees of social responsibility by engineering discipline? If so, how do these differences compare at entry (first-year students) and completion (senior students) of the programs?
6. Do students indicate different reasons for choosing their discipline of study, specifically with respect to elements of social responsibility?

7. Does departmental messaging on websites and recruitment flyers differ with respect to social responsibility by discipline?

## RESEARCH HYPOTHESES

Based upon the current literature about the development of social responsibility in students, the benefits of engaging in LTS activities, and preliminary research results, the following hypotheses are presented [and the chapter of the dissertation that addresses this hypothesis]:

1. Questions that address more general elements of social responsibility, such as an awareness that others need help, will have stronger agreement among engineering students compared to questions which address more specific and obligatory elements of social responsibility [Chapter IV].
2. Based upon previous literature pointing to a desire to have an impact on society as a stronger motivation for women than men to choose STEM fields, female students will have higher degrees of social responsibility than male students [Chapter V].
3. Students who have had more service experiences and/or have volunteered more frequently will have higher degrees of social responsibility than students with fewer service experiences [Chapter V].
4. Environmental and Civil Engineering students will have higher degrees of social responsibility than Mechanical Engineering students, perhaps which are linked to the perception of the projects that they do being more directly linked to social impact [Chapter VI].
5. The outward image and public perception of the different engineering disciplines guide students with higher degrees of social responsibility to disciplines more perceived to foster the ability to have a positive impact on society, such as Environmental Engineering, over other disciplines, such as Mechanical Engineering [Chapter VI].

## STUDY DESIGN

This study design was built around the testing and analysis of results from progressive versions of the EPRA tool. Interviews were also conducted with engineering students which focused on their views of engineering and social responsibility. This study was developed with an advisory board which included professors of engineering at each of the five institutions surveyed, a professor from the School of Education, and the director of a prominent organization fostering engineering service. This advisory board gave feedback on the EPRA tool twice, before the beginning of the year and end of the year distributions at each institution, aided in gaining access to students at each institution, and provided feedback on future directions for this study. Each chapter contains a methods section which highlights the data sources specific to that paper, but this section is intended to describe all the data sources used, including participant selection, distribution methods, participant demographics, and analysis methods.

## PILOT STUDY

The EPRA tool was piloted four times at Large Public U (described in the next section) during the 2011-2012 academic year. Table 1 shows the classes that were surveyed, including the disciplines, academic rank, response numbers, and when they were surveyed. The majority of classes were surveyed both at the beginning and

**TABLE 1. PILOT STUDY CLASS INFORMATION**

| | Class | Discipline | Academic Rank | Class Size | Pre-Survey Date | Post-Survey Date | Response Numbers | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Pre | Post |
| Fall Pre/Post Distribution | Intro to Environmental Engr. | Environmental | First-year | 69 | 9/2011 | 12/2011 | 21 | 43 |
| | Intro to Civil Engr. | Civil | First-year | 48 | 8/2011 | 12/2011 | 45 | 35 |
| | Intro to Engineering (sent electronically to multiple classes) | All | First-year | 671 | 8/2011 | 12/2011 | 211 | 57 |
| | First-year Projects | All | First-year | 31 | 8/2011 | 11/2011 | 24 | 18 |
| | Fundamentals of Environmental Engr. | Civil | Junior | 81 | 8/2011 | 12/2011 | 73 | 53 |
| | Civil Engr. Senior Design | Civil | Senior | 79 | 8/2011 | 11/2011 | 15 | 33 |
| | Analysis of Framed Structures | Civil | Senior/ Graduate | 33 | 9/2011 | 12/2011 | 31 | 23 |
| | Sustainable Community Development I | Civil/ Environmental | Graduate | 27 | 8/2011 | 11/2011 | 27 | 24 |
| Fall Mid-Distribution | Thermodynamics | Civil | Sophomore | 113 | 10/2011 | | 37 | |
| | Fluid Dynamics | Mechanical | Junior | 141 | 11/2011 | | 89 | |
| | Water Chemistry | Environmental | Junior/ Senior | 62 | 10/2011 | | 55 | |
| Spring Pre/Post Distribution | Engr. Geology | Civil | Sophomore | 89 | 1/2012 | 4/2012 | 75 | 75 |
| | Fundamentals of Environmental Engr. | Environmental | Sophomore | 52 | 1/2012 | 4/2012 | 49 | 31 |
| | Intro. to Environmental Microbiology | Environmental | Junior/ Graduate | 82 | 1/2012 | 5/2012 | 57 | 49 |
| | Environmental Engr. Design | Environmental | Senior | 36 | 1/2012 | 4/2012 | 35 | 23 |
| | Sustainable Community Development II | Civil/ Environmental | Graduate | 26 | 1/2012 | 5/2012 | 24 | 16 |

the end of each semester, although three classes (Thermodynamics, Fluid Dynamics, and Water Chemistry) were surveyed once in the middle of the Fall semester in order to increase the number of responses to test reliability and validity and to get more responses from Sophomore, Junior, and Mechanical Engineering students. Overall, classes were selected to capture many of the Civil and Environmental Engineering students at each academic level as well as to capture classes which contained elements of project-based learning or service-learning such as the First-year Projects, Civil Senior Design, Sustainable Community Development I & II, and Environmental Engineering Design. Paper copies of the survey were handed out in class and students were given time then to fill them out except for the Intro to Engineering courses where the survey was distributed electronically. When the surveys were handed out, the researcher verbally explained the Institutional Review Board (IRB) policies about confidentiality and that their participation was independent of their class. Students had to sign a written consent form as well. No incentives were given to students for participation in the pilot study. The demographic breakdowns of participants from each distribution are shown in Table 2.

**TABLE 2. PILOT STUDY PARTICIPANT DEMOGRAPHICS**

| Demographic | Fall 2011 | | | | Spring 2012 | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Pre- | Mid- | Post- | Both Pre- & Post- | Pre- | Post- | Both Pre- & Post- | |
| **Total** | 435 | 181 | 229 | 188 | 240 | 194 | 171 | **1279** |
| | | | | | | | | |
| **Male** | 280 | 130 | 146 | 121 | 145 | 129 | 112 | **830** |
| **Female** | 117 | 45 | 70 | 62 | 84 | 61 | 57 | **377** |
| | | | | | | | | |
| **First-year** | 228 | 0 | 76 | 62 | 4 | 3 | 3 | **2** |
| **Sophomore** | 41 | 32 | 27 | 24 | 79 | 68 | 61 | **373** |
| **Junior** | 62 | 104 | 38 | 35 | 50 | 44 | 37 | **298** |
| **Senior** | 40 | 35 | 45 | 27 | 55 | 42 | 38 | **217** |
| **Graduate** | 47 | 2 | 40 | 38 | 46 | 35 | 31 | **170** |
| | | | | | | | | |
| **Civil** | 175 | 30 | 138 | 112 | 97 | 89 | 77 | **529** |
| **Environmental** | 34 | 63 | 54 | 41 | 130 | 102 | 92 | **383** |
| **Mechanical** | 50 | 72 | 7 | 7 | 4 | 2 | 2 | **135** |
| **Other Engineering** | 176[2] | 16 | 30 | 28 | 9 | 1 | 0 | **232** |

Using the data from each distribution, reliability was checked for each dimension of the EPRA tool using Cronbach's Alpha. Items which did not load well into a given dimension were removed or reworded, and new items were added to strengthen different dimensions. Using data from the Fall pre- and mid- distributions, evidence of validity was examined according to the hypothesized model using Confirmatory Factor Analysis. This also guided

[2] A large number of first-year students from other majors came from the electronic distribution of EPRA to all intro-engineering courses

the removal and addition of new items. See (Canney & Bielefeldt, 2012) for further discussion of that preliminary examination of reliability and validity and Appendix B for more detail about items which were removed and deleted throughout the EPRA development process. By the end of the pilot study, the EPRA tool had been through four iterations and the research team felt that it was ready to be distributed to a larger population in the Tier 1 field test. The results from the Pilot data also informed the specific research hypothesis explored for this dissertation.

## TIER 1 SURVEY

The Tier 1 survey was designed to target first-year, senior, and graduate students in Civil, Environmental, and Mechanical engineering programs at five different institutions. Data from the pilot study showed that beliefs of social responsibility were lower at cut points between the end of the first-year through the sophomore and junior years and into the beginning of the senior year, suggesting that aggregate averages decrease through these years (Canney & Bielefeldt, 2012b). These results lead to the research team targeting only first-year, senior, and graduate students for the Tier 1 distribution.

The three engineering disciplines were chosen for several reasons. Mechanical Engineering is the largest engineering discipline nationally, accounting for 23% of the engineering degrees earned, but it has one of the lowest percentages of females of the engineering disciplines (11.7%) (Yoder, 2012). Additionally, Mechanical Engineering was seen as a broad field, providing a wide range of skills and career opportunities for graduates, ranging from product design, to prosthetics, to working on oil rigs. This was important because it seemed to be a major which allowed its students to pursue their passions in a wide variety of ways. Environmental Engineering was chosen because it has the highest percentages of women enrolled (44%) (Yoder, 2012) and also seemed to be an area of study which was easily associated with improving society through the environment. Civil engineering was chosen because it seemed to be a discipline somewhere in between the others. It is the second largest major, nationally, with 15% of the degrees earned and comprised of a median percentage of women (22%) for all engineering disciplines (Yoder, 2012). Additionally, similar to Environmental Engineering, Civil Engineering projects seemed easier to tie to social benefits than many other engineering disciplines.

The five institutions which were chosen for the Tier 1 survey were chosen to represent a diversity of engineering institutions. Table 3 provides a broad overview of the characteristics of each institution (pseudonyms are used in accordance with IRB protocols to protect anonymity). Large Public U is the largest university in the state and is located in a college town with a reputation for outdoors activities and being politically liberal and 'green.' Engineering students make up approximately one sixth of the total population. The student demographics in engineering reflect national trends for gender, but, similar to the university as a whole, has little ethnic or racial diversity, consisting predominately of white students. Curricular SL opportunities are few and are generally up to the discretion of the professors, as opposed to institutionalized programs. In the targeted majors, service projects are potentially encountered in the first year design course and senior design course in civil/environmental engineering. There is, however, a graduate certificate program in engineering for developing communities and a strong presence of extra-curricular engineering service, including Engineers Without Borders (EWB) and Bridges to Prosperity (B2P).

**TABLE 3. TIER 1 INSTITUTION CHARACTERISTICS**

| School | Carnegie Classification[3] | | | Engineering Population[4] |
|---|---|---|---|---|
| | Control | Total student population | Classifications | |
| **Large Public U** | Public | 29,278 | High undergraduate, Large 4-yr, primarily nonresidential, RU/VH | 4,988 |
| **Engineering U** | Public | 7,136 | High undergraduate, Medium 4-yr, primarily residential, RU/H | 4,153 |
| **Mid-Private U** | Private not-for-profit | 10,252 | Majority undergraduate, Medium 4-yr, highly residential, RU/VH | 1,385 |
| **Small Research U** | Public (201 | 13,391 | High undergraduate, Large 4-yr, highly residential, RU/H | 987 |
| **Military U** | Public | 4,621 | Exclusively undergraduate, Medium 4-yr, highly residential, Bac/A&S | 1,230 |

Engineering students make up the majority of Engineering U's student population, and non-engineering majors are generally in the life and physical sciences. Engineering U is advertised as a premier technical institution, located in a small, safe town with lots of outdoor opportunities. Similar to Large Public U, Engineering U has a graduate program in engineering for development, but also has other opportunities for engineering service in the curriculum such as a senior design course focused on projects in Central America which takes students there as part of the class. Other SL opportunities are mainly up to individual instructors to initiate. Engineering U is predominately white and has female student populations near the national average.

Mid-Private U is pitched as international, civically engaged, and involved with life sciences. Tuition is very high (>$40,000), though a number of students receive significant financial aid, creating a bimodal distribution

[3] http://classifications.carnegiefoundation.org/lookup_listings/institution.php
[4] enrollment numbers from 2011/2012 academic year, http://profiles.asee.org/

of student family income. Service is a key institutional message, aimed at creating an engaged group of citizens. Females are overrepresented in the engineering department compared to national averages, a fact that is touted by the university. Engineering students at Mid-Private U all enter as undeclared in their first-year, and are not able to declare a specific major until mid-way through their first year, thereby exposing students to each possible major before they choose. Despite a university atmosphere around service, most LTS opportunities for engineering students are outside of the classroom in the forms of clubs such as EWB.

Small Research U is advertised as a premier small research university, located in a small, rural, environmentally friendly town and state. Small Research U is the only in-state institution for residents of its state, and therefore attracts a wide range of students from within. Out-of-state tuition, however, is one of the highest in the nation and nearly 75% of the student population at Small Research U is out-of-state students, creating an interesting split in student economic backgrounds. The engineering program is predominately white and the proportion of female students is slightly below the national average. The Civil and Environmental Engineering department at Small Research U received a federal grant several years prior to incorporate SL into classes throughout the curriculum. At one point, students in these programs would have at least one SL project in each year of their four years. The senior capstone for Civil and Environmental Engineering students has been a SL project for over six years. There is also an administrative office at Small Research U which helps faculty incorporate SL into their classrooms. EWB is also very active at Small Research U.

Military U was a notable outlier from traditional engineering programs, consisting entirely of students pursuing military careers and is an undergraduate only institution. Military U has a strong focus on character development, service to nation, and has a long standing tradition of excellence in engineering education. All students at Military U are fully financed and are admitted to represent the diversity of the country from a socio-economic standpoint. Women, however, are extremely underrepresented in engineering at Military U (7%, (American Society of Engineering Education, 2013)). While formalized SL is sparse at Military U, students routinely work on ‘real-world’ problems through case-studies or socially contextualized projects in their classes. Similar to the other institutions surveyed, extracurricular opportunities such as EWB are common, as well as many opportunities for summer internships or research in developing countries with non-governmental or governmental aid organizations.

These five institutions represent a wide variety of engineering programs. There were LTS opportunities at each institution, some had curricular programs and all had extracurricular programs. Large Public U is located in the West, Engineering U in the Midwest, and the other three are located in the Northeast. They represented students with diversity in socio-economic status, but, with the exception of Military U, mainly represented white ethnic groups. Women were represented both above and below the national averages for engineering at these institutions.

EPRA was distributed electronically at each institution at the beginning and end of the 2012-2013 academic year. Student emails were gathered from departmental email lists for the academic ranks and majors of interest. Additionally, partners at each institution gave brief pitches about the study to classes where groups of the target population would be, such as first-year introductory, or senior capstone classes. Surveys were considered valid if the respondent electronically signed the informed consent form, appropriately checked 'Slightly Disagree' on one questions asking them to do so as a check, and completed at least 90% of the 50 Likert-items. One thousand students completed the survey to this level at the beginning of the year distribution, and only those students were solicited at the end of the year distribution. Six-hundred and ninety-eight students completed the survey the second time. Students were given a $5 gift card for completing the first survey, and another $10 gift card for completing the second; with the exception of Military U that did not allow incentives. Demographic information for the Tier 1 data set is given in Table 4.

The Tier 1 data was used to further develop the EPRA tool, including evidence of reliability and validity, and this process is presented in Chapter IV. The data was also used to examine differences in beliefs of social responsibility between genders, academic ranks, and majors. The results from these examinations are given in Chapters V and VI.

**TABLE 4. TIER 1 PARTICIPANT DEMOGRAPHICS**

| | Fall 2012 | | Spring 2013 | |
|---|---|---|---|---|
| | # of Students | Approx. Response Rate | # of Students | Total Response Rate*[5] |
| **Total** | 1000 | 28% | 698 | 68% |
| | | | | |
| **Male**[6] | 657 | 24% | 455 | 65% |
| **Female** | 310 | 42% | 238 | 75% |
| | | | | |
| **First-year** | 236 | 27% | 147 | 61% |
| **Senior** | 344 | 25% | 222 | 67% |
| **Graduate** | 315 | 30% | 273 | 77% |
| | | | | |
| **Civil** | 262 | 24% | 180 | 65% |
| **Environmental** | 182 | 47% | 131 | 70% |
| **Mechanical** | 474 | 23% | 340 | 69% |
| **Other** | 82 | - | 47 | 58% |
| | | | | |
| **Large Public U** | 319 | 28% | 243 | 73% |
| **Engineering U** | 317 | 24% | 245 | 71% |
| **Mid-Private U** | 148 | 50% | 96 | 65% |
| **Small Research U** | 109 | 25% | 75 | 67% |
| **Military U** | 107 | 32% | 37 | 42% |

### STUDENT INTERVIEWS

Towards gaining deeper insights into student views of personal and professional social responsibility, 25 interviews with engineering students were conducted at Large Public U. Student names were gathered by talking to professors in Civil, Environmental, Mechanical, and Aerospace engineering departments and asking for the names of students who they felt represented a wide range of experiences and beliefs. These students were then contacted by the researcher and asked to participate a thirty minute to one hour long interview. Twenty-five students agreed to participate and demographic information for those participants is given in Table 5. Before each interview, students read and signed an informed consent form, consistent with IRB protocols, and were asked to take the EPRA survey. After completing the survey, the interview commenced, and would last another 20 to 45 minutes. Interviews were recorded and later transcribed for analysis. No incentives were provided to the students in exchange for their participation in the interview.

[5] On the pre- survey, students were asked to select a specific response on one Likert-item as a check. Students who did not appropriately answer this question were removed from analysis in the pre-survey, but were still solicited in the post survey, bringing the total number of students emailed for the post to 1029.

[6] Students had the option to leave demographic items blank or respond ‘prefer not to say’, so in some cases the totals from sub-populations will not sum to the total number of respondents

**TABLE 5. STUDENT INTERVIEW PARTICIPANT DEMOGRAPHIC INFORMATION**

| Interview method | # students | Gender | Engineering Majors | | | | Year | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Civil | Env | Mech | Aero | Jr | Sr | Grad |
| **Semi-structured** | 11 | M – 6 | 5 | 0 | 0 | 1 | 0 | 2 | 4 |
| | | F – 5 | 2 | 3 | 0 | 0 | 0 | 2 | 3 |
| **Survey focus** | 8 | M – 5 | 3 | 0 | 2 | 0 | 1 | 2 | 2 |
| | | F – 3 | 1 | 1 | 1 | 0 | 0 | 2 | 1 |
| **Timelines** | 6 | M - 4 | 1 | 0 | 3 | 0 | 0 | 3 | 1 |
| | | F – 2 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| **Total** | **25** | **M 15** | **9** | **0** | **5** | **1** | **1** | **7** | **7** |
| | | **F 10** | **4** | **4** | **2** | **0** | **0** | **5** | **5** |

Three different methods were used in conducting the interviews. The first set of interviews (11) used a semi-structured format with focused on questions around their motivation to study engineering, feelings about pro bono work, career aspirations, and sources of foundational beliefs around social responsibility. Eight more interviews used the EPRA tool as a discussion point where the student and researcher went through student responses and they explained why they responded as they did. This provided a topical springboard (and a physical element) to encourage conversation. The final six interviews used a timeline exercise adapted from Rappaport timelines, which were originally used to study how life histories influence perceptions of time (Rappaport, Enrich, & Wilson, 1985). For the timeline exercise, students were given a piece of paper with three lines on it, the top line representing a timeline up to them coming to college, the middle line representing a timeline from their entering college to now, and the last line was looking into the future. They were asked to mark three events on each line that influenced their view of engineering and the engineer they wish to become. They then discussed their responses. Many of these interviews also returned to the survey for additional discussion.

Data from these interviews were coded once using deductive coding methods where students' responses were coded with respect to a rubric addressing varying degrees of social responsibility for each of the eight dimensions of the PSRDM, and once using inductive coding methods where themes were allowed to emerge from the data. Appendix E shows the rubric which was used for the deductive coding and Chapter IV discusses how those results were used as evidence of validity for the EPRA tool. These data were also used in Chapter III to exemplify the development of different aspects of the PSRDM in engineering students. From the inductive coding approach, a code book was developed using three separate reviewers, the author, a professor, and an undergraduate research assistant. Each reviewer independently developed code books based upon four interviews. They compiled their code books, and then used the compiled code book to code four new interviews, adding any codes which were not already present. The final code book was then used by the author to code all twenty five interviews. Results from the inductive coding were not used for any of the chapters of this dissertation, but were used in other publications to look at correlations between religious beliefs and social responsibility (Canney & Bielefeldt, 2013b), and student views of the relationship between engineering and society (Canney, Bowling, & Bielefeldt, 2013). These interviews provided a significant amount of data, worth revisiting for future work in this area.

The following four chapters make use of these data in order to develop an understanding of the development of personal and professional social responsibility in engineering students. Each chapter recaps the relevant methods used for that particular study, but this section has been provided in order to give a more cohesive understanding of the data sources used for this study as a whole.

# Chapter III

# A Framework for the Development of Social Responsibility in Engineers

## Abstract

This paper presents the Professional Social Responsibility Development Model, which is a framework to help understand the development of personal and professional social responsibility in engineers. Social responsibility is seen as a foundational disposition that informs how engineers relate to many professional skills valued in engineering including ethics and the impacts of engineering on society. This framework is rooted in the Ethic of Care philosophy, and uses three realms to describe the development of social responsibility: the development of personal social awareness, the development of professional skills and how they relate to social considerations, and the connection between personal and professional views of obligation or responsibility. Qualitative data from interviews with engineering students are used to exemplify development in each realm. This conceptual framework is intended as a blueprint for developing studies and assessment instruments which examine the development or identification of social responsibility in engineers or other professionals.

**Keywords**: social responsibility; ethics; Ethic of Care; professional skills; developmental framework

## Introduction

Many of the problems that engineers are being asked to solve are becoming more and more complex, requiring cross disciplinary and cross cultural interactions, with the potential for having lasting impacts on society for many generations. History has shown, especially in global development work, that engineering solutions which are conceived and developed outside of a cultural or social understanding tend to fail (Easterly, 2006). Moreover, as we realize the potential for negative intergenerational effects, such as global warming, engineers with broader perspectives and skills are needed to develop and implement socially responsible solutions.

With this context in mind, engineering educators are trying to create curricula that foster the development of more holistic engineers. A holistic engineer possesses knowledge and skills beyond just technical skills (i.e. math, physics, engineering, etc.) to include professional skills such as an understanding of ethical and professional responsibility, an understanding of the broad impacts of engineering solutions, multi-disciplinary teamwork skills, and other non-technical skills (ABET, 2008). In contrast to most technical skills, many professional skills are developed in students throughout their lives, in and out of the classroom, before, during, and after college. Therefore, it is critical to hold long term perspectives on the development of these attributes, while simultaneously considering how the engineering educational system can positively contribute to that development. Studying the development of social responsibility allows us to examine the underlying foundation of many professional skills. Social responsibility is seen as an obligation that an individual (or company) has to act with care and objectivity, aware of the impacts of their action on others, able to see issues from the perspectives of others, and with particular attention to disadvantaged populations (Moriarty, 1995; Harvard Kennedy School of Government, 2008). Beliefs of social responsibility reside in the very ethos of an individual, and influence the ways in which students relate to critical professional skills such as ethics, an understanding of societal context, and global awareness.

Many professional engineering societies have voiced the need for more holistic engineers to deal with complex social issues of the future and have called upon the educational system to train that type of engineer. In the National Academy of Engineering's report *Educating the Engineer of 2020,* they call for a reinvention of engineering education to include more interaction with community and industrial partners, more diverse teaching methods such as service-learning, and an increased focus on engineering problems in developing countries (National Academy of Engineering, 2005). The ABET accreditation board establishes criteria for engineering programs to develop many skills, including the professional skills listed above, in their graduates (ABET, 2008). The bodies of knowledge (BOK) from both the American Society of Civil Engineers (ASCE) and the American Academy of Environmental Engineers include an understanding of the societal impacts of engineering solutions and ethical and professional responsibility (American Society of Civil Engineers, 2008; American Academy of Environmental Engineers, 2009). Furthermore, the ASCE BOK2 focuses on attitudes, in addition to knowledge and skills, with the understanding that "attitudes will affect how knowledge and skills are applied…" (American Society of Civil Engineers, 2008, p. 172). Included in their list of attitudes that are important for professional engineers are fairness, respect, consideration of others, sensitivity, thoughtfulness, and tolerance; all attributes of social responsibility. One of New Zealand's professional organizations, Engineers for Social Responsibility, has as an objective “to encourage and support social responsibility and a humane professional ethic in the uses of technology" (Engineers for Social Responsibility, n.d.nz). In Canada, the Ritual of the Calling of an Engineer charges engineering graduates to recognize the significance of their profession and the need to act ethically and with conscience in their practice (The Calling of an Engineer, 2013).

A greater sense of personal and professional social responsibility is believed to help foster these skills and attitudes in students, guiding them to use their engineering abilities appropriately to address many of the complex problems that face the world today. Through the lens of Ethic of Care (Gilligan, 1982; Nair, 2005; Held, 2006), social responsibility can also be used to examine issues of sustainability, environmentalism, humanitarian engineering, and professional ethics. For example, using social responsibility and Ethic of Care to examine sustainability would guide engineers to consider future generations more fully as stakeholders in the design process. Additionally, social responsibility could be a useful perspective to examine how increased attention to professional service may increase the attraction and retention of women and underrepresented minorities in engineering (Carberry, 2010; Wang, Patten, Shelby, Ansari, & Pruitt, 2012; Duffy, Barrington, & Heredia Munoz, 2011).

This paper presents a framework for the development of personal and professional social responsibility, called the Professional Social Responsibility Development Model (PSRDM). Other frameworks and assessment tools related to social responsibility are summarized. Additionally, Ethic of Care as the theoretical grounding for this framework is described, including how Ethic of Care informs the definition of social responsibility used for the PSRDM. Three other theoretical models which are foundational for the eight dimensions of this framework are also described. Finally, the eight dimensions relating to the three realms of the framework are described in detail to serve as a blueprint for future research studies or assessment instrument development. Samples from interviews with engineering students are provided as evidence of how a person may speak about the development of their views with respect to each of the three realms. It is worth noting that the framework presented here is for the development of social responsibility, not for the identification of an individual’s orientation towards social responsibility, though it may form a foundation for such work.

## BACKGROUND

The term 'social responsibility' has been used in many different ways in educational studies. Studies have used it to talk about democratic values (Smith & McKitrick, 2010), civic responsibility (Finley, 2011), ethical and moral reasoning (O'Neill, 2012), an awareness of the social and environmental effects of engineering designs (Lathem, Neumann, & Hayden, 2011), and, in terms of the lack of social responsibility, issues of unprofessional behavior such as academic cheating (Carter, 2011),. There are several tools that have been developed to examine social responsibility through these different perspectives, or to look at elements which may contribute to social responsibility. The Personal and Social Responsibility Inventory (PSRI) has been used to assess the institutional climate which could foster the development of social responsibility in students (Association of American Colleges and Universities, n.d.). The PSRI focuses on five dimensions of personal and social responsibility: 1) Striving for Excellence, 2) Cultivating Personal and Academic Integrity, 3) Contributing to a Larger Community, 4) Taking Seriously the Perspectives of Others, and 5) Developing Competence in Ethical and Moral Reasoning and Action. No study was found that used this tool to look specifically at engineering students. The Student Attitudes Survey focuses on student views of the roles and responsibilities of engineers in a global society, and was used to examine how curricular changes affected the development of social responsibility in civil and environmental engineering students (Lathem, Neumann, & Hayden, 2011). The Community Service Attitudes Scale (CSAS) uses a framework of altruistic behavior development to examine students' propensity towards service work, which could be seen as an element contributing to social responsibility (Shiarella, McCarthy, & Tucker, 2000). CSAS has been used to assess both engineering and non-engineering populations (Bauer, Moskal, Gosink, Lucena, & Munoz, 2007). This list is neither exhaustive, nor are the descriptions of each tool comprehensive, but the discussion serves to highlight that there are many different ways of conceptualizing social responsibility and many ways to examine each orientation.

For this study, we use a different conceptualization of social responsibility than the previously highlighted studies. We see social responsibility as both a value orientation and as a guiding principle for taking action. Our view of social responsibility focuses on feelings of obligation to help others as both a person and a professional, with a special focus on helping disadvantaged or marginalized populations. Social responsibility is seen as both personal and professional, where individuals can develop the personal and professional orientations independently and potentially to varying degrees. The PSRDM also addresses elements which enable the bridging and integration of personal and professional views of social responsibility.

## ETHIC OF CARE

With the definition of social responsibility used for this study, the Ethic of Care framework provides many useful elements to understand and enhance the PSRDM. Different from other moral theories which are based on fairness and justice, Ethic of Care focuses on the importance of relationships, broadly seen as the co-created connection between the "carer", one who provides care, and the "cared-for" (Noddings, 2003). Essential in Ethic of Care are practices of care and objectivity. Care focuses on the relationship between all parties involved and objectivity encourages an engineer to look outward in the design process, leading to more socially responsible practices.

Moriarty (1995) posited that adopting an Ethic of Care in engineering can provide engineers with a basis from which to balance the variety of values that they must address, including efficiency of design, technical needs, and environmental and social sensitivity. She also argued that "the practice of virtues such as care and objectivity by any professional as a professional should help to shape his or her whole character and, in particular, should help to shape for the engineering profession collectively a caring and objective group ethos. In turn, as the ethos of the engineering profession becomes more caring and objective, individual engineers, in drawing from this ethos and living up to it, will become themselves more caring and objective" (Moriarty, 1995, p. 76). This aligns with our view of social responsibility as both personal (individual) and professional (collective). Whereas Moriarty speaks about the cyclical influence of one to the other, our framework allows for disconnect between the individual and the collective, between the personal and the professional at the individual level. This has advantages at both the collective and the personal levels. At the collective level, this accounts for the situation in which individuals who have high social responsibility to remain isolated in the greater profession, working on engineering service activities on their own time with little or no institutional support. At the individual level, it seemed reasonable to consider the potential for a separation between one's views of personal and professional social responsibility. Interviews with engineering students confirmed this perspective where a few students, though very active in volunteer work, spoke directly about how they kept that separate from their views of engineering, intentionally compartmentalizing their lives with service in one bin and engineering in another.

Ethic of Care's focus on relationships also highlights the need for a wider view of stakeholders during the engineering design process, i.e., being aware of all groups that could be affected by the engineering work and, most importantly, engaging those groups in caring relationships throughout the design process. This relates well to the views of Humanitarian Engineering which is a framework focused on "the application of engineering skills or services for humanitarian aid purposes, such as disaster recovery or international development" (Campbell & Wilson, 2011, p. 2). Ethic of Care also parallels the Design Method and the Problem Solving frameworks which are traditionally used to describe the engineering process. It is stronger than these traditional frameworks towards developing more holistic engineers, however, because it "enables students to become aware of those non-technical dimensions of engineering and navigate through their intricate links" (Pantazidou & Nair, 1999, p. 205). The necessity of recognizing the many non-technical dimensions of engineering projects is central to our view of social responsibility because it focuses on identifying the needs of others and working with all affected parties to find appropriate solutions.

## Underlying Theoretical Models for the PSRDM

Three theoretical models more directly form the foundation for the PSRDM. Schwartz's (1977; Schwartz & Howard, 1982) altruistic helping behavior model identifies the moral and emotional development that leads to a person taking action to help others. This model formed the basis for the CSAS instrument mentioned above. Ramsey's (1993, 1989) model for integrating social responsibility into the decision process of scientists is used to describe the development of professional social responsibility. Delve, Mintz and Stewart (1990) developed the Service Learning Model based on five-phases of development for people who are already engaged in voluntary community service. This model later formed the basis for the Scale of Service Learning Involvement (Olney & Grande, 1995). Each of these three models is described in more detail below, as well as how they work together to form the PSRDM.

Schwartz's model uses five discrete phases in an accumulative process to describe the development of altruistic behavior. The first phase (*Attention*) contains three sub-phases which categorize 1) the development of an awareness that problems exist, 2) that action needs to be taken, and 3) that one has the ability to address those problems. In order to progress to the next phase, it is critical that the individual believes that they have the skills necessary to help others, allowing for the development of personal norms of motivation. The second phase is the

*Motivation* phase which relates to the activation of the one's value system in relation to taking or not taking action. In this phase, Schwartz differentiates between helping behavior and altruistic behavior by the source of the moral obligation that drives one to take action, either from a social norm or from a personal norm, respectively. This vision of moral obligation plays into the crux of our model whereby individuals feel a moral obligation to act because of their professional skills. The third phase is the *Anticipatory Evaluation* phase where the costs and benefits of engagement are weighed by the individual. The fourth phase is the *Defense* phase where an individual may "play down" moral obligation if the costs and benefits are seen as even, therefore upsetting the balance and leading to inaction. This phase only occurs if the costs and benefits from phase three are equal. The final phase is the *Behavior* phase where the decision to act or not act is executed based upon the results of phases one to four.

All five phases are used to support key dimensions in the PSRDM. While Schwartz's model thoroughly develops the stages of progression towards engaging in action, it stops at that point and does not distinguish between peripheral volunteering and deeply connected social engagement. This model also approaches feelings of obligation as general, but the PSRDM includes how one's professional association may also influence his/her development of moral obligation.

Ramsey's model is used in the PSRDM to tie the development of altruistic behavior to the scientific decision making process (Ramsey, 1993; Ramsey, 1989). This model uses six tenets as prerequisites for creating socially responsible and affective science students. These six prerequisites are: 1) identifying how science plays a role in social issues; 2) the ability to analyze issues, including identification of "key players" and how their beliefs and values will influence the solution; 3) the ability to use the scientific problem-solving process to examine the issue more holistically, including social, economic, political, legal and economic ramifications; 4) the ability to evaluate all the evidence gathered to determine the most effective solution; 5) using decision-making models to develop action plans to implement the determined solution; and 6) the ability to execute the plan if it aligns with the individual's value system.

Ramsey's model is not a developmental model as Schwartz's is, and it does not hold a defined linear, sequential relationship between the six tenets. There are, however, parallels between the attributes discussed by Ramsey and the different stages discussed by Schwartz. For example, tenet one, an ability to identify science-related social issues, is similar to the awareness of social issues addressed by Schwartz's first phase, but in

Ramsey's model it's specifically related to the involvement of science in social issues. Similarly, tenets three and five relate to one's ability to use scientific skills (problem-solving and decision-making models) and these parallel the ability sub-phase, also in Schwartz's first phase. Using Ramsey's six tenets, in combination with Schwartz's developmental stages, allows us to see how a science-based perspective can be incorporated into the development of social responsibility. In theory, examining the presence of all six of Ramsey's tenets would be important in assessing the development of professional social responsibility in an individual. Neither model, however, address the formative effects of actually engaging in the service of others. Delve et al.'s (1990) Service Learning Model is used to explain these effects, specifically the movement from peripheral to full involvement.

The Service Learning Model was developed to focus on community service as an essential aspect of developing strong social values. One of the three development models that the Service Learning Model is based on is Gilligan's Model of the Development of Women's Moral Judgment (Gilligan, 1982) which also formed a foundation for Ethic of Care. Delve et al.'s model was designed to measure the effects of service-learning educational interventions through five linear, sequential phases, with four key variables for each phase. The four variables are *Intervention* (mode and setting), *Commitment* (frequency and duration), *Behavior* (needs and outcomes), and *Balance* (challenges and supports). Progression through the five phases explains how engagement leads to a deepening commitment and identification with social issues. The first phase is *Exploration* where participants are eager to get involved, but are generally naïve about social issues and are perhaps motivated by external factors such as spending time with friends, or getting a free t-shirt. *Clarification* is the second phase where the individual is trying multiple service experiences, searching for a "good fit." The third phase is *Realization* where the individual begins to grasp larger truths about him- or herself and about service. Generally the individual begins to identify more strongly with a single population or issue in this phase. In the fourth phase, *Activation*, the individual begins to understand more fully the complexity and interrelatedness between their service experiences and larger social issues. The individual may start to become an advocate for the population being served at this phase. In the last phase, *Internalization*, the individual has fully integrated her/his service experiences into her/his daily lives. At this point, the individual is willing to adjust her/his life and career to better align with the personal views that were developed through deep engagement in service.

The five phases of Delve et al.'s model describe how involvement in service deepens one's connection with social issues, eventually providing a moral grounding that affects that person's life choices, such as a choice of career. In the PSRDM, this model is used to describe how engagement in engineering service can deepen one's sense of professional social responsibility by grounding their views of obligation in the social values developed through their action.

The PSRDM draws from all three of these models to explain the development of both personal and professional social responsibility through stages of: recognition that problems exist, an awareness of an ability to act, feelings of moral obligation to act, evaluation of costs and benefits, taking action, and into the five stages of deepening personal and professional social responsibility. Schwartz's model provides a basis to talk about how an individual develops feelings of obligation to help others, leading to some form of action or inaction based upon those beliefs. Ramsey's model provides a roadmap for how to include social issues into the engineering design process. Relating to Schwartz's model, using Ramsey's model helps allow the integration of the development of moral obligation with the engineering design process through a recognition of the impacts of engineering on society, and a belief that a broader range of social perspectives are necessary for successful engineering projects. Finally, the Service Learning Model from Delve et al. provides a way to discuss the moral grounding that occurs through engagement in service, and how engineering service can further develop social responsibility. Schwartz's model lacks a discussion of the effects of engaging in service, and Ramsey's model lacks the continued personal growth that occurs once an individual adopts a wider, more holistic perspective of design. The Service Learning Model addresses how engaging in service further develops both the individual and professional sense of obligation to help others in a cyclical fashion. By combining the three models we can discuss the development of personal and professional social responsibility within the context of the engineering profession, including how engagement in engineering service can deepen one's sense of moral obligation to help others.

## THE PROFESSIONAL SOCIAL RESPONSIBILITY DEVELOPMENT MODEL

The PSRDM uses three realms to address the development of social responsibility: Personal Social Awareness, Professional Development, and Professional Connectedness. The Personal Social Awareness realm describes the development of feelings of moral obligation to help others separate from one's professional identify and draws from the *Attention* and *Motivation* Phases in Schwartz's model. The Professional Development realm describes the development of professional abilities, with a focus on how those abilities could be used to help others. This realm draws from all six of Ramsey's tenets and from the *Attention* Phase of Schwartz's model. The Professional Connectedness realm describes how a moral obligation to help is tied to one's professional identity and how engagement in service influences that feeling of obligation. This realm combines Schwartz's *Motivation* and *Costs and Benefits* Phases with Ramsey's model and draws from Delve et al.'s model to characterize the personal development that occurs through engaging in service. Three dimensions comprise both the Personal Social Awareness and the Professional Development realms. The Professional Connectedness realm results from the combination of the first two realms and is a cyclical pathway whereby taking action leads to more developed personal and professional social responsibility. The development and relationships between these three realms was influenced by qualitative and quantitative data, discussed in the following sections. The PSRDM is shown in Figure 1.

Though this model describes the development of social responsibility, it is important to note that the progression within each realm, through each dimension, is not a strictly linear or stage-like process. For the purposes of this paper, and the framework at large, dimensions are discussed separately, but are also hypothesized to be related to one another. Evidence for the relationships between dimensions is presented. Future work will gather evidence to examine the developmental relationships between different dimensions and levels within each dimension, but at present, such evidence is not available.

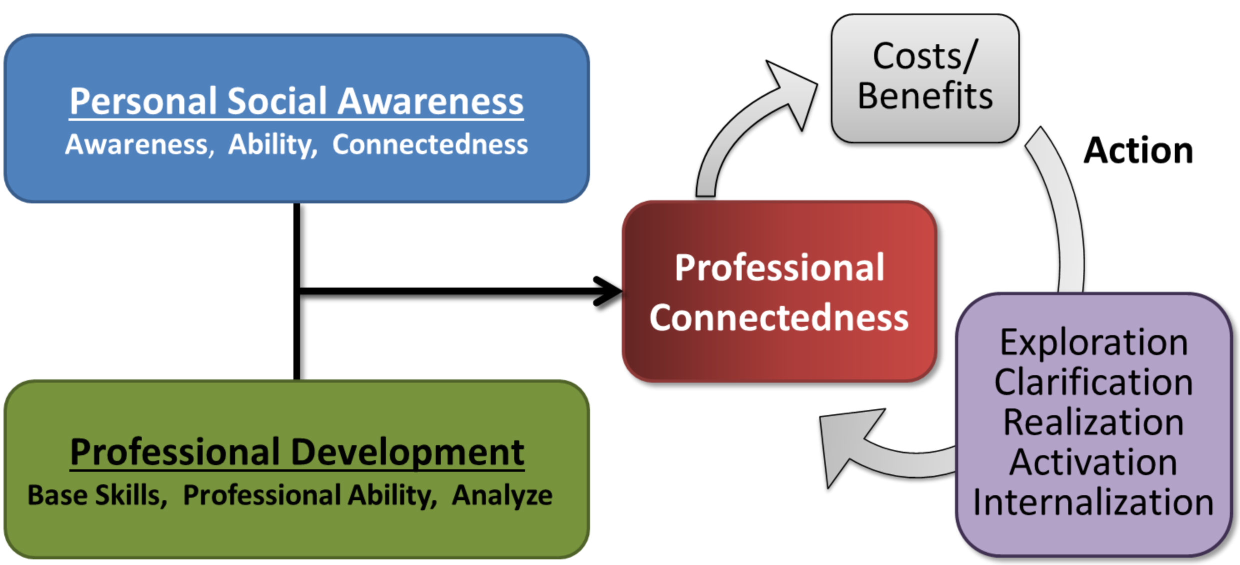



**FIGURE 1. PROFESSIONAL SOCIAL RESPONSIBILITY DEVELOPMENT MODEL**

In addition to providing descriptions of each dimension, quotes from a series of in-depth interviews with engineering students are given related to the influences on each of the three realms. Twenty-five semi-structured interviews were conducted primarily with senior (n=12) and graduate (n=12) engineering students in Mechanical (n=7), Civil (n=13), and Environmental (n=4) programs. One Civil Engineering student was a junior and one graduate student was in Aerospace Engineering. Fifteen of the interviewees were males and ten were females. Students were solicited through contacts with professors in each department who were asked to provide names of students who they felt represented a range of beliefs and experiences with respect to social responsibility (see (Canney, Bowling, & Bielefeldt, 2013) for more details about the interviewees' demographics, selection process, and interview formats). Interviews lasted about one hour and no incentives were provided.

The original purpose of the interviews was to understand what students believed their personal and professional social responsibilities were and what life experiences had informed those beliefs. Interview questions focused on why students chose engineering as a major, their career aspirations, how they defined social responsibility, their views of the role of an engineer in society, and what life experiences formed the foundations of their views of personal and professional social responsibility. Prior to each interview, students were asked to take a written survey related to personal and professional social responsibility in engineering. Questions from this survey became topics of discussion in some of the interviews. Deductive coding was used to analyze the interview data, drawing from definitions of each dimension which were developed with a panel of experts in engineering and engineering education. Two reviewers coded each interview for evidence supporting students' views and development of each of the eight dimensions. Samples from three of these coded interviews are used as evidence for how students speak about these different realms, and about life experiences that influenced those students' views. Pseudonyms are used for each student, consistent with IRB protocols.

### PERSONAL SOCIAL AWARENESS REALM

The Personal Social Awareness realm describes the development of altruistic behavior, paralleling Schwartz's model for altruistic behavior development. The first dimension is *Awareness* and addresses an awareness that others are in need. *Awareness* includes both knowledge of people or groups who are in need, and also of the relationships and interconnections between complex social issues and those in need. The development of *Awareness* could come from external sources such as friends, media, the news, school, or from personal experiences, such as volunteering at a soup kitchen or helping a family member with a disability.

The second dimension is *Ability* where one recognizes that he/she has the ability to do something to help others who are in need. Factors which could influence the development of *Ability* include: observing others who take action and believing that one could as well, support from family, friends, or mentors that one could be affective, or reflecting upon past experiences and believing that the individual did have an effect. All of these influences could build an individual's belief or confidence that he/she could have a positive effect in the future.

The third dimension of the Personal Social Awareness realm is *Connectedness*, a term that comes from the CSAS model, and addresses a feeling of moral obligation to help others. The development of *Connectedness* is rooted in Schwartz's use of personal or social norms as motivators. For this dimension motivations could come from a wide variety of sources, either external or internal, such as religion, just for fun, social guilt, or a sense of spiritual, civic, or moral obligation. In the Personal Social Awareness realm there is no relation to one's professional skills, and this realm could describe the development of social responsibility in any person.

*Qualitative Evidence Related to Influences on the Personal Social Awareness Realm*: Owen was a graduate student in Aerospace Engineering. He completed his undergraduate education at a liberal arts school, finishing with an English degree. After graduating, he went and worked at a public mental health facility and spoke of that experience in relation to influences on his views of social responsibility. He said,

> "… there was a guy who was the same age as me, who was really intelligent and he'd read all of the science magazines I brought. He was deeply, deeply mentally ill, like very strong schizophrenia and the medications required to keep him under control would make him sleep twenty hours a day. And I remember just watching this guy, you know, he was only a couple years younger than me… and so it really struck home to me that just for a very small chance that I had no control of, I could be in his position."

Owen spoke about many personal experiences like this one which helped him to recognize that there are others who need help, developing both his awareness of needs and in seeing ways in which he could help others. When Owen was asked to describe what social responsibility meant to him, he responded,

> "Simply put, it's the responsibility we have for the privileges that we've received. I think a lot of progressives talk about this, though I don't really put myself in the camp, but they point out that most of us, you and me for example, are here because we have all sorts of advantages that have been given to us. Least of which is being born in the United States where we have schools and roads and all sorts of stuff. And we have a responsibility to make use of those advantages in a way that helps everyone else… to recognize that we don't deserve the benefits that we have necessarily. It's that we should act according to that. That's how I define social responsibility."

Here we see how Owen is describing the source of his feelings of moral obligation. He believed that he had social benefits which were gained through no effort of his own, and that this brought with it a responsibility to use those advantages to help others. Later in the interview, he spoke about how this feeling of obligation, combined with his experiences at the mental health facility and other personal life events, led him to strive for an "empathetic realization" that there are social problems which need to be addressed. In Owen, we see how his Personal Social Awareness has developed because of personal interactions with others who are disadvantaged and how his beliefs have developed to include the recognition of personal advantages, leading to a belief in the responsibility for him personally to "act accordingly" to help others.

## Professional Development Realm

The Professional Development realm addresses the development of professional skills in relation to the need to solve social problems. Our view of professional development with respect to social responsibility aligns closely with Vanasupa et al.'s definition as "the responsibility of engineers to carefully evaluate the full range of broader impacts of their designs on the health, safety and welfare of the public and the environment" (Vanasupa, Slivovsky, & Chen, 2006, p. 374). The Professional Development realm consists of the three dimensions described below.

The prerequisite for engaging in action as a professional is the development of *Base Skills*, which is the first dimension in this realm and encompasses the trade-specific skills necessary to be, for example, an effective engineer. An acknowledgment of the need to achieve a balance of both technical and professional skills is critical in the development of base skills with respect to social responsibility. In the simplest case, these skills would be developed through traditional educational systems, internships, or through the practice of engineering. Mentors who would teach and exemplify a larger understanding of the engineering profession would be critical agents for the development of base skills in this way.

The second dimension is *Professional Ability* which addresses the recognition that one's professional skills give them the ability to help others. In engineering, this includes recognition that engineering solutions have the ability to help solve social or environmental problems that face society. Similar to *Base Skills, Professional Ability* could develop through exposure by mentors or through personal experiences to understand the ways in which engineering could positively affect society and contribute to solutions for complex social issues.

The third dimension is *Analyze* which addresses the ability to examine social issues from a professional perspective. This dimension is characterized by views of who the stakeholders are for engineering projects and how they should be involved in the decision making process. The elements which would aid in the development of this dimension are similar to the other dimensions in this realm.

Combined, this path describes the progression of a professional from the development of skills to a recognition that those skills give her/him a unique ability to help others. As shown in Figure 1, the Personal Social Awareness and Professional Development realms run in parallel, each possibly developing independently. The bridging between these two is Professional Connectedness, described in the third realm.

*Qualitative Evidence Related to Influences on the Professional Development Realm:* Beau was a senior Civil Engineering student who had two consecutive internships working on civil projects in rural Alaska. In one of those summers, he was involved with "the business side of engineering… go[ing] out to villages and taking surveys, asking people how their plumbing and sewage systems were…" This experience exposed Beau to a wider view of engineering, to include more business applications such as grant writing and surveying those affected by his work, aiding in the development of his *Base Skills*.

These internships also influenced his development of *Professional Ability*. He said, "…those bush Alaska villages are like 50 years behind the rest of the country, so it's really interesting to see how those [water and wastewater treatment plants] affected life in those villages." This exposure showed him directly how engineering projects could have a tremendous effect on solving social issues, specifically improving the quality of life in rural Alaskan villages.

Beau talked about a different experience that seemed to influence his views of *Analyze*. He described a class experience where they visited a large construction site in a neighborhood setting, saying,

> "…we met with the project manager for these buildings… and that was pretty interesting because the project manager is in charge of a lot of non-engineering related things. There's a lot of houses neighboring the construction site and they're dealing with those people, whether they wanted the noise down, or construction at certain times…so that was another good example of seeing how engineering projects can relate to the community."

Beau spoke about valuing the "non-engineering" skills and gave good examples of how the community needed to be involved in many engineering decisions in order for the project to be successful. Through his exposure to the construction site, and the project manager as a sort of mentor, he began to see the importance of a larger view of stakeholders for construction projects.

## PROFESSIONAL CONNECTEDNESS REALM

The Professional Connectedness realm is characterized by a cyclical process centered on a sense of moral obligation to help others because of the professional skills that one possesses (*Professional Connectedness*). The combination of the Personal Social Awareness and the Professional Development realms support the development of moral obligation in relation to professional abilities. Some elements of *Professional Connectedness* would include public safety, environmental protection, pro bono work, and viewing engineering projects as service. A person's engineering identity would also be affected by their views of professional moral obligation, influencing the type of engineer they intended to be in society.

Similar to the Service Learning Model, the PSRDM holds that increased *Professional Connectedness* occurs through action, specifically service engagements as engineers. The cyclical nature of this realm is based in the consideration of C*osts and Benefits* of engaging in action, and then progressing through the deepening levels of relationship with social issues. This cycles the participant back, but with a potentially higher sense of moral obligation into the *Professional Connectedness* dimension. As an individual engages in more action, he/she would move further in the stages of the Service Learning Model and therefore deeper in *Professional Connectedness*, meaning that he/she would develop stronger beliefs of personal and professional social responsibility. The *Costs and Benefits* dimension addresses both how an individual views service work, but also the degree to which he/she recognizes the various costs and benefits and how that affects his/her decision to act or not.

*Qualitative Evidence Related to Influences on the Professional Connectedness Realm:* Laura was a graduate student in Environmental Engineering. She strongly tied her desire to serve communities with her abilities as an environmental engineer. She said, "I see my responsibility [as an engineer] as making their community better or safer through remediation, providing them with an environment that is less polluted." When she was asked about factors which influenced this desire, she pointed to many volunteer opportunities she had taken in high school and college. She also talked about a course in water and sanitation which "really opened [her] eyes" to many of the environmental issues which affect developing communities.

Speaking both to her *Professional Connectedness* and recognition of the *Costs and Benefits*, she said,

> "I just feel like engineering is different, I view it as like my job is doing something that is socially good. So I feel like it's different than my boyfriend [who is] a finance major, and there's part of me that just doesn't understand, like, it's basically just to make money… I don't know, it's just like the social responsibility is really different. A lot of engineers, especially Environmentals, I think, just really wanted to do good and to make a difference. And that's why we got into it. Like we're good at math and science, and we don't care about the pay as much. We want to do good things. I think a lot of us could've been [Chemical Engineers] and worked for oil companies if we wanted, but there's a reason we didn't. And I think that's a part of what I feel like social responsibility is, using my job to make a difference."

For Laura her identity as an engineer was directly tied to her ability and responsibility to help others by repairing and protecting the environment, giving evidence to her views of *Professional Connectedness*. Also, through her development of *Professional Connectedness*, she was willing to accept some sacrifices (pay) in order to connect her identity of service to her identity as an environmental engineer.

The PSRDM has been developed and revised through several interactions. The initial conception of the Professional Connectedness Realm was a linear, sequential progression through the stages of the Service Learning Model. After conducting interviews and looking at initial survey items to address each dimension, we found that the boundaries between each stage were blurred and it was difficult to develop survey items to uniquely address each sub-stage. Also, each stage ultimately related back to the idea of one's feelings of obligation to help others as a professional. Therefore we changed the professional connectedness realm to reflect the current cyclical understanding to support the idea that action ultimately increases overall feelings of professional connectedness, and that all the stages of the Service Learning Model could reside in that dimension.

## CONCLUSIONS

There is a need in the engineering profession for more holistic engineers who use and value a diverse range of skills, both technical and professional. Views of personal and professional social responsibility could provide a solid foundation from which those skills and perspectives develop. The framework presented here, the PSDRM, provides a blueprint from which to understand the development of personal and professional social responsibility in engineers. Rooted in the Ethic of Care, this framework helps to advance the understanding of the role of the engineer in society and how the virtues of care and objectivity can better enable engineers to work on complex social problems in responsible and sustainable ways. As a foundation for future studies and the development of assessment tools, the PSRDM will aid engineering educators to create and assess educational interventions to help develop more socially responsible engineers, emphasizing the importance of many professional skills such as ethical development and the understanding of the impacts of engineering decisions on society.

## FUTURE WORK

The framework presented in this paper is intended as a blueprint for future work that would examine the development of social responsibility to include professional skills and abilities, and to develop methods to identify an individual's levels of social responsibility. Efforts are currently underway to develop a survey instrument to identify degrees of agreement with each dimension, as well as factors which may influence the development of social responsibility in engineering students. This framework is also being used to examine the effects that engaging in engineering service as students has on their long term career pathways as engineering professionals. It could also be used for longitudinal studies, to examine the ways in which students or professionals develop in each realm, relating that development to educational, professional, or other life experiences. In this way, educational interventions aimed at increasing social responsibility could be designed.

## ACKNOWLEDGEMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1158863. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. Additional funding was provided through an institutional fellowship for Excellence in STEM Education.

# CHAPTER IV

# DEVELOPMENT OF THE ENGINEERING PROFESSIONAL RESPONSIBILITY ASSESSMENT TOOL TO MEASURE SOCIAL RESPONSIBILITY IN STUDENTS


## ABSTRACT

BACKGROUND – The development of social responsibility is an important step towards educating more holistic engineers, able to work across social and cultural bounds to solve complex social issues. In order to examine the effectiveness of educational interventions at increasing engineering students' sense of social responsibility, an instrument is needed to gauge degrees of social responsibility.

PURPOSE/HYPOTHESIS - This paper presents the development, reliability, and validity of the Engineering Professional Responsibility Assessment (EPRA) tool, which was designed to identify students' degrees of social responsibility. EPRA operationalizes the Professional Social Responsibility Development Model theoretical framework, which describes the development of personal and professional social responsibility in engineers. This tool is intended to assess curricular interventions, such as service-learning experiences throughout a program, to examine changes in students' views of social responsibility.

DESIGN/METHOD – EPRA is an instrument which was developed through an iterative series of field tests. Data from first-year, senior, and graduate students in Civil, Environmental, and Mechanical Engineering at five universities were used to provide evidence of internal reliability using Ordinal Alpha, and validity evidence based on internal structure, how Likert-items relate with other elements of EPRA, and in-depth interviews with 24 engineering students related to views of social responsibility.

RESULTS – Evidence of reliability and validity are presented, which give good support for appropriateness of EPRA to measure degrees of social responsibility in engineering students at this developmental stage.

CONCLUSIONS – Preliminary evidence of reliability and validity support the EPRA as a tool to measure social responsibility in engineering students, but further work and development are necessary to strengthen this instrument.

# INTRODUCTION

## BACKGROUND

Since the development of modern engineering, engineers have contributed significantly to increasing the quality of life in nearly every aspect of society, including public health, public safety, manufacturing, transportation, housing, and food production. There are still, however, major issues affecting society which deserve more attention from the engineering profession, namely issues of poverty and underdevelopment, social equity, environmental degradation, sustainability, and the development of public policy (Catalano, 2007; American Society of Civil Engineers, 2008). There is a need for current and future engineers to acknowledge and act upon their ability to contribute to solutions for these issues. One dimension in which the role of the engineering is being re-envisioned is through increased personal and professional social responsibility, seen as "an obligation that an individual (or company) has to act with care and objectivity, aware of the impacts of their action on others, able to see issues from the perspectives of others, and with particular attention to disadvantaged populations" (Canney & Bielefeldt, 2013). Increased social responsibility could manifest itself in the engineering profession through increased pro bono work (Titus, Zoltowski, & Oakes, 2011), more professional service (Passino, 2009), or a wider view of sustainability to include "…areas of social equity, equal rights for development, democracy, public participation and empowerment…" (Fenner, Ainger, Cruickshank, & Guthrie, 2006, p. 147).

In response to these societal needs, many professional engineering organizations have called for a new view of the engineer's role in society (American Society of Civil Engineers, 2008; National Academy of Engineering, 2005; American Academy of Environmental Engineers, 2009). The new vision of what an engineer should be encompasses technical competency, business knowledge, teamwork skills, cross-cultural understanding, and a litany of personal attributes, including "commitment, confidence, consideration of others, curiosity, entrepreneurship, fairness, high expectations, honesty, integrity, intuition, judgment, optimism, persistence, positiveness, respect, self-esteem, sensitivity, thoughtfulness, thoroughness, and tolerance" (American Society of

Civil Engineers, 2008, p. 148). Many of these skills and attributes are rooted in wider visions of the role of the engineering profession in society, namely, increased social responsibility.

Towards creating future engineers with the skills and outlook necessary to meet these challenges, some engineering education programs have developed curricular or extracurricular interventions that promote a wider vision of engineering. Through departmental reform grants from the National Science Foundation (NSF), the entire College of Engineering at the University of Massachusetts – Lowell and the Civil and Environmental Engineering department at the University of Vermont strategically implemented service-learning projects throughout their four year programs, with the aim of increasing student social responsibility (Duffy, Barrington, West, Heredia, & Barry, 2011; Lathem, Neumann, & Hayden, 2011). Twenty four programs at American universities were highlighted as "education with conscience", teaching engineering students how to work for global development (Goodier, 2013). Other programs such as Purdue University's Engineering Projects in Community Service (EPICS Program & Purdue University , 2013), Stanford's Design School (Stanford University Institute of Design, 2013), and MIT's D-lab (Massachusetts Institute of Technology, 2013) push students to have meaningful experiences that enable the development of empathy and recognition of the myriad ways they can have positive impacts on society. Additionally, the rapid growth of Engineers Without Borders (EWB) across the country may evidence students' attraction to this type of engineering work, and could provide another avenue to positively affect students' social responsibility. The Engineering Professional Responsibility Assessment (EPRA) tool was designed to identify students' degrees of social responsibility towards assessing the effectiveness of programs such as these.

## LITERATURE REVIEW/THEORETICAL BASIS

The EPRA tool identifies engineering students' degree of social responsibility aligning with the eight dimensions of the Professional Social Responsibility Development Model (PSRDM) (Canney & Bielefeldt, 2013). The PSDRM is a framework to help understand the development of personal and professional social responsibility in engineers and is rooted in the Ethic of Care framework (Gilligan, 1982; Held, 2006). It consists of three developmental realms: Personal Social Awareness, Professional Development, and Professional Connectedness. The Personal Social Awareness realm describes the development of a feeling of moral or social obligation to help others. The Professional Development Realm focuses on the inclusion of social considerations and understanding social context in the engineering design process. These first two realms can develop independent of one another. The final realm, Professional Connectedness, is a cyclical path whereby these realms merge and one's professional obligation or responsibility to help others is enhanced through weighing costs and benefits and engaging (or not) in forms of service. Taking action has the potential to increase an individual's professional social responsibility, helping him/her to gain a deeper understanding of the need and ability for engineers to help solve social issues, and completing the cycle. The PSRDM holds that engagement in engineering service would increase professional social responsibility in a similar manner (Canney & Bielefeldt, 2013), drawing from the Service Learning Model to develop that relationship between service and social responsibility development (Delve, Mintz, & Stewart, 1990).

Each of the three realms of the PSRDM contains sub-realms, or dimensions, which describe the development of each perspective. Definitions for each of these eight dimensions are given in Table 6. The questions for EPRA were developed to measure these eight dimensions to provide evidence for an individual's degree of social responsibility.

**TABLE 6. DEFINITIONS FOR DIMENSIONS OF PSRDM**

| Realm | Dimension | Definition |
|---|---|---|
| **Personal Social Awareness** | *Awareness* | An awareness that others are in need |
| | *Ability* | A recognition that one has the ability to help others |
| | *Connectedness* | A feeling of moral obligation, responsibility, or social requirement to help others |
| **Professional Development** | *Base Skills* | With an expectation that all engineers value the technical skills, this dimension focuses on views of professional skills (i.e. communication, lifelong learning, teamwork, management, ethics, professional responsibility, understanding social and global impacts of engineering, etc.) and the role that they play for a professional engineer. |
| | *Professional Ability* | A recognition that engineers or the engineering profession has the ability to help others and/or solve social issues |
| | *Analyze* | A recognition of the importance of including social aspects in the engineering process, including community feedback, a broad sense of stakeholders, etc. |
| **Professional Connectedness** | *Professional Connectedness* | Addresses issues of responsibility or obligation that an engineer or the engineering profession may have to help solve social problems or help others |
| | *Costs/Benefits* | Discussion of the costs and/or benefits associated with engaging in socially responsible behavior, such as service. |

A key element for the development of both personal and professional social responsibility in the PSRDM is engaging in the service of others. One way in which this has been implemented in the classroom is through Service-Learning (SL) which ties course learning objectives to real world service projects with community partners. Research of the effects of SL have shown that students across disciplines who engage in SL have an increased understanding of civic and social responsibility, awareness of the world, and increased academic, personal and professional advancement (Astin, Vogelgesang, Ikeda, & Yee, How Service Learning Affects Students, 2000; Ariely, Banzaert, & Wallace, 2005; Ejiwale & Posey, 2008; Bielefeldt, 2006; Eyler, Giles, Stenson, & Gray, 2001). In a review of studies on the effects of SL, Kezar (2002) noted that SL has been associated with increased cultural awareness, acceptance of diversity, altruistic attitudes and social development (self-esteem, social self-confidence, public speaking and meeting people) in students. The reflection inherent in true SL also helps students to understand the role of engineering in the context of larger social issues (Oakes, 2009) which is a critical component in the development of social responsibility. Other benefits of SL in engineering, which may be associated with social responsibility, include greater attraction and retention of women and underrepresented students to engineering (Carberry, 2010; Duffy, Barrington, & Heredia Munoz, 2011). While SL is specific to service within a class, it is believed that extracurricular service activities, such as EWB, can have similar positive effects on students' development of social responsibility (Amadei & Sandekian, 2010; Litchfield & Javernick-Will, 2013). Because engagement in service is a critical aspect of advancing one's social responsibility in the PSRDM, EPRA contains questions which focus on participation in volunteer activities, service-learning, and extracurricular service.

## Study Goal

The PSRDM was operationalized in the current project through the development of the EPRA tool, towards measuring degrees of personal and professional social responsibility in engineering. This claim was supported by examining how the degrees of difficulty for different items on the tool correspond with the theorized developmental progression, and by examining correlation between the 50 Likert-items used to measure the eight dimensions with participants' views on social responsibility obtained through alternative means. Towards this end, Multidimensional Item Response Theory (MIRT) (Wilson, 2005) was used to explore item difficulty in relation to the theoretical basis, specifically multidimensional Rasch modeling. External sources were used to correlate student scores for the Likert-items to in-depth interviews, self-reported volunteer activities and frequencies, and student perspective of important attributes of their future careers. Data from a multi-institution assessment were used in the process of developing evidence of reliability and validity. Together, these pieces of evidence support the claim that this tool is appropriate to measure degrees of social responsibility.

# METHODS

The development of EPRA took place through two phases: 1) a pilot administration at a single institution, targeting specific courses over a variety of majors and ranks, and, 2) a wider field test at five diverse institutions, targeting specific majors and academic ranks, labeled as the Tier 1 field test. Data from the pilot distribution were used for preliminary development of EPRA through an iterative process, and data from the Tier 1 distribution were used to provide evidence of reliability, construct validity, and external validity for the instrument. In addition, semi-structured interviews were conducted with 25 engineering students and the results were correlated with survey responses as additional evidence of validity. The context, procedures, and description of participants are given for each of these three data sources.

## SURVEY – PILOT STUDY

PROCEDURES – Trial versions of EPRA were distributed to selected engineering courses at a large, public university during the 2011-2012 academic year. In total, five distributions were conducted, guiding four iterations of the EPRA development. Primarily, paper copies were given to students, who had time in class to complete them. No incentives were provided to students and approval for all recruitment, advertising, and survey documents was obtained from the Institutional Review Board (IRB) for human subject based research. Surveys were discarded if students failed to complete the IRB consent form, or if they failed to properly answer a "check" question where students were asked to mark "3" on a specific question.

PARTICIPANTS – In total, 1279 surveys were completed. Students from all academic ranks and many engineering majors were surveyed. The total sample population, combined from all five distributions, is given in Table 7.

ANALYSIS – This data set was used in the preliminary development of EPRA, mainly through Cronbach's Alpha for examining internal consistency. A preliminary examination of construct validity using Component Factor Analysis was done using this data set (Canney & Bielefeldt, 2012), but this method of analysis for validity was later determined to be inappropriate because of the Likert-items from this tool, and the extreme non-normality in response distributions for many of the survey items. For these and other reasons, Multidimensional Item Response Theory (MIRT) (Ackerman, Gierl, & Walker, 2003; Wilson, 2005) was used to examine construct validity for the study presented here. Additionally, Rasch models allowed for the testing of *a priori* expectations of item ordering and difficulty, based upon the underlying theoretical model.

**TABLE 7. SURVEY PARTICIPANT DEMOGRAPHICS BY DISTRIBUTION**

| Demographics | | Total Pilot Study | Tier 1 Pre- |
|---|---|---|---|
| **Total** | | **1279** | **1000** |
| **Gender** | Male | 829 | 657 |
| | Female | 377 | 310 |
| **Major** | Civil Engr. | 529 | 262 |
| | Environmental Engr. | 380 | 474 |
| | Mechanical Engr. | 135 | 182 |
| | Other Engr. | 232 | 60 |
| **Rank** | First-year | 311 | 236 |
| | Sophomore | 247 | 70 |
| | Junior | 298 | 13 |
| | Senior | 217 | 344 |
| | Graduate | 170 | 315 |
| **School** | Large Public U | 1279 | 319 |
| | Engineering U | - | 317 |
| | Mid-Private U | - | 148 |
| | Small Research U | - | 109 |
| | Military U | - | 107 |

## SURVEY – TIER 1

PROCEDURES – The survey resulting from the four iterations of the pilot study was used in the Tier 1 field test to engineering students at five diverse universities. The five universities used for the Tier 1 field test were chosen because 1) they had differing institutional characteristics, summarized in Table 8, 2) each institution had programs or curricula which included some form of engineering service, and 3) there were faculty members at each institution who were willing to help with the survey distribution, providing access to student emails. The service elements at each institution were important because of the centrality of service as a mechanism to increase social responsibility in the PSRDM. Large Public U was the institution also used in the pilot study.

**TABLE 8. CLASSIFICATIONS OF TIER 1 INSTITUTIONS**

| ID | Control | Carnegie Classification |
|---|---|---|
| **Large Public U** | Public | High undergraduate, large 4-yr, primarily nonresidential, RU/VH |
| **Engineering U** | Public | High undergraduate, Medium 4-yr, primarily residential, RU/H |
| **Mid-Private U** | Private, not-for-profit | Majority undergraduate, Medium 4-yr, highly residential, RU/VH |
| **Small Research U** | Public | High undergraduate, Large 4-yr, highly residential, RU/H |
| **Military U** | Military Academy | Exclusively undergraduate, Medium 4-yr, highly residential, Bac/A&S |

EPRA was sent electronically to all students for the Tier 1 distribution using the online platform, Survey Monkey. Faculty members working with the research team distributed the survey at their respective institutions through departmental email lists to the targeted student populations: first-year, senior, and graduate students in Civil, Environmental, and Mechanical Engineering. At Military U, students do not declare a major until mid-way through the sophomore year, and it was not possible to mass distribute the survey to all first-year students, therefore sophomore students who had expressed interest by signing up on departmental lists in any of the three targeted majors were solicited. In addition to emails, faculty members visited classes where a majority of the student population would be, such as introductory engineering or senior capstone classes, and gave a verbal pitch about the survey, explaining the study, and asking students to participate. At Small Research U, the Mechanical Engineering first-year students were accidentally omitted from the study, never receiving an email with a link to the survey. Students who completed at least 90% of the survey received a $5 gift card, with the potential for another $10 gift card for completing the post- survey, sent out eight months later. Students at Military U were prohibited from receiving any incentives due to the military affiliation of that institution.

PARTICIPANTS –In total, 1000 students completed at least 90% of the pre- survey, including consent and properly answering the "check" question described above. The demographic breakdown of the Tier 1 pre- participant population is shown in Table 7. Even though departmental lists only for first-year, senior and graduate students were used (except at Military U), some students self-reported as sophomores (17) or juniors (13). For the purpose of reliability and validity, these surveys were left in the data set. Senior standing included fifth year seniors as well, and the 'graduate' designation applied to both masters and doctoral students.

ANALYSIS – The Tier 1 data set was used to examine internal reliability through both Cronbach's Alpha and Ordinal Alpha (Gadermann, Guhn, & Zumbo, 2012; Zumbo, Gadermann, & Zeisser, 2007). It was also used to examine construct validity through MIRT. Finally, this data set was used to examine external validity by comparing the Likert-item scores to other elements of EPRA, including student self-reported volunteer activities and a career attributes question where students placed value on different attributes with respect to their future careers in engineering.

### INTERVIEWS

PROCEDURES – Interviews with students were conducted in the Spring 2012 semester, after the third iteration of EPRA in the pilot study and were used as a source of validity evidence. Without prior consent, previously taken surveys could not be used to find students to interview, therefore the research team approached professors from different departments at Large Public U, asking them to recommend students to talk to who would represent a wide range of beliefs and experiences regarding the development of social responsibility. Using these recommendations, students were emailed and asked to participate in an interview; 25 students agreed. Before each interview, students read and signed an informed consent form, consistent with IRB protocols, and were asked to take the EPRA survey. After completing the survey, the interview commenced, and would last another 20 to 45 minutes. Interviews were recorded and later transcribed for analysis. No incentives were provided to the students in exchange for their participation in the interview.

Three different interview methods were used to elicit relevant information from these students. The first method was a semi-structured format where students were asked questions regarding why they chose engineering as a major, their ideal future career, how they saw engineering contributing to society, their views on pro bono work, their definitions of social responsibility, and life experiences that had influenced their views of social responsibility. The second method used their responses to EPRA questions as a guide for conversation. Students were asked to lead the researcher through their survey responses, describing their general views regarding certain questions, what examples or experiences influenced their responses, or to explain why they selected a given response over others. This format was chosen because it provided a guide to help stimulate conversation in a more tangible way than the semi-structured method did, which seemed to help the engineering students to open up and share more. The final interview method used a variation on Rappaport timelines (Rappaport, Enrich, & Wilson, 1985) to guide conversation. Students were given a piece of paper with three lines drawn on it. The top line represented a time continuum leading up to their coming to college, the second line represented the beginning of college to the present, and the third line represented the future. Students were asked to write down at least three events on each line which influenced their choosing engineering, their view of engineering, and what they hoped to do as an engineer, respectively.

PARTICIPANTS – Twenty five students from Civil (13), Environmental (4), Mechanical (7) and Aerospace (1) Engineering were interviewed. All of the students were upperclassmen (One junior, 14 senior, and 14 graduate students) and were generally very active students in curricular and/or extracurricular activities; a result of the recruitment method. This was expected because the students who faculty would most likely know would be the most active or outgoing students. Ten of the interviewees were women and 15 were men.

ANALYSIS –To relate the interviews to the survey, a rubric was developed to help identify both when a person was talking about a certain dimension of the PSRDM and different degrees of each dimension. A preliminary rubric was created by the research team, then given to a panel of seven experts in engineering and engineering education and discussed in a focus group. Feedback from the focus group was used to develop the final rubric. Definitions used for each of the eight dimensions were based on the PSDRM framework (Canney & Bielefeldt, 2013) and are given in Table 6. The rubric for one dimension, *Ability*, is shown in Table 9 and the full rubric can be found in Appendix E. From the pilot study it became clear that item responses were generally skewed towards more positive answers. Therefore the rubric was also developed with a skew such that a “2” from the interviews correlated with a ‘neutral’ response (4) on the 7-point Likert scale of the survey. All three levels of disagreement were captured within a “1” for the rubric and Degrees 3, 4, and 5 corresponded to a 5, 6, or 7 on the Likert-items of the survey. The “0” designation was used if there was no evidence for a given dimension in that interview.

**TABLE 9. PARTIAL RUBRIC FOR INTERVIEW SCORING – *ABILITY* DIMENSION**

| Degree | Corresponding Likert Score | *Ability* |
|---|---|---|
| **0** | - | No Evidence |
| **1** | 1-3 | Speaks about an **inability** to help others in a meaningful way, or are averse to helping others. |
| **2** | 4 | Impersonal or distance acknowledgement of one’s ability to help, speaks about possibly ‘yes’, possibly ‘no’ that they have the ability to help, or speaks about not ever having opportunities to help. |
| **3** | 5 | Expresses that they have the ability to help others, but limiting themselves to small acts, helping individuals more than causes. |
| **4** | 6 | Expresses a strong belief in their ability to help people on systemic levels. They may also tend to recognize how the complexity of these systems may limit their ability to help. |
| **5** | 7 | Superman – they surely have an ability to help on any front – perhaps a seemingly naïve perspective that they can do anything. |

Two reviewers used the definitions and rubric to independently code 24 interviews, identifying evidence of each of the eight dimensions and assigning degrees of social responsibility to each. One interview was omitted because the participant spoke directly about what score she gave on which questions, making it difficult for the reviewers to remain objective in assigning degrees for each dimension. Then, based upon evidence from the coding, each participant was given a rating for each dimension. From the independent review, 80 of the 192 items (42%) matched perfectly between the two reviewers, and another 56 (29%) were within one degree, with an item being one dimension for one interviewee. There were 38 instances (20%) where one reviewer saw evidence of a given dimension and the other did not. The two reviewers discussed each item where there was disagreement, examining the evidence in order to come to consensus on an appropriate degree. After consensus was reached there remained 31 items (16%) where there was no evidence in the interview for that participants' views on a given dimension. The degrees determined through consensus were converted to the appropriate Likert-score equivalent and compared to median scores for each dimension and interviewee from their survey. Spearman's rank correlation coefficients and Wilcoxon signed rank test values were used to examine correlation and difference, respectively, between the dimension averages from the EPRA Likert-items and the interview degrees as evidence of external validity.

## THE ENGINEERING PROFESSIONAL RESPONSIBILITY ASSESSMENT TOOL

As mentioned above, the EPRA tool was developed through multiple iterations during the pilot study. Only the process by which the list of ABET skills were consolidated into the final format and the development of the "bins" question are described in this paper. Additionally, the final version of EPRA is described, including all the Likert-items for each dimension and the non-Likert elements as well. The full version of EPRA can be found in Appendix A.

### DEVELOPMENT PROCESS

Likert-items were chosen as the main element of this instrument because they were common to similar tools and seen as a comfortable survey method for engineering students. A seven point scale was chosen because it would allow for a finer grain assessment over the traditional four or five point scale, which proved critical given that the data obtained was heavily skewed toward agreement for many items. The quantity and exact wording of the Likert-items of EPRA were adjusted through multiple iterations during the pilot study, including feedback from three of the project advisory board members who are subject matter experts from both engineering education and education. This process resulted in the 50 items presented here, down from the original 65 items. These three project advisors independently read several versions of the survey, and their feedback included adding explanations for each of the professional skills, clarified instructions, and one additional question from the original set.

Many of the Likert-items came from other survey instruments, such as the Community Service Attitudes Scale (CSAS) (Shiarella, McCarthy, & Tucker, 2000) and the Attitudes towards Service Learning survey (Duffy, Barrington, & Heredia Munoz, 2011), and were collected in EPRA to measure the eight dimensions of the PSRDM. Items selected from CSAS were already developed and tested against Schwartz's theory of the development of altruistic behavior for the *Awareness*, *Ability*, and *Connectedness* phases (Shiarella, McCarthy, & Tucker, 2000). Items from other instruments were selected if they related to the role of engineering in society or about issues of service in engineering. A full list of the Likert-items and their source, if applicable, is shown in Table 10. Questions used from other sources were unaltered unless otherwise noted in the table. Two elements of EPRA had developmental paths worth highlighting: 1) the consolidation of the ABET outcomes (ABET, 2008) and ASCE BOK2 (ASCE, 2008) skills to five Likert-items, and 2) the development of the career attribute question from open-ended responses, through job rankings, and into the final "bins" question.

In the first version of EPRA, students were asked to rank on a 7-point scale, from "Very Unimportant" to "Very Important", the importance to a professional engineer of 20 skills described in ABET criterion 3, ASCE BOK2, and the APPLES survey (Atman, et al., 2010). The original 20 skills given were: Business Knowledge, Communication, Conducting Experiments, Contemporary Issues, Creativity, Cultural Awareness/Understanding, Data Analysis, Design, Engineering Tools, Ethics, Global Context, Leadership, Life-Long Learning, Management Skills, Math, Problem Solving, Science, Societal Context, and Teamwork. These questions were asked to assess the *Base Skills* dimension of the PSRDM. The research team desired to consolidate these items in order to shorten the survey and make it more convenient for students to take. To do this, over 600 student responses from the pilot year were examined, looking at the correlations between each of the twenty items, to find natural clusters of items. Not surprisingly, some of the strongest correlations were between skills with expected relationships such as Math and Science (0.612), Leadership and Management Skills (0.583), and Design and Engineering Tools (0.622). Using the data correlations and expert judgment, these 20 items were reduced to the five clusters shown in Table 10 for *Base*

*Skills*. Correlations between the skills clustered into Base 2 ranged from 0.32-0.62, for Base 3 ranged from 0.27-0.38, and for Base 4 from 0.21-0.46. Cultural Awareness/Understanding, Ethics, and Societal Context were left as standalone items because they were skills which were most directly relevant to the development of social responsibility. Volunteerism was also added as a professional skill, aligning with the calls for re-envisioning the engineering profession to include pro-bono work and service. These eight items formed a section which asked students to rate the importance of each skill or skills for a professional engineer.

In addition to identifying students' degrees of social responsibility, the research team was interested in seeing if ideas of service or a desire to help others influenced how students' perceived their future careers in engineering. In the first iteration, an open ended question asked students to "briefly describe your ideal engineering career (types of projects, clients, firm, field work, etc.)." A rubric was developed to rank student responses from 0-3 based upon their acknowledgment of community or society in their responses. Sorting these responses was laborious and nearly 50% of the respondents simply skipped the question anyhow. Additionally, student responses often didn't appear to represent the true limitations of engineering careers, such as how doing development work may result in a lower income, more travel, or living in undesirable places. In the second iteration, six job descriptions were presented which included combinations of the type of work (public works or private design), location (domestic, international in developed or developing country) and salary; students were asked to rank their preference. They were also asked to say "why" they chose what they did in an open response box. Emergent coding of their open responses showed consistent motivators such as salary, helping people, community development projects, a desire to travel, or a desire of US citizens to work and live domestically.

The version of the job attributes question in the final version of EPRA presents eight bins with labels of job attributes (the labels came from the emergent coding of the "why" responses): Salary, Helping People, Working on Industrial/Commercial Projects, Working on Community Development Projects, Living Domestically, Living Internationally in a Developed Country, Living Internationally in a Developing Country, and Own your Own Business (Be Self-Employed). Students were told to distribute 10 stones between the eight bins based upon "which qualities are important to you when you think of your future engineering career." This form presented both "what", and also an idea of "why" based upon how many stones they placed in a given bin. This form also forced students to prioritize what was important to them from a limited set of resources (10 stones). Results from this question helped to understanding the perceived trajectories that students see when then think of their future selves and the career they wish to have in engineering. In this study, these results were also examined with respect to the eight dimensions as a form of external validity.

## FINAL TOOL

The bulk of the EPRA tool is 50 Likert-items which measure the eight dimensions of the PSRDM. All of these items are on 7-point scales, from “Strongly Disagree” to “Strongly Agree”, except the eight professional skills questions which are from “Very Unimportant” to “Very Important.” Twelve of the Likert-items are phrased negatively to offset potential response bias, and negatively worded questions were reversed scored. There are four or five questions which address the characteristics for each dimension, except for *Professional Connectedness* which has 19 questions. The *Professional Connectedness* dimension has this many questions because it was initially developed to address the final three stages of the Service Learning Model, but it was later decided that the transition between the stages of that model were too difficult to distinguish in this context and so all of the questions were combined into one dimension. All of the Likert-items and their associated dimensions are given in Table 10. Questions were arranged such that negatively worded questions were distributed across the instrument and with questions addressing issues of engineering generally coming before items addressing personal views of social responsibility.

**TABLE 10. EPRA LIKERT-ITEMS AND SOURCE**

| Personal Social Awareness Realm<br>Dimension | Code | Question | Source | Average | Standard Deviation | Skew |
|---|---|---|---|---|---|---|
| ***Awareness*** | <u>aw1</u> | There are *not* communities in America that need help | | 6.35 | 1.14 | -2.65 |
| | aw2 | Community groups need our help | (Shiarella, McCarthy, & Tucker, 2000) | 5.38 | 1.03 | -0.65 |
| | <u>aw3</u> | There are *not* people in the community who need help | (Shiarella, McCarthy, & Tucker, 2000)* | 5.99 | 1.18 | -1.72 |
| | aw4 | There are people who have needs which are not being met | (Shiarella, McCarthy, & Tucker, 2000) | 6.07 | 1.07 | -2.18 |
| | aw5 | There are needs in the community | (Shiarella, McCarthy, & Tucker, 2000) | 6.15 | 0.92 | -1.91 |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Ability*** | ab1 | I can make a difference in my community | (Shiarella, McCarthy, & Tucker, 2000)** | 5.98 | 0.81 | -0.84 |
| | ab2 | I can have an impact on solving problems that face my local community | (Duffy, Barrington, & Heredia Munoz, 2011) | 5.60 | 0.92 | -0.70 |
| | ab3 | My contribution to society will make a real difference | (Shiarella, McCarthy, & Tucker, 2000) | 5.42 | 0.98 | -0.41 |
| | <u>ab4</u> | I *cannot* have an impact on solving problems that face underserved communities internationally | (Duffy, Barrington, & Heredia Munoz, 2011) | 5.27 | 1.26 | -1.00 |
| ***Connectedness*** | <u>co1</u> | It is *not* my responsibility to do something about improving society | (Shiarella, McCarthy, & Tucker, 2000)** | 5.40 | 1.38 | -1.05 |
| | co2 | It is my responsibility to take some real measures to help others in need | (Shiarella, McCarthy, & Tucker, 2000) | 5.22 | 1.15 | -0.81 |
| | co3 | I feel an obligations to contribute to society | (Shiarella, McCarthy, & Tucker, 2000) | 5.28 | 1.27 | -0.89 |
| | co4 | I think I should help people who are less fortunate with their needs and problems | (Olney & Grande, 1995)** | 5.41 | 1.26 | -1.00 |
| **Professional Development Realm** | | | | | | |
| ***Base Knowledge*** | ba1 | How important are Fundamental Skills (i.e. Math & Science) for a professional engineer | (ABET, 2008) | 6.43 | 0.89 | -3.27 |
| | ba2 | How important are Technical Skills (i.e. Conducting Experiments, Data Analysis, Design, Engineering Tools, & Problem Solving) for a professional engineer | (ABET, 2008; American Society of Civil Engineers, 2008) | 6.56 | 0.86 | -3.99 |
| | ba3 | How important are Business Skills (i.e. Business Knowledge, Management Skills & Professionalism) for a professional engineer | (Atman, et al., 2010) | 5.70 | 0.99 | -1.43 |
| | ba4 | How important are Professional Skills (i.e. Communication, Contemporary Issues, Creativity, Leadership, Life-Long Learning, & Teamwork) for a professional engineer | (ABET, 2008; Atman, et al., 2010) | 6.37 | 0.93 | -3.02 |
| | ba5 | How important is ethics for a professional engineer | (ABET, 2008) | 6.32 | 1.03 | -2.42 |
| ***Professional Ability*** | pa1 | Engineers have contributed greatly to fixing problems in the world | (Hilpert, Stump, Husman, & Kim, 2008) | 6.48 | 0.73 | -1.69 |
| | <u>pa2</u> | Engineering skills are *not* useful in making the community a better place | (Shiarella, McCarthy, & Tucker, 2000)** | 6.28 | 1.08 | -2.55 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | pa3 | Technology does *not* play an important role in solving society's problems | (Hilpert, Stump, Husman, & Kim, 2008)* | 6.26 | 0.95 | -1.86 |
| | pa4 | Engineers can have a positive impact on society | | 6.55 | 0.63 | -1.41 |
| ***Analyze*** | an1 | How important is Cultural Awareness/Understanding for a professional engineer | (ABET, 2008) | 5.45 | 1.17 | -1.05 |
| | an2 | How important is Societal Context for a professional engineer | (ABET, 2008) | 5.79 | 1.13 | -1.48 |
| | an3 | I would *not* change my design if it conflicted with community feedback | | 5.11 | 1.39 | -0.98 |
| | an4 | It is important for engineers to consider the broader potential impacts of technical solutions to problems | | 6.15 | 0.88 | -1.67 |
| | an5 | It is important to incorporate societal constraints into engineering decisions | (McCormick, et al., 2010)** | 5.67 | 1.00 | -1.04 |
| **Professional Connectedness Realm** | | | | | | |
| ***Professional Connectedness*** | pc1 | How important is volunteerism for a professional engineer | | 4.99 | 1.32 | -0.70 |
| | pc2 | Volunteer experience(s) have changed the way I think about spending money | (Olney & Grande, 1995) | 4.93 | 1.33 | -0.62 |
| | pc3 | It is important to me personally to have a career that involves helping people | (Duffy, Barrington, & Heredia Munoz, 2011) | 5.66 | 1.18 | -0.95 |
| | pc4 | Service should *not* be an expected part of the engineering profession | (Duffy, Barrington, & Heredia Munoz, 2011)* | 4.68 | 1.49 | -0.41 |
| | pc5 | I will use engineering to help others | (Duffy & Raque-Bogdan, 2010)** | 5.99 | 0.92 | -1.24 |
| | pc6 | I view engineering and community service work as unconnected | (Duffy & Raque-Bogdan, 2010)** | 4.87 | 1.50 | -0.61 |
| | pc7 | I feel called to serve others through engineering | (Duffy & Raque-Bogdan, 2010)** | 4.68 | 1.50 | -0.44 |
| | pc8 | The needs of society have no effect on my choice to pursue engineering as a career | (Duffy & Raque-Bogdan, 2010)** | 4.66 | 1.69 | -0.47 |
| | pc9 | I feel called by the needs of society to pursue a career in engineering | (Duffy & Raque-Bogdan, 2010)** | 4.29 | 1.60 | -0.23 |
| | pc10 | Engineering Firms should take on some pro bono work | | 4.73 | 1.35 | -0.42 |
| | pc11 | I doubt that volunteer work will ever have much affect on my career | (Olney & Grande, 1995)** | 5.10 | 1.39 | -0.72 |
| | pc12 | I think it is important to use my engineering to serve others | (Duffy & Raque-Bogdan, 2010)** | 5.46 | 1.20 | -1.06 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | pc13 | Engineers should use their skills to solve social problems | (Duffy, Barrington, & Heredia Munoz, 2011) | 5.33 | 1.26 | -0.92 |
| | pc14 | It is important to use my engineering abilities to provide a useful service to the community | (Shiarella, McCarthy, & Tucker, 2000)** | 5.54 | 1.11 | -0.96 |
| | pc15 | I believe that I will be involved in social justice issues for the rest of my life | (Olney & Grande, 1995) | 4.36 | 1.54 | -0.15 |
| | pc16 | I do not think it is important to use engineering to serve the greater community | (Duffy & Raque-Bogdan, 2010)** | 5.68 | 1.26 | -1.32 |
| | pc17 | I think people who are more fortunate in life should help less fortunate people with their needs and problems | (Olney & Grande, 1995) | 5.60 | 1.23 | -1.18 |
| | pc18 | I believe it takes more than time, money, and community efforts to change social problems: we also need to work for change at a national or global level | (Olney & Grande, 1995) | 5.46 | 1.25 | -1.05 |
| | pc19 | It is important to me to have a sense of contribution and helpfulness through participating in community service | (Shiarella, McCarthy, & Tucker, 2000) | 5.23 | 1.22 | -0.78 |
| ***Costs/Benefits*** | cb1 | I would be willing to have a career that earns less money if I were serving society | | 4.65 | 1.51 | -0.41 |
| | cb2 | My engineering skills are strengthened through participation in engineering service opportunities | | 5.23 | 1.21 | -0.55 |
| | cb3 | I believe my life will be positively affected by the volunteering that I do | | 5.66 | 1.19 | -1.06 |
| | cb4 | I believe that extra time spent on community service is worthwhile | | 5.74 | 1.00 | -1.07 |

* Question has been negatively worded from original source
** Question has been reworded from original source, such as changing 'career' to 'engineering career'

Other elements of the EPRA tool include the job attributes question described in the previous section. There is a section asking students to check any elements that had been or would be motivators for them to engage in some form of community service from a list of ten options, such as: "I went with a friend", "Because of my religious beliefs", "Makes me feel good", and "To build my resume." Most of these motivators were adaptations from CSAS (Shiarella, McCarthy, & Tucker, 2000) and one, "With my Fraternity/Sorority", emerged from write-ins on the "other" category. A similar list of 11 possible limiting factors is given, such as: "Lack of time due to course work", "Family obligations", "Not interested in volunteering", and "Previous negative experience(s) with volunteering."

Because engagement in service is a central element for increasing social responsibility according to the PSRDM, EPRA includes a question about previous volunteer activities. This question asks students to indicate the frequency with which they had engaged in a list of 17 different service activities that are common to college campuses. Examples of the volunteer activities listed include: Habitat for Humanity build, unpaid tutoring, short-term on-site service projects (i.e. Spring Break Service trip, EWB/Engineers for a Sustainable World/Bridges to Prosperity in-country work), working with professional societies such as ASCE or American Society of Mechanical Engineers, and helping at a sports camp or unpaid coaching. The frequency options include “Have not participated”, “Once”, “Twice”, “More than twice but not routinely”, “Monthly”, and “Weekly.”

EPRA also includes an open-ended question, asking students to “briefly describe any events that have influenced your views of community service and social responsibility.” From the Tier 1 data set, these responses were coded using emergent coding, and factors such as religion, family, specific classes, or unique life experiences such as growing up in poverty were observed. Many of the responses would not be able to be captured in a more quantitative way, like this response from a female engineering student: “My brother died from a brain stem tumor at 14 years old, and was a passionate advocate for brain tumor research, awareness, and support for all children suffering from a brain tumor.” Life events such as these can be very powerful in the development of how a person sees her- or himself in society, but are difficult to anticipate with lists or Likert-items.

The final element of EPRA asks for demographic information. Students are asked to report their major, academic rank, gender, age range, GPA, race, if they were in the first generation to attend college, religious preference and how active they were in that religious preference. Some students left these items blank, while others explicitly selected the “prefer not to answer” option. An additional demographic question asks about any previous engineering work experience, choosing from “none”, “summer or part time internships/co-terms”, or “full time employment.” Students with previous full time employment in engineering, are then asked to report how many years they worked.

## RESULTS

The following section presents evidence of reliability and validity for the EPRA tool. The Tier 1 data set of 1000 responses was used for all statistical evaluations of reliability and validity, and examinations of correlation and difference with interview coding was also used as evidence for validity.

### RELIABILITY

Reliability is a measure of the stability of an instrument when repeated under similar circumstances (Allen & Yen, 1979). For the EPRA tool, internal consistency estimates of reliability were explored using both Cronbach's and Ordinal alphas. Cronbach's alpha is the traditional method used, but for ordinal data, such as Likert-items, Cronbach's alpha has been shown to underestimate reliability (Gadermann, Guhn, & Zumbo, 2012). The Ordinal alpha was developed specifically for ordinal data, like Likert-items, and uses polychoric correlations to estimate reliability, rather than the Pearson covariance matrix which assumes continuous data (Zumbo, Gadermann, & Zeisser, 2007). An additional advantage of the Ordinal alpha is that the underlying data does not have to be normally distributed, which data for EPRA is not, as seen by the range of item skewness shown in Table 10. Both the Cronbach's and Ordinal alpha values are given for each dimension of the EPRA tool in Table 11.

**TABLE 11. DIMENSION DESCRIPTIVE STATISTICS AND INTERNAL RELIABILITY MEASURES**

| Dimension | # of Items | Average | Standard Deviation | Cronbach's Alpha | Ordinal Alpha |
|---|---|---|---|---|---|
| ***Awareness*** | 5 | 5.99 | 0.70 | 0.674 | 0.814 |
| ***Ability*** | 4 | 5.57 | 0.76 | 0.755 | 0.835 |
| ***Connectedness*** | 4 | 5.33 | 0.97 | 0.809 | 0.859 |
| ***Base Skills*** | 5 | 6.28 | 0.73 | 0.828 | 0.729 |
| ***Professional Ability*** | 4 | 6.39 | 0.57 | 0.566 | 0.737 |
| ***Analyze*** | 4 | 5.63 | 0.75 | 0.674 | 0.732 |
| ***Professional Connectedness*** | 19 | 5.12 | 0.84 | 0.890 | 0.930 |
| ***Costs/Benefits*** | 4 | 5.32 | 0.95 | 0.689 | 0.813 |

Rules of thumb for internal reliability hold that alpha values greater than 0.70 shows 'acceptable' reliability, and greater than 0.80 shows 'good' reliability (Nunnally, 1978; George & Mallery, 2003). Using Ordinal alpha, all dimensions have 'acceptable' reliability, with five of the eight having 'good' reliability. Cronbach's alpha, however, underestimates reliability, showing that half of the dimensions are below the 0.7 threshold. Based on the Ordinal alpha results, which are more appropriate for the Likert-item data from EPRA, there is good evidence of internal reliability for this tool.

### VALIDITY

Validity addresses how well an instrument measures the attribute or skill it is intended to measure (Allen & Yen, 1979), in the case of EPRA this would be degrees of social responsibility in engineers. Content validity was used in the initial development of EPRA by gaining feedback from six practicing engineers and three engineering education experts on the items and format of the instrument. Additionally, the eight interviews using the survey-focused method addressed not only the content of each question, but also the language, helping to confirm that students were interpreting questions appropriately. More rigorous evidence of validity was developed through Multidimensional Item Response Theory (MIRT) for construct validity, and through the use of the interview data and other aspects of the EPRA tool for external validity.

CONSTRUCT VALIDITY – A common way to develop evidence of construct validity for surveys is through exploratory or confirmatory factor analysis, in order to examine underlying characteristics, or latent variables, which are assumed to be measured by the observed variables. These methods, however, have several limitations which make them difficult to use with ordinal data including underlying structures which assume continuous and normally distributed data, problems of item-person confounding, and restrictions of purely linear relationships between latent and observed variables (Yang-Wallentin, Joreskog, & Luo, 2010; Osteen, 2010). Though there are adaptations of factor analysis models which have been explored for ordinal data (Joreskog & Moustaki, 2001), MIRT is a method which overcomes these limitations and is more appropriate for the underlying theory and data type of this study.

MIRT is useful in assessing non-linear relationships between multiple items, based upon the determination of both the item's inherent characteristic or difficulty and the individual's ability (Wilson, 2005; Osteen, 2010). Estimates of both item difficulty and the individual's ability are based upon two underlying assumptions: 1) an individual with more of the trait being measured by that item will have a higher likelihood of answering higher on that item than an individual with less of that trait, and 2) any individual will have a greater likelihood of answering higher on an item which requires less of that trait than on items requiring more of that trait (Müller, Sokol, & Overton, 1999). Additionally, for Likert-items, MIRT provides estimates of the relative difficulty for crossing between different thresholds, say the difficulty between answering ‘agree’ (6) versus ‘strongly agree’ (7) on a given item (Osteen, 2010). Used for scales development, MIRT provides evidence of how items align with the underlying theoretical model, and provides evidence of the relationship between respondents’ ability and item difficulty with the underlying traits being measured.

For this study the unit of analysis was taken at each of the three realms, therefore the underlying traits that were examined were Personal Social Awareness, Professional Development, and Professional Connectedness. The program Construct Map was used to help develop and analyze the Rasch model. Within each realm, the relative difficulties of items were examined using Wright Maps to look at the relative locations of item thresholds and respondents’ traits. In this paper, graphical representations of the full Wright Maps are considered, which neglect respondent traits. Full Wright Maps for the each realm are presented in Appendix D. The graphical Wright Maps show the Thurstonian Thresholds for each item, which is the location, in logits, for the 50% likelihood of crossing from one level on the Likert-scale to the next. By examining the graphical Wright Maps and the Thurstonian Thresholds for different items and steps within items, we can see the relative difficulties between and within items, and test this against the developmental progressions hypothesized by the PSRDM. See (Wilson M. , 2005) for a more detail discussion on the development, use and interpretation of Wright Maps for scales development.

The graphical Wright Map for the Personal Social Awareness realm is shown in Figure 2. There were no *a priori* theories about the difficulties of items within each of the three dimensions of the Personal Social Awareness realm, but there were theories about the relative difficulties between each dimension. It was hypothesized that a higher degree of agreement with *Awareness* was necessary for middle to higher degrees of agreement for *Ability*. A similar relationship between *Ability* and *Connectedness* was also expected. Looking at the graphical Wright Map in Figure 2 shows that, except for aw2, the 6 and 7 thresholds for that *Awareness* dimension are lower than the corresponding thresholds for the items in the *Ability* and *Connectedness* dimensions. This supports the *a priori* theory of order between the three dimensions within this realm. Viewed another way, an individual who resides at the 0 logit level of Personal Social Awareness has about a 50% likelihood of answering “agree” on most of the *Awareness* items, and also a 50% likelihood of answering only “slightly agree” on half of the *Ability* items and all of the *Connectedness* items. The distinction between the items of the *Ability* and *Connectedness* dimensions is less pronounced, however, though there is a general upward trend from aw1 through co4, especially at the 6 threshold.

This suggests a slight degree of increased difficulty (or decreased probability for a participant at the same location) for the *Connectedness* items over the *Ability* items. Also worth noting is the clustering of lower thresholds for many of the items, signifying that most respondents are not using the lower ends of the scale for those items. This is expected for items such as those in the *Awareness* dimension because they require little personal buy-in or obligation, but are based mainly on observations or abstract general knowledge. For more difficult items, such as those in the *Professional Connectedness* dimension, it would be expected to see a wider spread on the graphical Wright Map. The "2 Thresholds" are missing for ab1, ab2, and ab3 because none of the 1000 respondents selected "Strongly Disagree" for these items, therefore providing no data on the difficulty of crossing the 2 threshold from 1 on the Likert-scale.

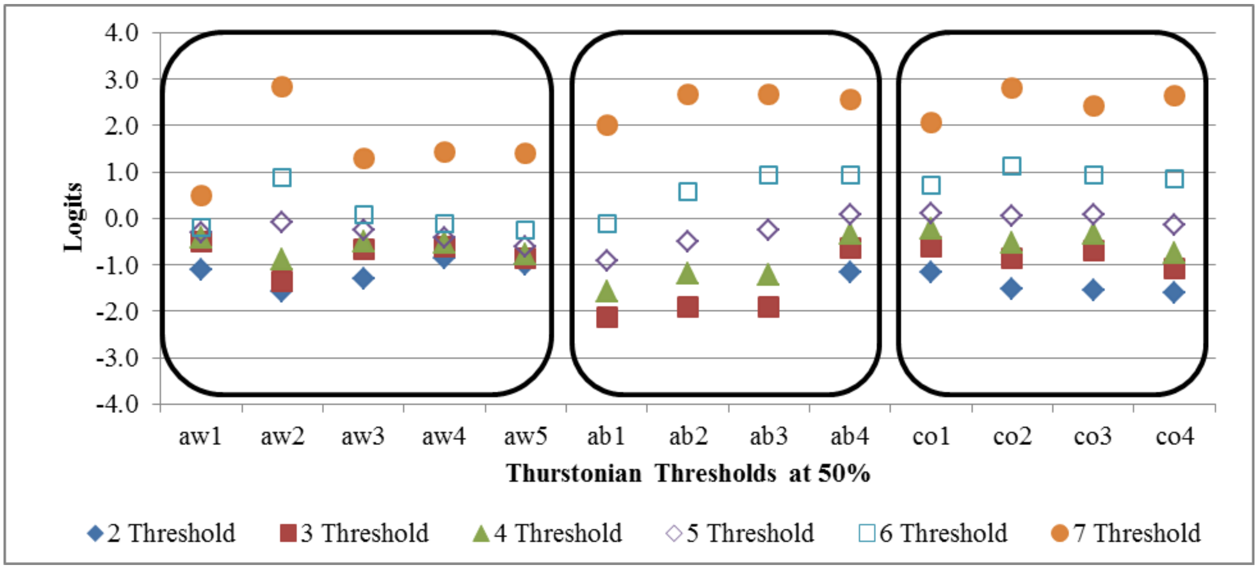



**FIGURE 2. GRAPHICAL WRIGHT MAP FOR PERSONAL SOCIAL AWARENESS REALM**

The item fit measures for this model are shown in Figure 3 and show that all of the items except aw1 are within the recommended upper (4/3) and lower (3/4) bounds for reasonable fit from the literature (Wilson M. , 2005). Upon examining this item more closely it was seen that the frequency distribution is very tight, with 60% marking 7 and nearly 30% answering 6. This explains the tight cluster seen on the graphical Wright Map. The main difference in wording between this item and the other four items in this dimension is the specificity of "… in America" rather than more general statements such as "…in the community" from the other questions. Because the fit of this item is only just above the upper bound, it remained in the tool.

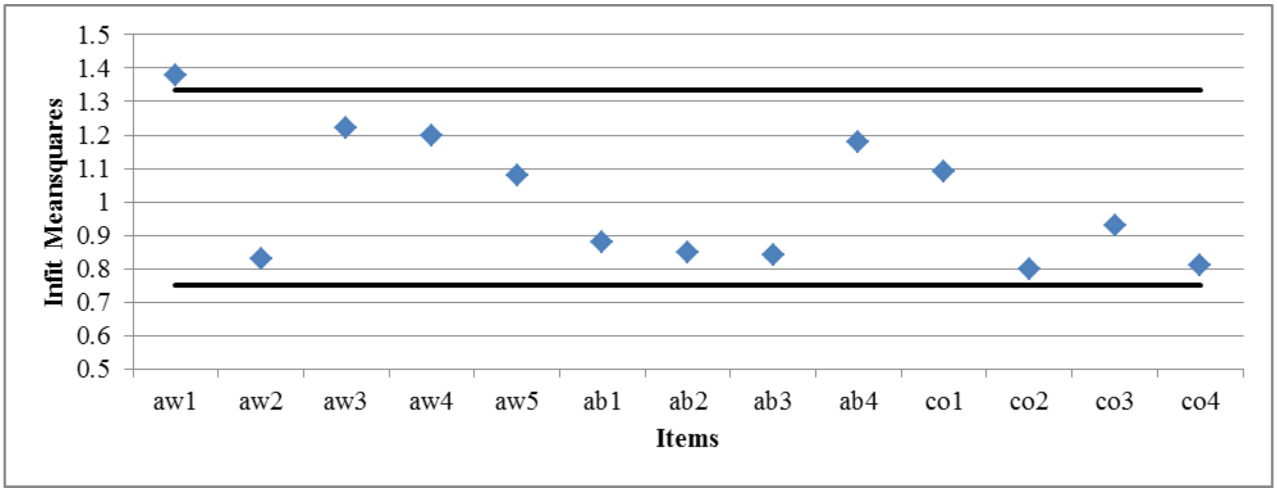



**FIGURE 3. ITEM INFIT STATISTICS USING MEAN SQUARES FOR PERSONAL SOCIAL AWARENESS REALM**

Figure 4 and Figure 5 show the graphical Wright Maps for the Professional Development and the Professional Connectedness realms, respectively. Examining the graphical Wright Map for the Professional Development realm shows that all of the items from the *Base Skills* and *Professional Abilities* dimensions have fairly tight clusters, except for ba3, which asks about the importance of business skills for a professional engineer. They also all have relatively low thresholds, compared to the items for the *Analyze* dimension, which push more towards a wider vision of the role of social issues in engineering design. From the full Wright Map (though not shown in this paper) the histogram of respondents for this realm resides mainly between 1 and 2 logits, which is above the 7 threshold for most of those items, suggesting that nearly every respondent had a greater than 50% likelihood of responding “strongly agree” to questions about the importance of various skills for professional engineers and the ability of the engineering profession to have positive effects on society. This is not surprising, given that all student respondents were engineers. Perhaps a wider breadth of responses would be obtained if these questions were asked of non-engineers. That the same thresholds for the items of the *Analyze* dimension are higher than those of the other two aligns with the *a priori* theory about relationships of items between dimensions, showing that agreement with the items in *Analyze* is relatively more difficult than items from the other dimensions.

Many of the questions in the *Professional Connectedness* realm were written to be more divisive, deviating from many cultural and professional norms such as sacrificing income or expecting pro bono work. These items, as seen in the graphical Wright Map, are less clustered, showing that respondents answered across the majority of the Likert-scale. There were no *a priori* theories about the levels of difficulty of these questions with relation to each

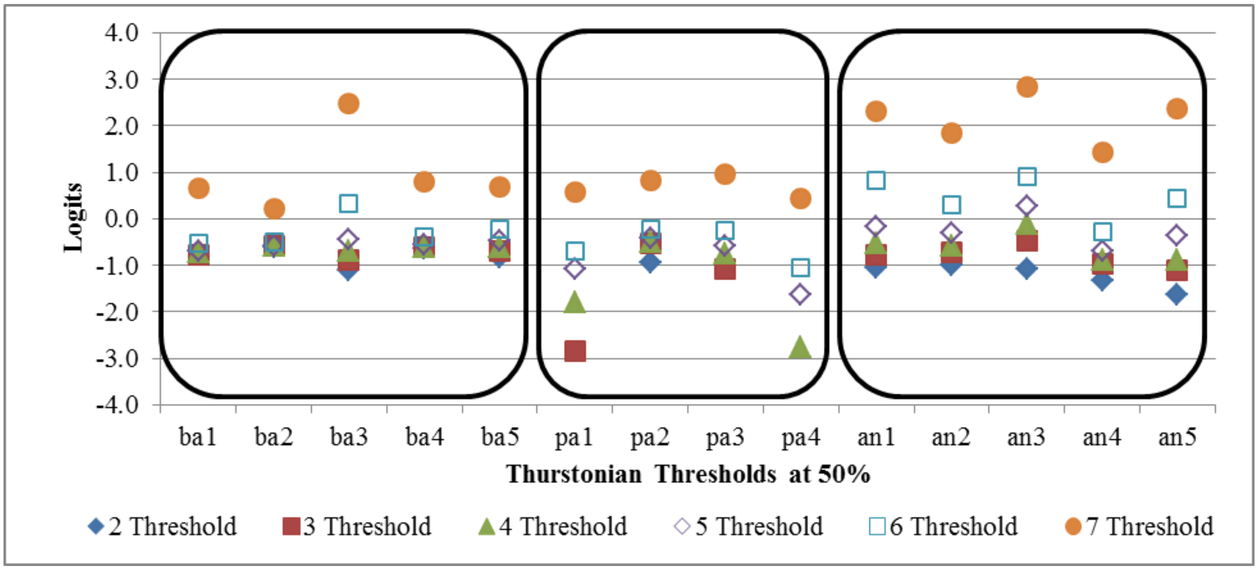



**FIGURE 4. GRAPHICAL WRIGHT MAP FOR PROFESSIONAL DEVELOPMENT REALM**

other and no real pattern of difficulty is expressed by the graphical Wright Map either. Similarly, the items from the *Cost/Benefits* dimension were not expected to be different from those in the *Professional Connectedness* dimension, which they are not. The distribution of respondents for this realm is much wider than for the Professional Development realm, with the majority of respondents falling between -0.5 and 2.5 logits. Many of these questions relate most directly to ideas of professional social responsibility, and therefore this wide range in respondents and of Thurstonian Thresholds suggest that these items are useful at differentiating between individual's levels of social responsibility. Therefore, as evidence of validity for this tool, this shows that the tool can in fact detect different views of social responsibility.

The *a priori* theory from the PSRDM suggested that dimensions which address issues of responsibility and professional obligation (*Connectedness, Analyze,* and *Professional Connectedness*) would be more difficult than more broad dimensions such as *Awareness, Base Skills*, and *Professional Ability*, suggesting a developmental progression. Figure 6 presents the average Thrustonian Thresholds for each of the eight dimensions and supports this developmental progression. The average Thrustonian Thresholds for *Awareness*, *Base Skills*, and *Professional Ability* are lower than those for *Connectedness*, *Analyze*, and *Professional Connectedness*. In other words, an individual whose degree of social responsibility places them at 0 logits would have a 50% likelihood of crossing the 6 threshold for the *Awareness* items, but only about a 27% likelihood of crossing that same threshold for items in the *Connectedness*, and *Professional Connectedness* dimensions which are about one logit higher.

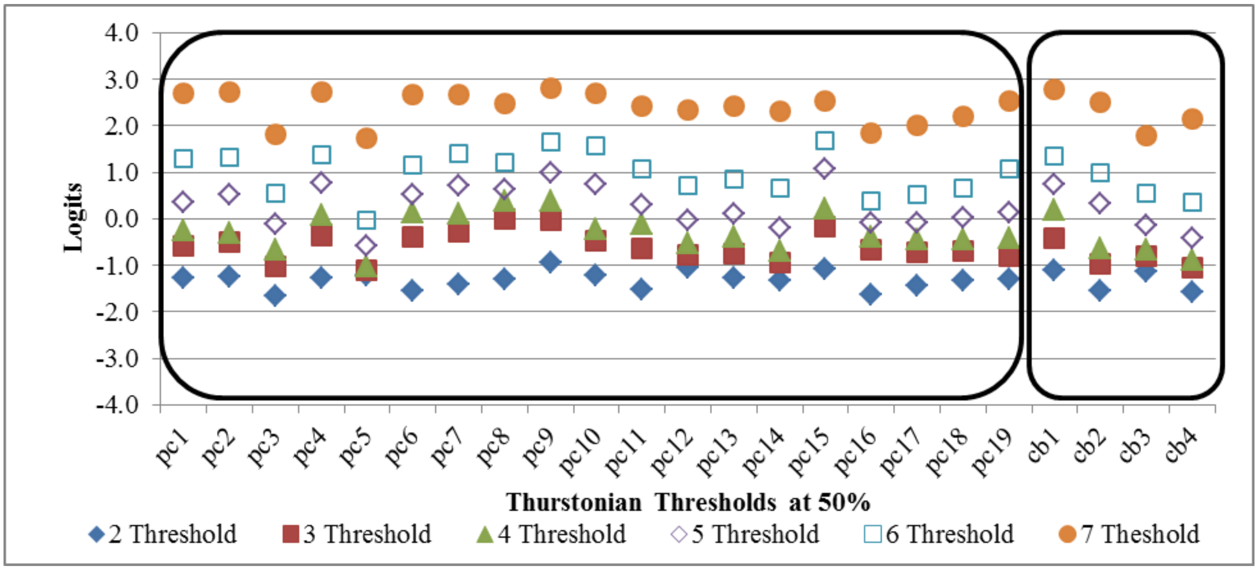



**FIGURE 5. GRAPHICAL WRIGHT MAP FOR PROFESSIONAL CONNECTEDNESS REALM**

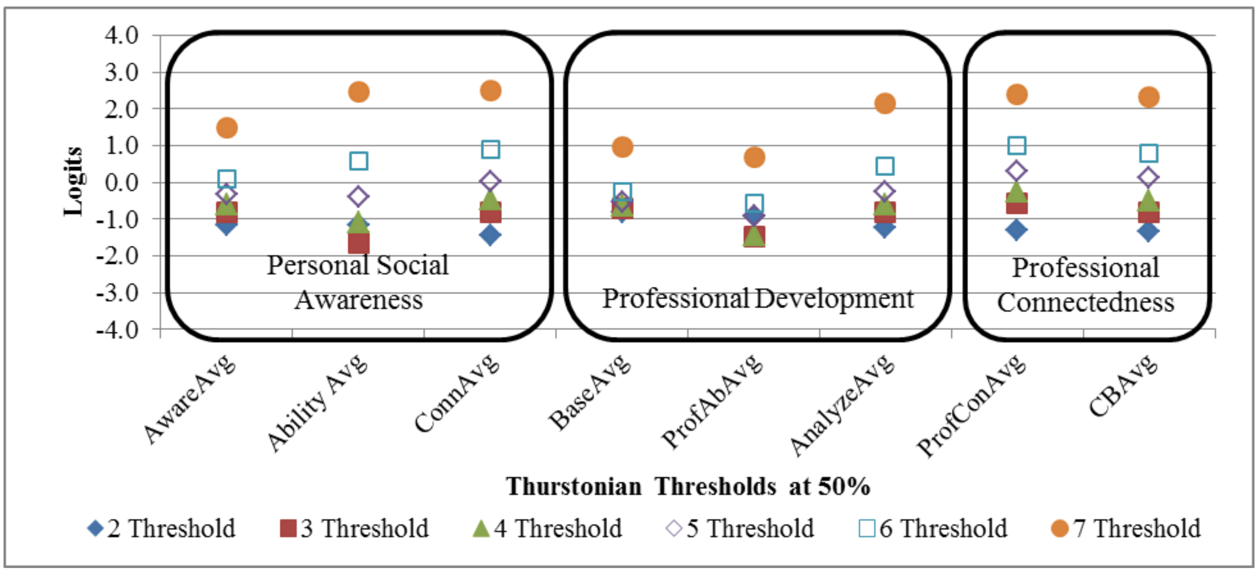



**FIGURE 6. DIMENSION AVERAGE THURSTONIAN THRESHOLDS AT 50%**

EXTERNAL VALIDITY – Three different sources were examined to provide evidence for external validity; 1) correlations between degrees of social responsibility as assessed from interviews and responses to EPRA Likert-items for each dimension, 2) comparisons of EPRA dimension scores between participants with varying amounts of service experience, and 3) examining EPRA dimension scores based upon relative importance placed on "Salary" versus "Helping People" in the career attributes question. Each piece of evidence supports that the Likert-items appropriately measure each of the eight dimensions, and that service experiences correlate with higher degrees of social responsibility.

CORRELATIONS & DIFFERENCES USING INTERVIEW DATA - As described earlier, interviews with 24 engineering students were coded for degrees of social responsibility related to each of the eight dimensions of the PSRDM. These ratings were compared to participant responses on the EPRA Likert-items, using median scores for each dimension. Both the EPRA median scores and the interview degrees for each interviewee are given in Table 12. Using radial plots, differences and similarities between the survey scores and interview ratings can be qualitatively examined, as seen in Figure 7. The radial axis represents the 7-point Likert-item scale used in the survey and the recoded degrees from the interviews. NC10, NC13, and NC14 represent three different students who were interviewed. Visually, NC10 and NC13 seem to have good matches between the EPRA survey responses and the recoded rubric scores from the interviews, whereas the survey and interview results for NC14 are clearly different. Both NC10 and NC13 had an item where there was no evidence to support a rating from the interviews, Ability and Base Skills, respectively.

**TABLE 12. INTERVIEWEE EPRA DIMENSION AVERAGES, INTERVIEW DIMENSION RATINGS, AND CORRELATION AND DIFFERENCE MEASURES**

| ID | Method | Dimension Medians and Interview Degrees per Interviewee | | | | | | | | **Spearman** | | **Wilcoxon** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Aware | Ability | Conn | Base | ProfAb | Analyze | ProfCon | CB | $R^2$ | p | p |
| **NC01** | EPRA | 6 | 5.5 | 5.5 | 5.9 | 6 | 6 | 5 | 5.5 | 0.171 | 0.309 | 1 |
| | Interview | 6 | 6 | 7 | 4 | 6 | 5 | 6.5 | 5 | | | |
| **NC02** | EPRA | 6 | 5 | 5 | 6.0 | 6 | 5 | 4.5 | 5.5 | 0.240 | 0.264 | 0.705 |
| | Interview | 7 | 5 | 4 | 0 | 6 | 5 | 5 | 4 | | | |
| **NC03** | EPRA | 7 | 4.5 | 6.0 | 6 | 7 | 5 | 5 | 4.5 | 0.947 | 0.005 | 0.180 |
| | Interview | 7 | 5 | 6 | 0 | 7 | 0 | 6 | 0 | | | |
| **NC04** | EPRA | 6 | 6 | 6 | 6 | 5.5 | 6 | 6 | 6 | 0 | 1 | 0.581 |
| | Interview | 6 | 5 | 6 | 7 | 6 | 7 | 5.5 | 0 | | | |
| **NC05** | EPRA | 7 | 6 | 5.5 | 4 | 6 | 5 | 6 | 6 | 0.194 | 0.383 | 0.276 |
| | Interview | 6 | 6 | 6 | 0 | 5 | 5 | 6 | 0 | | | |
| **NC06** | EPRA | 7 | 6 | 6 | 5.7 | 6 | 6 | 5 | 5 | 0.031 | 0.675 | 0.131 |
| | Interview | 5 | 5 | 5 | 5 | 7 | 5 | 5 | 5 | | | |
| **NC07** | EPRA | 7 | 7 | 6 | 7 | 7 | 7 | 6 | 7 | 0.466 | 0.091 | 0.317 |
| | Interview | 6 | 6 | 7 | | 6 | 5 | 7 | 7 | | | |
| **NC08** | EPRA | 6 | 4.5 | 4.5 | 5.6 | 6.5 | 5 | 5 | 6 | 0.045 | 0.650 | 0.786 |
| | Interview | 6 | 0 | 6 | 6 | 6 | 7 | 5 | 4 | | | |
| **NC09** | EPRA | 6 | 6 | 5.5 | 5.6 | 6 | 5 | 6 | 6.5 | 0.045 | 0.648 | 0.244 |
| | Interview | 5 | 0 | 5 | 7 | 5 | 5 | 5 | 5 | | | |
| **NC10** | EPRA | 7 | 6 | 6 | 6 | 5.5 | 6 | 6 | 6 | 0 | 1 | 0.214 |
| | Interview | 6 | 0 | 5 | 5 | 6 | 6.5 | 6 | 6 | | | |
| **NC11** | EPRA | 6 | 6 | 6 | 7 | 6 | 7 | 6 | 6.5 | 0.178 | 0.345 | 0.357 |
| | Interview | 7 | 6 | 6 | 0 | 6 | 5 | 5 | 6 | | | |
| **NC13** | EPRA | 7 | 6 | 4.5 | 7 | 7 | 6 | 5 | 4 | 0.803 | 0.006 | 0.458 |
| | Interview | 6 | 5 | 5 | 0 | 7 | 6 | 5 | 4.5 | | | |
| **NC14** | EPRA | 7 | 6.5 | 5 | 7 | 7 | 6 | 5 | 5.5 | 0.100 | 0.446 | 0.027 |
| | Interview | 5 | 7 | 4 | 3 | 7 | 4 | 4 | 4 | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NC15** | EPRA | 7 | 4 | 5 | 6 | 6.5 | 6 | 4 | 4.5 | 0.650 | 0.029 | 0.141 |
| | Interview | 6 | 4 | 3 | 6 | 7 | 5 | 4 | 0 | | | |
| **NC16** | EPRA | 7 | 7 | 6 | 6 | 7 | 6 | 6 | 6.5 | 0.774 | 0.021 | 0.034 |
| | Interview | 7 | 0 | 5 | 5 | 6 | 4.5 | 5 | 0 | | | |
| **NC17** | EPRA | 7 | 6 | 6.5 | 6 | 7 | 7 | 6 | 7 | 0.331 | 0.136 | 0.041 |
| | Interview | 7 | 5 | 6 | 6 | 6 | 5 | 4 | 7 | | | |
| **NC18** | EPRA | 6 | 5 | 5 | 7 | 6.5 | 5 | 4 | 5.5 | 0.132 | 0.548 | 0.063 |
| | Interview | 0 | 4 | 4 | 0 | 4 | 0 | 4 | 3 | | | |
| **NC19** | EPRA | 6 | 6 | 6 | 6 | 7 | 6.0 | 5 | 6 | 0.250 | 0.253 | 0.020 |
| | Interview | 5 | 5 | 4 | 5 | 6 | 0 | 5 | 5 | | | |
| **NC20** | EPRA | 7 | 7 | 7 | 7 | 5.5 | 7 | 7 | 6 | 0.009 | 0.837 | 0.045 |
| | Interview | 7 | 6 | 5 | 0 | 6 | 5 | 6 | 5 | | | |
| **NC21** | EPRA | 6 | 4 | 4 | 7 | 6 | 5 | 4 | 4 | 0.033 | 0.726 | 1 |
| | Interview | 6 | 5 | 5 | 0 | 4 | 5 | 4 | 0 | | | |
| **NC22** | EPRA | 6 | 6 | 5.5 | 7 | 7 | 5 | 5 | 5 | 0.100 | 0.488 | 0.168 |
| | Interview | 5 | 5 | 6 | 5.5 | 5 | 5 | 6 | 0 | | | |
| **NC23** | EPRA | 6 | 6 | 5 | 6 | 6 | 6.0 | 5 | 5 | 0.500 | 0.293 | 0.414 |
| **0.443** | Interview | 0 | 4.5 | 6 | 0 | 5 | 0 | 5 | 0 | | | |
| **NC240** | EPRA | 6 | 4 | 3 | 7 | 6.5 | 6 | 3.5 | 5 | 0.410 | 0.088 | 0.443 |
| | Interview | 5.5 | 4 | 4 | 6 | 5 | 5 | 5 | 3 | | | |
| **NC25** | EPRA | 6 | 6 | 6 | 6 | 6.5 | 6 | 6 | 6.5 | 0 | 1 | 0.102 |
| | Interview | 6 | 0 | 5 | 0 | 6 | 0 | 6 | 5.5 | | | |

Black cells denote importance and statistical significance from Spearman ($p<0.05$) and rejection of hypothesis of difference from Wilcoxon ($p>0.05$). Dark gray cells denote suggestive importance and significance from Spearman ($p<0.10$).

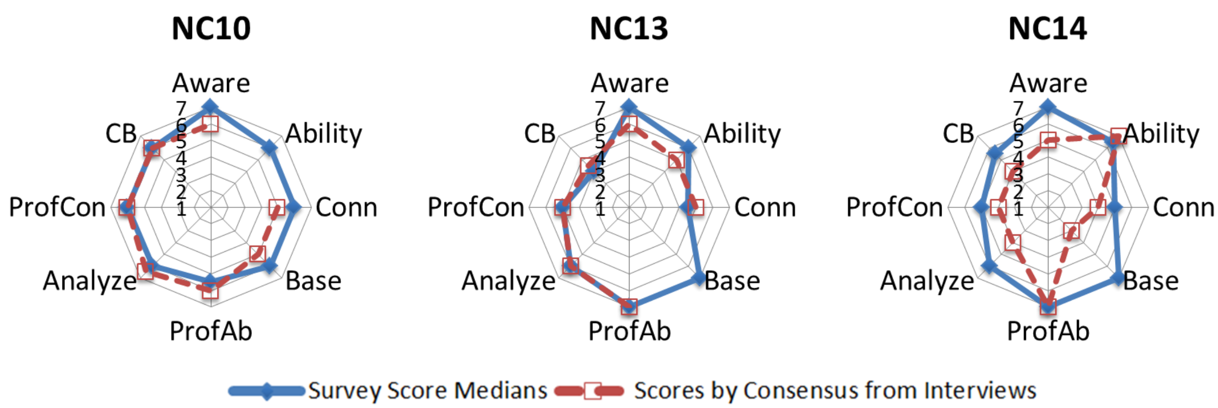



**FIGURE 7. SAMPLE INTERVIEWEE DEGREES OF SOCIAL RESPONSIBILITY AND SURVEY DIMENSION MEDIAN SCORES**

Quantitatively, the correlation and difference between these two methods were examined using the Spearman's rank correlation coefficient and the Wilcoxon signed-rank test, respectively. The data were examined from two perspectives, one focusing the overall correlation for each individual, similar to the plots shown in Figure 7, and the other looking at each of the eight dimensions using all 24 interviewees. Spearman's rho, p-values and Wilcoxon p-values for each interviewee are given in Table 12. Examining the p-values for the Spearman test showed that four of the interviewees had statistically significant ($p<0.05$) correlation between the interview and EPRA construct values. Two more individuals had suggestive correlation ($p<0.10$). Examining the rho-squared valued helps to inform the importance of the correlation, and, of the six interviewees with significant or suggestive correlation, three were 'very important' ($R^2>0.74$ for n=8) and three had fair to low importance ($R^2>0.25$) (Siegel & Castellan, 1988). One of those interviewees with a 'very important' correlation was NC13, supporting what is observed qualitatively using the radar plots. NC10, however, has no correlation per Spearman's rank correlation test because the relationship between the two methods switches, where one is higher for one dimension, but lower for the next, and then back. This 'crossing over' leads to low Spearman values. The Wilcoxon test is used to support a hypothesis of difference. Eighteen samples rejected the hypothesis of difference ($p>0.05$), including five of the six interviewees with correlation from the Spearman test. Therefore, five of the 24 data pairs provide supportive evidence of both correlation and a lack of difference. It is worth noting that the qualitative examination of NC14 from the radar plots was supported by the statistical methods shown here, where the Spearman test showed no correlation and the Wilcoxon test showed difference.

Correlation and difference for each dimension was also examined, similar to above. The relevant values are given in Table 13, as well as construct averages from the EPRA tool across all interviewees. Three of the eight dimensions showed statistically significant ($p<0.05$) correlation from Spearman, two of which were also 'very important' ($R^2>0.406$ for n=24). Three dimensions rejected the hypothesis of difference based upon the Wilcoxon test ($p>0.05$). No single dimension met all three requirements.

**TABLE 13. CORRELATION STATISTICS BETWEEN INTERVIEW AND SURVEY DATA**

| **Dimension** | **Spearman** $R^2$ | **Spearman** p | **Wilcoxon** p | **EPRA Dimension Averages** | **EPRA Dimension Standard Deviations** |
|---|---|---|---|---|---|
| ***Awareness*** | 0.053 | 0.304 | 0.017 | 6.22 | 0.55 |
| ***Ability*** | 0.430 | 0.002 | 0.013 | 5.54 | 0.88 |
| ***Connectedness*** | 0.102 | 0.127 | 0.330 | 5.40 | 0.82 |
| ***Base Skills*** | 0.044 | 0.491 | 0.088 | 6.30 | 0.50 |
| ***Professional Ability*** | 0.067 | 0.224 | 0.007 | 6.17 | 0.62 |
| ***Analyze*** | 0.014 | 0.624 | 0.033 | 5.87 | 0.57 |
| ***Professional Connectedness*** | 0.233 | 0.017 | 0.885 | 5.10 | 0.76 |
| ***Costs/Benefits*** | 0.543 | 0.001 | 0.003 | 5.59 | 0.74 |

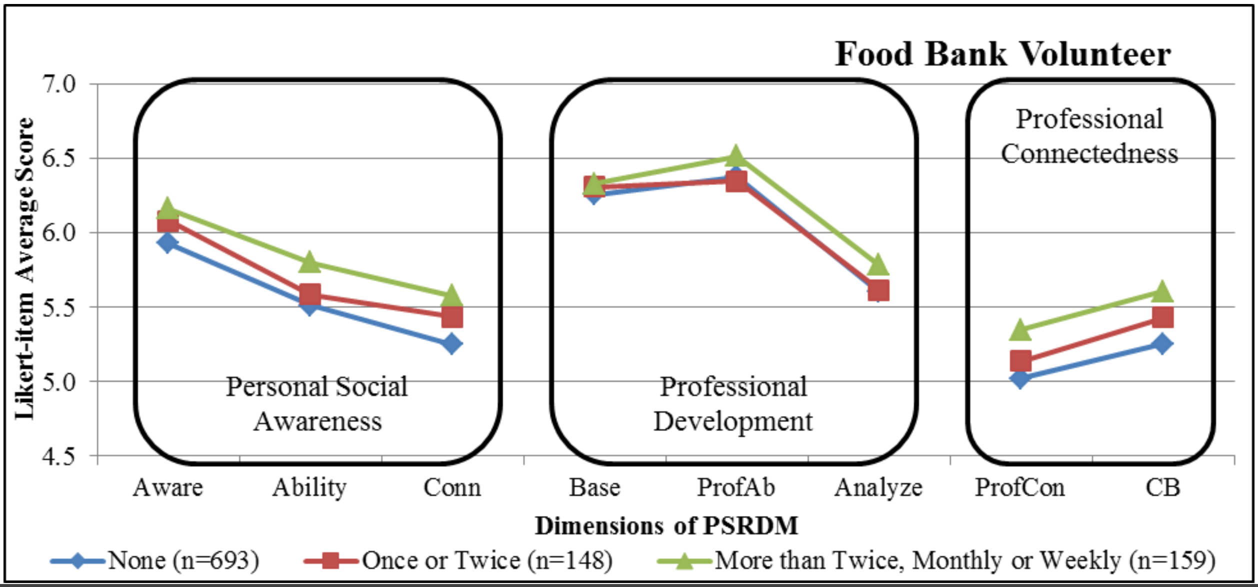
Black cells denote importance and statistical significance from Spearman and rejection of hypothesis of difference from Wilcoxon.

Examining the dimensions with poor Spearman p-values and difference based upon the Wilcoxon test, these dimensions also tended to have higher average scores and lower standard deviations across all interviewees. Perhaps the saturation and narrow distribution on these dimensions, specifically *Awareness* and *Base Skills*, influenced the disparity between the interview ratings and survey responses. Additionally, the interviews were not conducted with this purpose in mind, and therefore the conversations were not focused directly on these base level perspectives. Most of the evidence for both of these dimensions came from peripheral comments, or from examples that the interviewees used in relation to some other topic. Few of the interviewees spoke directly about their awareness that others needed help. Exemplifying this disparity between the interview focus and some of the survey dimensions, there were 11 interviews where no evidence for *Base Skills* was seen by the reviewers. On the other hand, all 24 interviews had some evidence to support a rating for *Professional Connectedness*. Perhaps more focused interviews, with questions directed at perceptions of each dimension, would produce data that would fill in these gaps and provide stronger evidence of agreement across the dimensions.

CORRELATION BETWEEN LIKERT-ITEMS AND VOLUNTEER ACTIVITY - More evidence for external validity can be seen through other elements of the EPRA tool. The PSRDM holds service experiences as a significant contributor to increased social responsibility. Figure 8 shows dimension average scores based upon how frequently students had volunteered at food banks since coming to college (or before college for first-year students). Students who reported having volunteered routinely, or at least more than twice, at food banks (n=159) had statistically significantly higher scores ($p<0.05$) on seven of the eight dimensions of social responsibility than students who had never volunteered at a food bank (n=693), using two-tailed, unpaired t-tests to test significance. They also had statistically significantly higher averages for *Ability*, *Professional Ability*, *Analyze*, and *Professional Connectedness* over other students who had only volunteered once or twice at a food bank (n=148). The students who had volunteered once or twice also had statistically significantly higher scores on three dimensions (*Awareness*, *Connectedness*, and *Costs/Benefits*) over those students who had never volunteered. It is also worth noting that the differences between no volunteer experience and just one or two is in the Personal Social Awareness and the Professional Connectedness realms. Engagement in service activities does not seem to differentiate students in the Professional Development realm, generally.

This same pattern, where those who participated more frequently had higher dimension averages, was seen across most types of volunteer activities supporting correlation between engaging in service activities and increased personal and professional social responsibility in engineering students. As evidence for validity, this supports the relationship between engagement in service, and the personal attributes that EPRA measures in engineering students through Likert-items.

CORRELATION BETWEEN LIKERT-ITEMS AND CAREER ATTRIBUTES - The final element of evidence for external validity is the correlation between students' distribution of stones on the career attributes question and the dimension average scores. As seen in Figure 9, students who placed more than two of their ten stones in the "Helping People" bin (n=389), marking an important attribute of their future career in engineering, had statistically significantly higher scores ($p<0.05$) on every dimension except *Professional Ability*, over students who placed more than two stones in the "Salary" bin (n=411). As evidence of validity, this data supports that a desire to help others correlates with higher degrees of social responsibility as seen from dimension averages from the EPRA tool. Moreover, 283 of the 389 students who placed more than two stones in the "Helping People" bin had that as the highest number of stones of any bin, and another 59 had equal distributions between the "Salary" and "Helping




| t-test results (X denotes p<0.05) | | Aware | Ability | Conn | Base | ProfAb | Analyze | ProfCon | CB |
|---|---|---|---|---|---|---|---|---|---|
| **None** | Once or Twice | X | | X | | | | | X |
| | More than Twice | X | X | X | | X | X | X | X |
| **Once or Twice** | More than Twice | | X | | | X | X | X | |

**FIGURE 8. DIMENSION AVERAGE SCORES BY VOLUNTEER FREQUENCY AT FOOD BANKS**

People" bins, both greater than two. Therefore, for 283 of the respondents, "Helping People" was the most important career attribute when they considered their future engineering pathways, and this correlates well with higher degrees of social responsibility across almost every dimension of the EPRA tool.

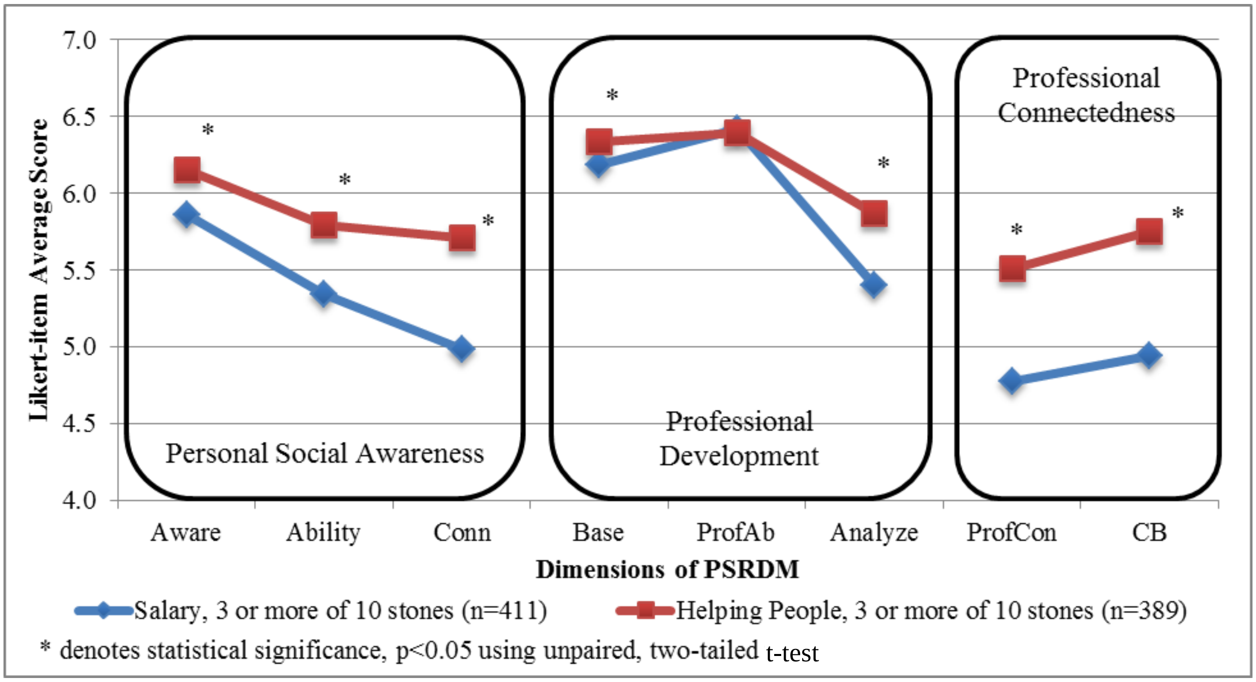



**FIGURE 9. DIMENSION AVERAGE SCORES BY STONE DISTRIBUTION ON "BINS" QUESTION - MORE THAN 2 STONES IN "SALARY" OR "HELPING PEOPLE"**

## CONCLUSION

The EPRA tool has been developed to assess degrees of personal and professional social responsibility in engineering students, operationalizing the PSRDM framework. This paper has presented evidence of reliability for this instrument using the Ordinal alpha, with 'acceptable' reliable shown for three dimensions and 'good' reliability shown for the remaining five dimensions. Evidence of construct validity has been given through MIRT, showing how the relative difficulties of items follow the developmental progressions set forth by the PSRDM, whereby dimensions such as *Awareness* or *Base Skills* have items which are easier to ascribe to than items from dimensions that require higher social responsibility, such as *Connectedness* or *Professional Connectedness*. This supports the theory that there are threshold levels of agreement with 'lower' dimensions, which build foundations for agreement to 'higher' dimensions. Finally, further evidence of validity was provided by looking at external sources and comparing students' performance or stated beliefs with average dimension scores for each of the eight dimensions from the EPRA tool. The interview analysis showed that there was significant and important correlation and a lack of difference for five students across all dimensions, providing evidence that perceived degrees of social responsibility aligned well between the interviews and the Likert-items from EPRA. This analysis also showed that three of the eight dimensions had significant correlation across all interviewees, and three rejected the hypothesis of difference. Other elements within the EPRA tool itself showed that engagement in volunteer activities correlate with higher degrees of social responsibility as measured by the Likert-items. Similarly, students' preference towards "helping people" as an attribute of their future careers correlated with higher degrees of social responsibility as measured by the Likert-items. Together, these elements provide good evidence supporting the claim that the Likert-items from the EPRA tool are measuring social responsibility and are able to differentiate between varying degrees of agreement with the eight dimensions which form the foundation of the PSRDM. This tool could be used to assess curricular interventions or extracurricular activities designed to have positive effects on the development of personal and professional social responsibility in engineering students.

## Future Work

While the results given here provide good evidence of reliability and validity, especially at this developmental stage, there is room to improve the strength of the EPRA tool. From the Rasch model Thurstonian Threshold graphs, it was evident that, for many items, the entire Likert scale is not being used. The wording and usefulness of these questions should be re-examined, perhaps changing the wording or adding new questions that would guide students to use the entire scale. While the use of interviews in this study provided some evidence for validity, more focused interviews could be more useful towards providing strong and clear qualitative support for student views related to each construct. Data from these interviews could also be compared to the latest version of EPRA, hopefully providing stronger evidence of validity. Finally, the very use of Likert-items to measure degrees of social responsibility could be further examined. Perhaps future iterations of this tool or new tools could move to a behaviorally-anchored assessment, examining more deeply the connection between actions and the development of social responsibility in engineers.

## ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1158863. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. Additional funding was provided through an institutional fellowship for Excellence in STEM Education. This research is only possible because of the institutional support to distribute the survey, the students who took time to honestly complete the survey and those who engaged in interviews with the researcher. Additionally, in gratitude to Dr. Littlejohn and Dr. Maul from the College of Engineering and the School of Education, respectively, for guidance on appropriate statistical methods for reliability and validity of this instrument.

# CHAPTER V

# ADDRESSING THE GENDER GAP IN ENGINEERING THROUGH A LENS OF SOCIAL RESPONSIBILITY


## ABSTRACT

BACKGROUND – The number of students studying engineering has decreased in recent decades, but finding ways to bring more women into engineering could increase both the size and the diversity of the profession. Multiple studies point to a desire to have a positive impact on society as a strong motivator for many women to study engineering and a possible avenue to increase attraction and retention in engineering.

PURPOSE/HYPOTHESIS – This study focuses on beliefs of social responsibility as a differentiating element between female and male engineering students, and as a potential focus that could help increase the attraction and retention of women to engineering.

DESIGN/METHOD – The Engineering Professional Responsibility Assessment (EPRA) tool was distributed to Civil, Environmental, and Mechanical engineering students at five institutions. One thousand responses and 698 responses were obtained at the beginning and end of the academic year, respectively. Average Likert-item scores were examined by gender, as well as academic rank and major, using two-tailed t-tests to assess differences.

RESULTS – Overall, women had higher degrees of social responsibility than men. Social responsibility was highest among females majoring in Environmental over Civil and Mechanical engineering and for first-year students over senior and graduate students. Women generally volunteered in more activities and more frequently than men, which correlated with higher scores on the EPRA tool.

CONCLUSIONS – Because women in engineering show stronger beliefs of social responsibility, perhaps increasing the ways in which social responsibility is advertised and realized in engineering could be a way to increase the attraction and retention of women into the field.

## INTRODUCTION

The consistent and relatively low percentage of women in engineering programs compared to some other Science, Technology, Engineering, and Mathematics (STEM) fields is alarming and necessitates the examination of individual and systemic elements which could be contributors to this disparity. In the life sciences and mathematics, for example, the percentage of women has reached, or in some cases exceeded, parity (Hill, Corbett, & St. Rose, 2010), whereas women engineers earn only 18% of total degrees, and as low as 10% within some disciplines (Yoder, 2012). The ways in which gender plays into engineering pathways are complex. Females and males are not homogeneous groups, the effects of socialization influence gendered views of roles and beliefs from early on in an individual's life, and each individual has unique positive and negative experiences which influence her/his choices. Whatever the causes, this lack of diversity in engineering restricts the profession's ability to fully address many of the complex problems which face society and is a pressing issue for the profession as a whole (Wulf, 1999).

The role that the engineering educational system plays in increasing the number of women in engineering is similarly complex. Previous studies have focused on many elements related to gender in engineering pathways, including STEM education in primary and secondary schools (Hill, Corbett, & St. Rose, 2010), the public perception of engineering as a field (National Academy of Engineering, 2008), positive or negative elements of the engineering culture (Chachra, Chen, Kilgore, & Sheppard, 2009; Amelink & Creamer, 2010; Tonso, 2006), student motivations (Meyers & Mertz, 2011; Brawner, Lord, & Ohland, 2011), and many others. This study was inspired by results which point to the desire to help society as a significant motivator for women to pursue STEM fields (Hill, Corbett, & St. Rose, 2010; Romkey, 2007; Eccles, 2006; Canney, Bowling, & Bielefeldt, 2013; Hewlett, et al., 2008).

Gender in engineering is examined through the lens of personal and professional social responsibility. To assess student beliefs of social responsibility, the Engineering Professional Responsibility Assessment (EPRA) tool was distributed to engineering students in three majors at five different institutions. The results from this distribution were analyzed with respect to gender differences in Likert-items as well as volunteer histories, reasons for choosing their major, and relative importance of job attributes for their future careers. The following research questions are addressed in this paper using these data:

1. Are there differences between female and male engineering students with respect to beliefs of personal and professional social responsibility?
2. If there are gender differences in views of social responsibility, could previous volunteer experiences, choice of major, or views of a future engineering career help explain those differences?

# Background

## Importance of Diversity in Engineering

Many professional societies in engineering have spotlighted the need for more diversity in engineering in order to address the complex and multifaceted problems that society faces (National Academy of Engineering, 2005; American Society for Civil Engineering, 2008; Augustine, et al., 2010). The diversity that is needed is both within the individual, and in the profession as a whole. Within the individual, there is a need for a well-rounded set of skills, including both technical and professional skills, and dispositions which help an engineer to recognize the broader impact of her/his work. The need of this sort of disposition is highlighted in the American Society for Civil Engineering's (ASCE) Body of Knowledge (American Society for Civil Engineering, 2008), which contains, among other things, a focus on attitudes, recognizing that the attitude of an engineer affects the manifestation of her/his technical and professional knowledge in the world. The following attitudes are listed as key to the effective practice of civil engineering: consideration of others, fairness, honesty, integrity, judgment, positiveness, respect, sensitivity, thoughtfulness, thoroughness, and tolerance. These attributes align strongly with the Ethic of Care philosophy (Gilligan, 1982; Held, 2006) which forms the basis of EPRA. They are also attitudinal characteristics which are more associated with women from Socialization theory (Zelezny, Chua, & Aldrich, 2000), supporting the need for more women and feminine qualities in engineering.

At the professional level, the former president of the National Academy of Engineering, William Wulf, highlighted the detrimental effects for engineering without diversity, saying "sans diversity, we limit the set of life experiences that are applied, and as a result, we pay an opportunity cost in products not built, in designs not considered, in constraints not understood, in processes not invented" (Wulf, 1999, p. 2). Others have pointed to historical instances where engineering designs which were developed from a narrower range of life experiences produced dangerous results, such as car airbags which were designed to resist an average male's body, but proved harmful to women and children (Hill, Corbett, & St. Rose, 2010). Aiding in the attraction and retention of women in engineering is a key element towards the profession reaching its full potential.

## Women in Engineering

The issues of women in engineering has been examined from many different perspectives, but central to this study are results which point to a desire to help society or help others as a key motivating factor for women to pursue STEM fields. A majority of women in STEM professions (63%) cited "…a desire to contribute to society's health and well-being…" (Hewlett, et al., 2008, p. 14) as the main reason they chose their career. Similar results have been seen for students choosing to study engineering (Meyers & Mertz, 2011). Not all engineering is viewed the same, however. Some engineering majors which appear to have "… a clearer social purpose, such as Biomedical Engineering and Environmental Engineering…" (Hill, Corbett, & St. Rose, 2010, p. 23), also have much higher percentages of women in them than other engineering majors like Mechanical and Electrical Engineering (Yoder, 2012). This suggests that engineering with a "clear social purpose" may be better equipped to achieve gender parity; a message which could apply to each engineering discipline in different ways.

There have been several educational approaches proposed as ways to tie a social purpose into engineering education, notably Service-Learning and Science, Technology, Society, and the Environment (STSE) (Romkey, 2007) pedagogies. Service-Learning helps to improve confidence in engineering skills among female students (Wang, Patten, Shelby, Ansari, & Pruitt, 2012), which is an influencing factor in persistence (Seymour, 1995). Service-Learning is also an effective source for learning professional and technical skills for women, more so than men (Carberry, 2010). Additionally, alignment between one's personal and engineering identities is a key element for retention (Matusovich, Streveler, & Miller, 2010), so if a personal desire to help society connects many women to engineering preliminarily, it is even more critical to adopt educational approaches which clearly tie social good into engineering education, such as Service Learning (Litchfield, Javernick-Will, & Paterson, 2013). More broadly, Service-Learning has also been tied to increases in social responsibility, global awareness, and altruistic attitudes, all critical components for creating a more diverse profession (Ariely, Banzaert, & Wallace, 2005; Astin, Vogelgesang, Ikeda, & Yee, 2000; Kezar, 2002). Ideas of service and responsibility to contribute to society are integrally tied into perspectives of social responsibility for the engineering profession. Therefore, examining social responsibility may provide an effective way to capture, at a deeper level, why service learning appears to be more attractive and affective for female engineering students.

## Social Responsibility in Engineering

This study uses the lens of personal and professional responsibility to address the role of the engineer in society. Social responsibility in engineering is seen as an obligation to consider the full ramifications of engineering design on society with special consideration given to parties whose voices may not be a part of the design process. In Humanitarian Engineering, for example, social responsibility would manifest itself by including the community as a partner in the conception, design, implementation and maintenance of engineering projects such as water filtration systems (Donwey, et al., 2006). In civic design, social responsibility would manifest itself by the engineer working with the neighborhoods that would be positively and negatively affected by the civil system, such as a freeway off-ramp or a waste water treatment plant, taking both opinions into her/his design. In general, social responsibility in engineering guides engineers to design with "care and objectivity" (Moriarty, 1995), taking measures to fully consider the perspectives of others and striving to incorporate those perspectives into their designs. Personal social responsibility relates to how these value orientations plays into one's personal life, and professional social responsibility relates to how they play into one's professional life (Canney & Bielefeldt, 2013).

The Professional Social Responsibility Development Model (PSRDM) is a framework which describes the development of social responsibility in engineering students, with a focus on an obligation to act with care and objectivity throughout the engineering process (Canney & Bielefeldt, 2013). One important aspect of the PSRDM with respect to the retention of women in engineering is the alignment between the personal and engineering identities. The PSRDM is comprised of three realms, the first realm (Personal Social Awareness) addresses one's personal beliefs of social responsibility, the second realm (Professional Development) addresses the development of engineering skills and perspectives to include social elements, and the third realm (Professional Connectedness) addresses how those personal beliefs tie into one's professional beliefs of social responsibility. The Personal Social Awareness and Professional Connectedness realms, in particular, are interesting to examine because they address how one's personal views align with one's professional views, which has been seen as a key element with respect to identity formation and retention (Matusovich, Streveler, & Miller, 2010). A lens of social responsibility is well suited for this study also because of the potentially positive effects of service and the inclusion of social aspects in engineering to the attraction and retention of women as suggested in previous studies.

By examining student beliefs of social responsibility, this study builds upon previous research which points to a desire to have an impact on society as a key reason for women to choose STEM fields. This study examines if views of social responsibility differ between men and women and, if so, what may be some causes of those differences. Overall, this study makes new contributions to the conversation of gender in engineering by examining differences through a new lens, social responsibility, and by correlating other behaviors and beliefs with those views. These results set possible trajectories for future studies, to go deeper into how beliefs of social responsibility influence the attraction and retention of women in engineering.

## METHODS

Data for this study came from a pre-post distribution of the EPRA tool to first-year, senior, and graduate students in Civil, Environmental, and Mechanical Engineering programs at five universities.

### SURVEY INSTRUMENT

EPRA is a survey instrument with strong evidence of reliability and validity, which was designed to assess beliefs of personal and professional social responsibility in engineering students (Canney Dissertation, Chapter IV). The tool consists of 50 Likert-items which map to eight dimensions of social responsibility based upon the Professional Social Responsibility Development Model (PSRDM) (Canney & Bielefeldt, 2013); each dimension is summarized in Table 14. These eight dimensions describe the development of social responsibility through three realms: Personal Social Awareness, Professional Development, and Professional Connectedness. Seven-point Likert-items were used, ranging from “Strongly Disagree” to “Strongly Agree” except on eight items where students were asked to rate the perceived importance of certain skills for a professional engineer; these items ranged from “Very Unimportant” to “Very Important.” Likert-item data were compared using average scores and two-tailed t-tests on item sets for each dimension, consistent with (Sarle, 1995) and (Baker, Hardyck, & Petrinovich, 1966). Student responses to negatively worded items were reversed prior to calculating averages and t-tests.

Other elements of EPRA include a question about the importance of different career attributes to students when thinking of their future engineering career, a question about students' previous volunteer experiences, motivations and limitations for volunteering, and demographic information. The career attributes question asked students to signify the importance of different career attributes by distributing ten 'stones' among eight 'bins' labeled with different career characteristics. The eight labels were "Salary", "Help People", "Working on Industrial/Commercial Projects", "Working on Community Development Projects", "Living Domestically", "Living Internationally in a *Developed* Country", "Living Internationally in a *Developing* Country", and "Own your Own Business (Be Self-Employed)", and were developed from emergent coding of previous open ended questions related to this topic. Frequency distributions of stones based upon demographics and social responsibility scores from Likert-items are compared.

For the survey administered at the beginning of the academic year, an open ended question was added which asked students to "Briefly describe any events that have influenced your views of community service and social responsibility." When the EPRA assessment was given to the same students near the end of the same academic year, three different open ended questions were asked in order to investigate emerging trends seen from the pre- distribution data. One question related to factors which influenced students' choice of major, another asked students about individuals who had been influential to their views of social responsibility, and the third asked if there were any classes in the previous year which had been influential to those views. Responses to each were analyzed using inductive coding methods, where themes were allowed to emerge from the data, and then each response was coded using those themes. Code frequencies were later correlated to demographic information for each respondent. Data from each of these survey elements were used to paint a larger picture of student views of social responsibility and of behavioral and influential differences by gender which may correlate with any variance in perspective of social responsibility

**TABLE 14. EIGHT DIMENSIONS OF THE PSRDM (FROM CANNEY DISSERTATION, CHAPTER IV)**

| Realm | Dimension | Definition |
|---|---|---|
| **Personal Social Awareness** | *Awareness* | An awareness that others are in need |
| | *Ability* | A recognition that one has the ability to help others |
| | *Connectedness* | A feeling of moral obligation, responsibility, or social requirement to help others |
| **Professional Development** | *Base Skills* | With an expectation that all engineers value the technical skills, this dimension focuses on views of professional skills (i.e. communication, lifelong learning, teamwork, management, ethics, professional responsibility, understanding social and global impacts of engineering, etc.) and the role that they play for a professional engineer. |
| | *Professional Ability* | A recognition that engineers or the engineering profession has the ability to help others and/or solve social issues |
| | *Analyze* | A recognition of the importance of including social aspects in the engineering process, including community feedback, a broad sense of stakeholders, etc. |
| **Professional Connectedness** | *Professional Connectedness* | Addresses issues of responsibility or obligation that an engineer or the engineering profession may have to help solve social problems or help others |
| | *Costs/Benefits* | Discussion of the costs and/or benefits associated with engaging in socially responsible behavior, such as service. |

## STUDY PARTICIPANTS

For this study, the pre- assessment was conducted within the first month of the 2012 Fall term, and the post- assessment was conducted in March and April of the 2013 Spring term. Students at five diverse universities were solicited for this study. Three of the schools were public, one private and one was a military academy. Schools ranged in size from 4,500 to over 30,000 students, and one was a predominately engineering institution. These schools were selected because they represented a range of institutional characteristics, and each of them had some form of engineering service either embedded in their courses or through active extracurricular organizations. Response numbers and demographic breakdowns for both the pre- and post- surveys are given in Table 15.

The survey was sent electronically to first-year, senior, and graduate students in Civil, Environmental, and Mechanical engineering programs. These academic ranks were chosen because they generally represent the beginning and end of a students' academic career, and they are also the years most likely to include projects or service-learning which would expose students to the social elements of engineering. Mechanical Engineering was chosen because it represents the largest engineering major nationally (Yoder, 2012) and Civil and Environmental Engineering were chosen because the work in these majors seems to most clearly relate engineers to society and societal improvement. Additionally, Environmental Engineering programs have a larger representation of female students (44%) than engineering as a whole (Yoder, 2012). Students were solicited via departmental email lists for the pre- survey, and then students who completed at least 90% of the pre- survey were again solicited for the post- survey using respondent volunteered emails. A $5 gift card was given to students who completed the pre- survey and another $10 gift card to those who completed the post- survey.

**TABLE 15. EPRA PRE- AND POST- PARTICIPANTS**

| | Fall 2012 Pre- | | | | Spring 2013 Post- | | | |
|---|---|---|---|---|---|---|---|---|
| | # of Students | % Female | Approx. Response Rate | Female Response Rate | # of Students | % Female | Total Response Rate* | Female Response Rate |
| **Total** | 1000 | 31% | 28% | 42% | 698 | 34% | 68% | 75% |
| | | | | | | | | |
| **1st-Year** | 236 | 32% | 27% | 34% | 147 | 34% | 61% | 68% |
| **Senior** | 344 | 27% | 25% | 32% | 222 | 30% | 67% | 71% |
| **Graduate** | 315 | 40% | 30% | 60% | 273 | 40% | 77% | 81% |
| | | | | | | | | |
| **Civil** | 262 | 32% | 24% | 33% | 180 | 34% | 65% | 69% |
| **Environmental** | 182 | 54% | 47% | 48% | 131 | 57% | 70% | 73% |
| **Mechanical** | 474 | 22% | 23% | 37% | 340 | 23% | 69% | 83% |
| **Other** | 82 | 29% | - | - | 47 | 47% | 58% | 64% |

*Note: On the pre- survey, students were asked to select a specific response on one Likert-item as a check. Students who did not appropriately answer this question but competed more than 90% were removed from analysis in the pre-survey, but they were still solicited in the post survey, bringing the total number of students emailed for the post to 1029.

Overall, women were overrepresented in this sample, making up 31% of the respondents compared to 18.4% of engineering degrees earned nationally (Yoder, 2012). This overrepresentation comes both from sampling Environmental Engineering programs which have a higher percentage of female students nationally (44%) and also from higher response rates from female students (75%) than male students (65%) in the post- data set, which is consistent with findings from previous studies (Smith W. G., 2008). The proportion of female respondents within each major was representative of national statistics (though higher due to higher female response rates) which show that women earned 44%, 21%, and 12% of the total degrees in Environmental, Civil, and Mechanical Engineering, respectively (Yoder, 2012).

# RESULTS

## RESEARCH QUESTION 1: DIFFERENCES IN SOCIAL RESPONSIBILITY BY GENDER

The first research question in this study asked if there were differences in views of social responsibility between male and female students. Average scores on each of the eight dimensions of the PSRDM for male and female engineering students are shown in Figure 10, using data from the pre- distribution. The majority of respondents to the Likert-items answered mainly in the positive half of the scale; therefore graphs which show Likert-item averages only show the upper half of the Likert-scale on the y-axis. Female students had statistically significantly higher averages (p<0.01) than male students on seven of the eight dimensions using unpaired, two-tailed t-tests. In general, the differences seen by gender were more pronounced than differences seen between any other demographic categories gathered in this data set. The largest differences were seen in the Professional Connectedness realm, where female student averages were nearly a half point higher on the seven-point Likert-scale for both dimensions. This realm addresses the connections between one's personal and professional views of social responsibility, suggesting that women, on average, not only have stronger personal beliefs of social responsibility (seen in the Personal Social Awareness realm), but they also connect those views more strongly with their professional views than men do.

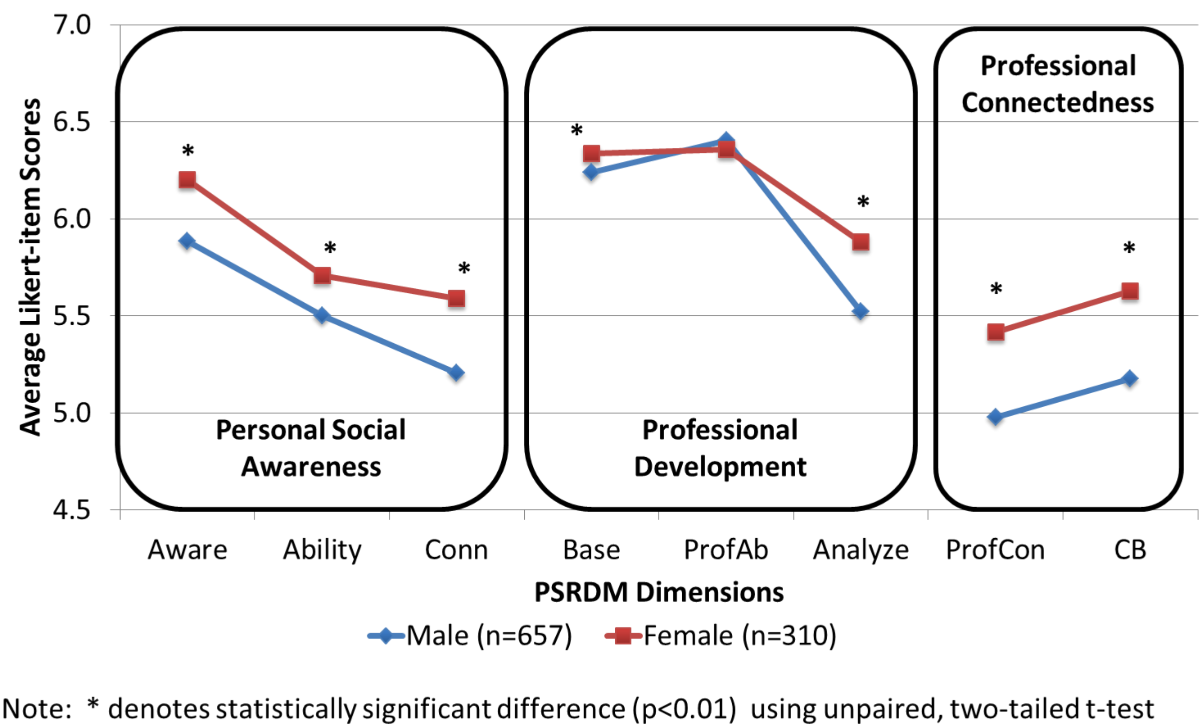



**FIGURE 10. EPRA DIMENSION AVERAGE SCORES BY GENDER**

Examining the Likert-items closer showed that there were nine questions in total with a difference greater than 0.5 between female and male student averages. All but one of these questions were in the *Professional Connectedness* and *Costs/Benefits* dimensions. There were only two questions where average scores for males were higher than females ("Technology does not play an important role in solving society's problems", Δ=0.07 and

"Engineers have contributed greatly to fixing problems in the world", Δ=0.21) and both were in the *Professional Ability* dimension. Figure 11 shows the percentages of men and women who answered each of the seven Likert-item options for five of those nine questions. Each of these questions relate to perceptions of career and service. Three more questions with differences greater than 0.5, but related to volunteering, are shown in Figure 16, and will be discussed later. Note that in Figure 11 the original response distributions for ProfCon8 are shown, which was a negatively worded item.

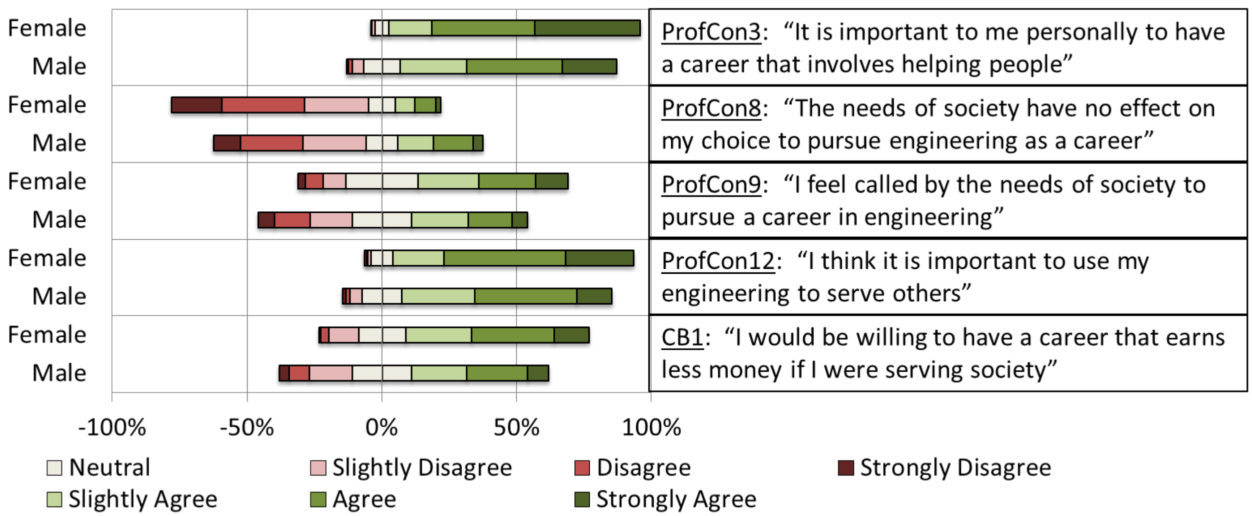



**FIGURE 11. FREQUENCY DISTRIBUTIONS FOR EPRA QUESTIONS RELATING TO CAREER WITH DIFFERENCES BETWEEN FEMALE AND MALE STUDENTS GREATER THAN 0.5**

The question with the greatest difference, ProfCon8, showed that 31% (n=206) of male students agreed to some degree that the needs of society had no effect on their choice to pursue engineering, while only 17% (n=52) of female students similarly agreed to some degree. Sixty-eight percent (n=311) of the female students agreed to some degree that they would be willing to sacrifice salary in order to have a job which they felt was serving society (CB1), compared to 51% (n= 333) of male students. In other words, 49% of male respondents were neutral or disagreed about their willingness to sacrifice salary in order to have a career that was serving society. It is interesting that the questions which emerged with the largest differences between men and women mostly related to perceptions of helping people through one's career, or the effects of volunteering on one's career. These data suggest that a desire to align one's career with personal desires to help society is more important to female engineering students than male students.

CHANGES THROUGH ACADEMIC RANKS - The research team was further interested in differences in views of social responsibility across academic ranks. Figure 12 shows differences between male and female student average scores for first-year, senior, and graduate engineering students from the pre- data set. Positive values show female averages that were higher than male averages within the same academic rank. Statistical significance is noted on the figure for both the 95% and 99% thresholds.

The greatest differences by gender were seen in first-year students, generally in the Personal Social Awareness and the Professional Connectedness realms. Differences between male and female students for senior and graduate students were generally lower, suggesting that male and female beliefs of social responsibility become more similar after progressing through their engineering program or due to the selective attrition of some female students with higher social responsibility. Except for averages for senior and graduate students in the *Professional Ability* realm, female students consistently have higher averages than male students across all academic ranks.

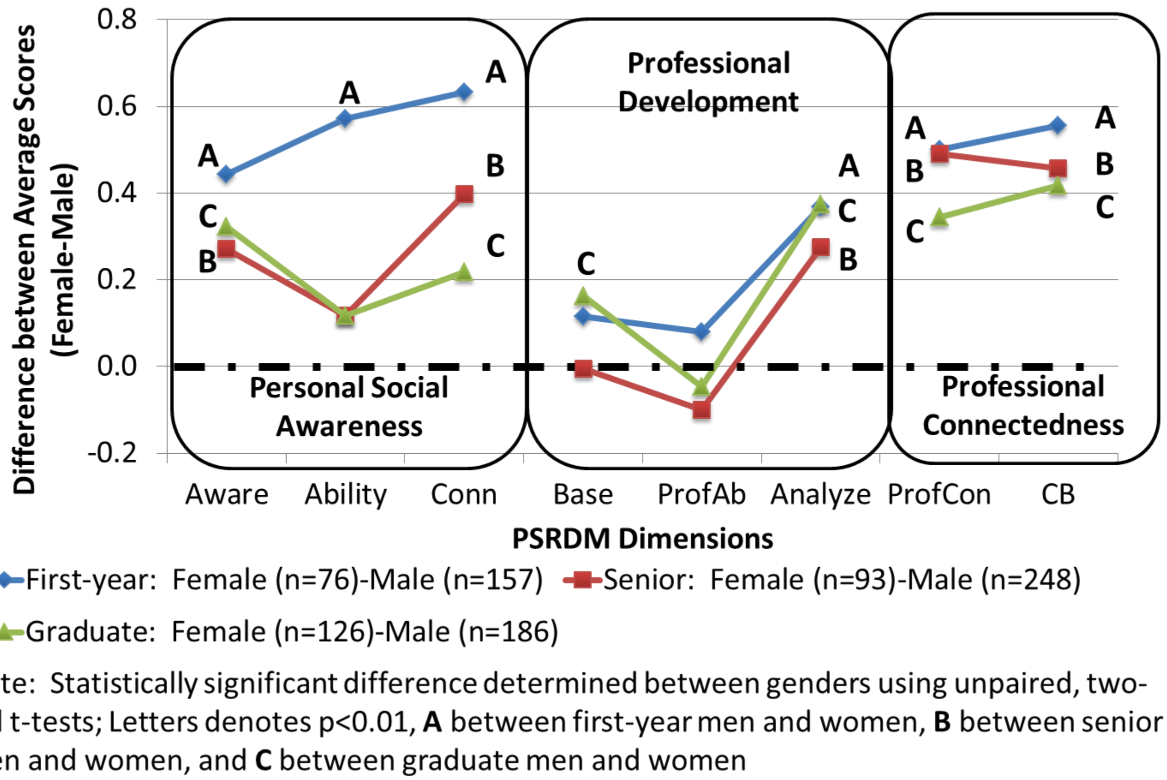



**FIGURE 12. DIFFERENCES IN EPRA DIMENSION SCORES BETWEEN FEMALE AND MALE STUDENTS BY ACADEMIC RANK**

Though this data set was not longitudinal across years, these results could suggest potential impacts of college and life experience on views over time. Alternatively, differences might be attributable to which students persist within the three engineering majors or interest and/or self-select to continue to graduate studies. Differences might have been due to the cohorts in general; the seniors and graduate students having entered college more than 3 years prior to the first year students and may have started with different views.

Looking closer at the pseudo-longitudinal data, Figure 13 shows average scores for each dimension for men and women from both the pre- and post- surveys. This perspective gives insight into how, on average, student views of each dimension differs through the undergraduate and graduate years. For each dimension in the Personal Social Awareness realm (*Awareness*, *Ability*, and *Connectedness*), average scores for female students where higher for students entering college (First-year pre-) than for those who were finishing (Senior post-). Graduate student scores were similar or slightly higher for these dimensions than senior student scores. This is in contrast to male students whose scores were more similar across the academic ranks. With respect to one's ability to help others (*Ability*) first-year women had higher beliefs of their ability to help others than first year men, but looking at the senior year, women's beliefs in their ability to help was lower by nearly half a point than their first year counterparts, becoming about the same as male students. This difference was statistically significant ($p<0.05$) between the first-year pre- and post- and between the first-year post- and senior pre- female survey populations. The difference between the first-year post- and senior pre- female survey populations for *Connectedness* was also statistically significant ($p<0.01$).

For the Professional Development realm, average scores for the *Base Skills* and *Professional Ability* dimensions were high for both male and female first-year and senior students. With the exception of the senior post-average for *Base*, the average scores for males and females were similar in both of these dimensions as well. Scores for the *Analyze* dimension, however, were higher for both male and female students at higher academic ranks, most notably in graduate students. This suggests that perhaps students' recognition of the importance of considering social elements in engineering design grows through their academic career, potentially reflecting positive contributions from their academic experiences towards the development of social responsibility. In fact, *Base Skills* and *Analyze* were the only dimensions where female student had higher averages between the first-year pre- and senior post- and graduate post-; average scores for all other dimensions were lower by the end of the senior and graduate years than they were for the first-year female students.

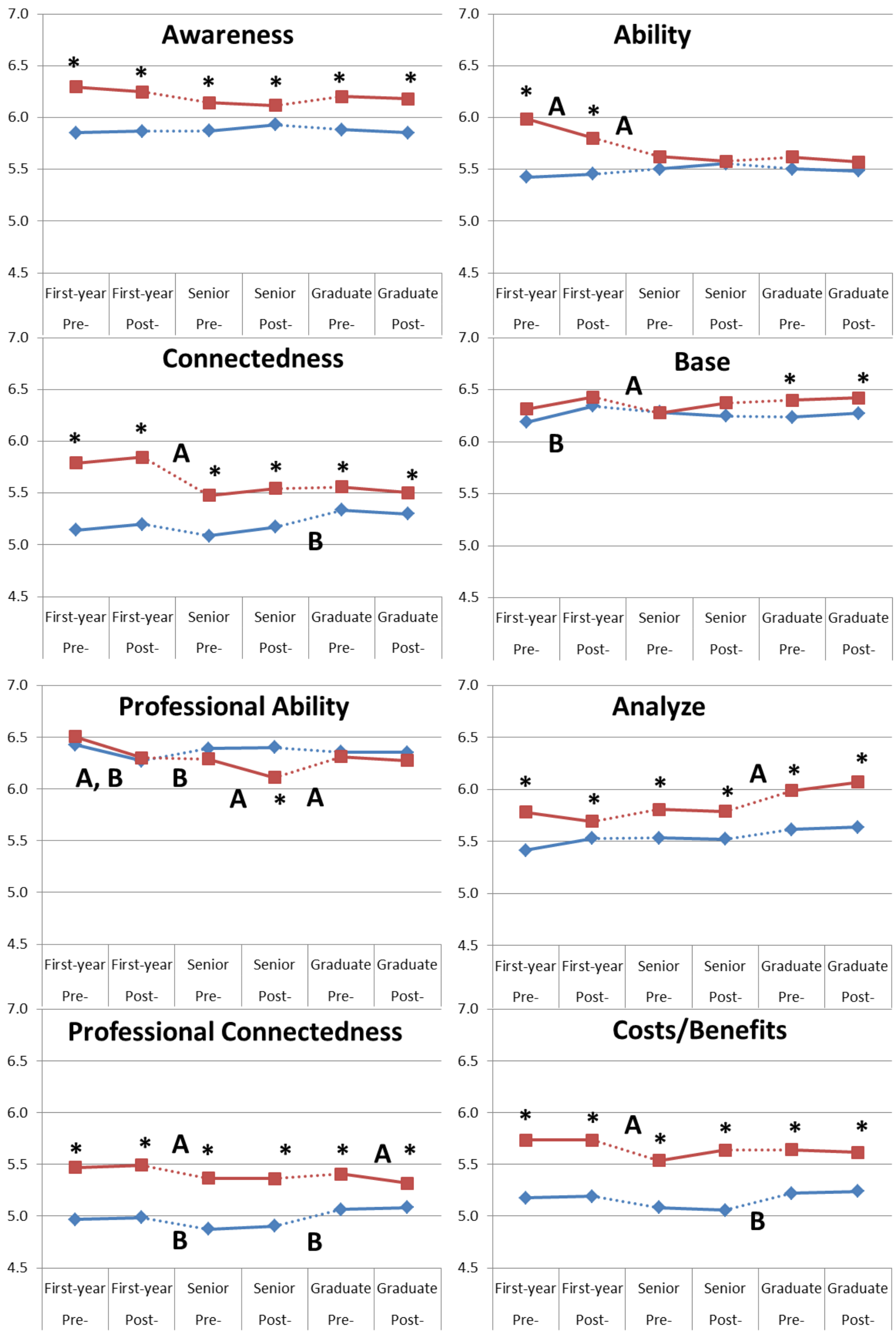
For both dimensions in the Professional Connectedness realm (*Professional Connectedness* and *Costs/Benefits*), average scores for both female and male students were lower between the first-year post- and senior pre- populations. For male students, the average scores for graduate students was again, higher than seniors (statistically significant between senior post- and graduate pre-, $p<0.01$ for *Professional Connectedness* and $p<0.05$ for *Costs/Benefits*), but female student averages were similar or lower for graduate students (statistically significant between graduate pre- and graduate post-, $p<0.05$ for *Professional Connectedness*).

Examining the true longitudinal data, comparing pre- and post- data across the same survey respondents (n=698) using paired, two-tailed t-tests, showed similar findings. In general, female student averages decreased significantly ($p<0.05$) for the *Ability* ($\Delta$= -0.07), *Professional Ability* ($\Delta$= -0.13), and *Professional Connectedness* ($\Delta$= -0.06) dimensions, with the drop in first-year and senior female students contributing most prominently to the results for the *Professional Ability* dimension. Male students had statistically significant gains only in *Base Skills* ($\Delta$= +0.05, $p<0.05$) and no statistically significant decreases.

## Research Question 2: Contributing Factors to the Development of Social Responsibility among Women and Men

The second research question explores potential differences in the behaviors and aspirations of female and male engineering students as possible explanations for differences in social responsibility. Three elements of the EPRA data were examined toward answering this research question: views and experiences of volunteering, responses to why students chose their major, and responses to the relative importance of different job attributes.

Volunteering – Engaging in service activities is a central aspect of the PSRDM with respect to advancing beliefs of personal and professional social responsibility (Canney & Bielefeldt, 2013). Volunteering has been shown to have positive effects on many elements of personal development, including academic performance, values development, self-efficacy, and leadership (Astin, Vogelgesang, Ikeda, & Yee, 2000; McCormick, Swan, & Matson, 2008). From the pre- survey, students were asked to briefly describe events which had influenced their views of community service and social responsibility. Over half of the respondents, both male and female, referenced




**A** denotes statistical significance (p<0.05) between Female students at different academic ranks
**B** denotes statistical significance (p<0.05) between Male students at different academic ranks
* denotes statistical significance (p<0.05) between Female at Male students at same academic rank

FIGURE 13. PSEUDO-LONGITUDINAL AVERAGE SCORES BY GENDER FOR EACH DIMENSION

previous service experiences as a key influencing factor towards their development of social responsibility. These guided the research team to look at potential differences in previous volunteer experiences as an explanation for the measured differences in social responsibility between male and female students.

Previous volunteer activities for incoming first-year students were examined because that is where the largest difference between male and females students was seen. On the EPRA survey, students were asked to indicate how frequently they had volunteered with a list of options prior to coming to college, shown in Figure 14. Frequency options were "Have not Participated", "Once", "Twice", "More than twice but not routinely", "Monthly" or "Weekly".

Nearly half of the activities listed had very low participation rates (<25% for seven of the 15 activities). Tutoring elementary and secondary students was the most common form of volunteering for both female and male students prior to entering into college, though a higher percentage of the female students (71%) than male students (59%) had done some tutoring. Food bank and soup kitchen volunteering were the next two most common activities. Overall, female students reported engaging more in volunteer activities in all but one category (donating blood), and generally with higher frequencies; this result is similar to that of previous studies (Wilson, 2000). It is plausible, then, that the differences between male and female engineering students in beliefs of social responsibility could be partially due to different levels of participation in prior volunteer activities. Alternatively, differences in social responsibility views could have motivated the differences in participation in volunteer activities.

In order to explore the relationship between volunteering and social responsibility scores, a weighting system was used based upon the frequency with which an individual engaged with different activities, shown in Table 16. This weighting system was used to approximate the amount of time, energy and commitment required to engage at each frequency, recognizing that doing an activity weekly requires more, generally, than doing an activity once, and that the relationship is non-linear. Scores for each student were calculated by summing the weighted frequency values for each activity. For example, if a person had volunteered twice with a soup kitchen and monthly at Habitat for Humanity, their score would be 22 (2+20).

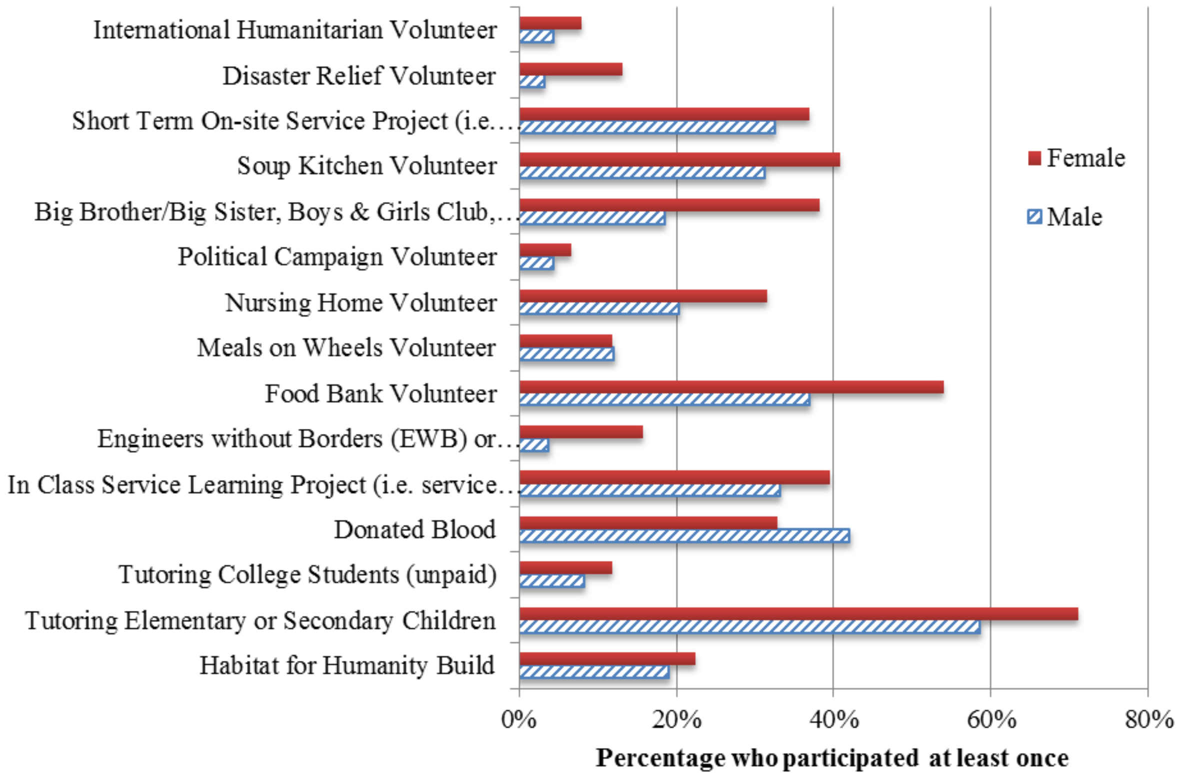



**FIGURE 14. PRE-COLLEGE VOLUNTEER ACTIVITIES FOR FIRST-YEAR ENGINEERING STUDENTS, SEPARATED BY GENDER**

**TABLE 16. VOLUNTEER FREQUENCY WEIGHTING SYSTEM**

| Volunteer Frequency | Weighted Score |
|---|---|
| **Once** | 1 |
| **Twice** | 2 |
| **More than twice but not routinely** | 5 |
| **Monthly** | 20 |
| **Weekly** | 50 |

This weighting system neglected to account for the difference between various activities under the belief that any volunteering would be beneficial. This assumption was examined by looking at each volunteer activity individually, and it was seen that, generally, the same pattern emerged whereby the frequency differentiated EPRA scores more than the activity itself. For this reason, no weighting system was used to differentiate between different forms of volunteering, though future work may with so revisit this assumption. See Appendix F for more discussion on this point.

Figure 15 shows average scores for the *Costs/Benefits* dimension for both male and female first-year students based upon weighted volunteer scores (line graph). Frequency distributions of respondent scores by gender are also shown (bar graph). For both male and female students, there is a positive correlation between the amount and frequency with which they volunteer, and their views of the costs and benefits of engaging in service. This trend was consistent across academic ranks and for all dimensions of the Personal Social Awareness and Professional Connectedness realms, though the *Cost/Benefits* dimension had the most pronounced difference. See (Canney Dissertation, Appendix F) for further discussion and results for each dimension. It is also worth noting that, though volunteering is an important element of social responsibility, at the same level of volunteer experience, women still had higher averages than men.

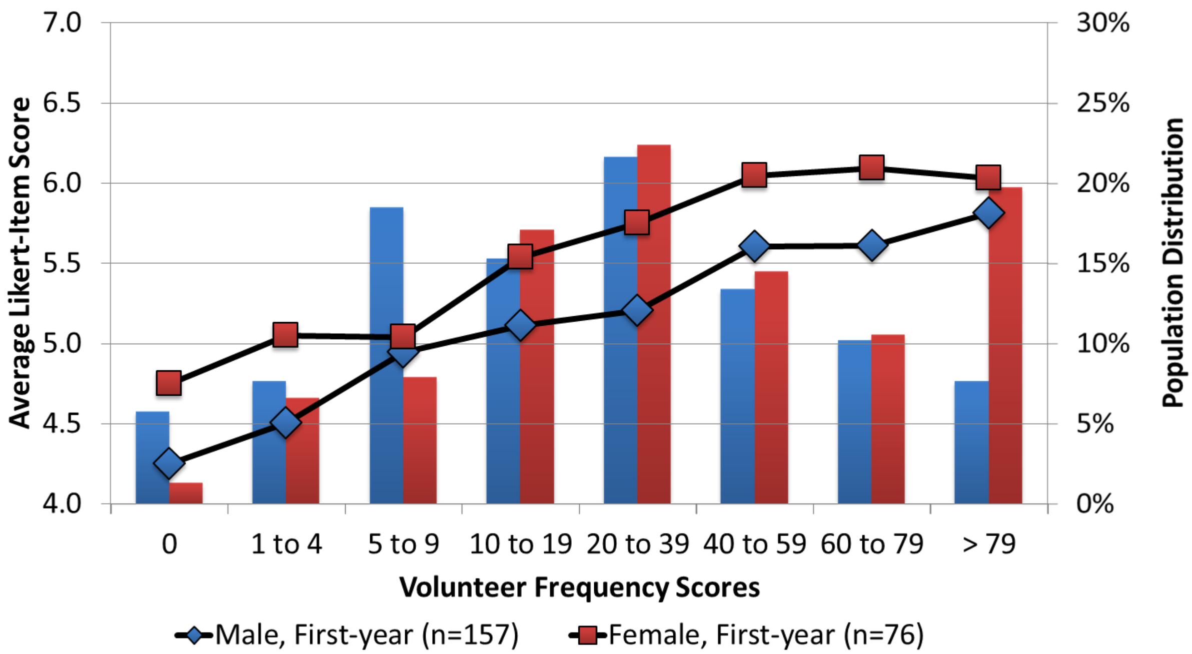



**FIGURE 15. *COSTS/BENEFITS* DIMENSION AVERAGES FOR FIRST-YEAR STUDENTS BY WEIGHTED VOLUNTEER FREQUENCY SCORES AND GENDER AND FREQUENCY DISTRIBUTION AMONG SCORE GROUPS**

In addition to differences in previous volunteer experiences, three of the six Likert questions which asked about volunteering or community service had differences greater than 0.5 between female and male students, shown in Figure 16. Seventeen percent (n=113) of male students responded to some degree that they agreed that volunteer work would not have an effect on their career (ProfCon11), whereas only 8% (n=25) of female students responded similarly. Both female and male students overwhelmingly agreed that their lives would be affected positively by volunteering that they do (CB3), though female students were more likely to answer ‘strongly agree’ (37%), compared to male students (21%). These results show that not only do female students engage more in volunteer activities and more frequently than male students do, but they also hold stronger beliefs about the positive effects that their volunteering will have on their lives and their careers.

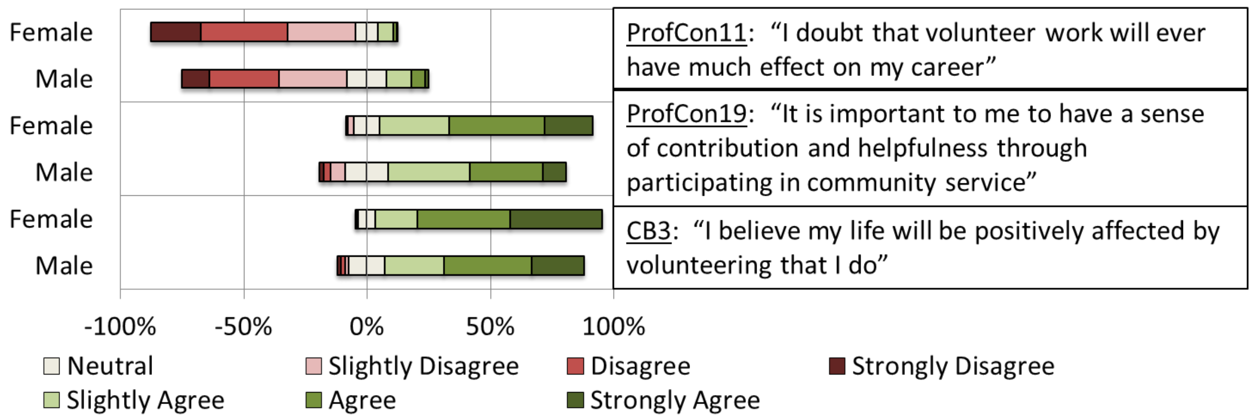



**FIGURE 16. FREQUENCY DISTRIBUTIONS FOR EPRA QUESTIONS RELATING TO VOLUNTEERING WITH DIFFERENCES BETWEEN FEMALE AND MALE STUDENTS GREATER THAN 0.5**

FACTORS INFLUENCING CHOICE OF MAJOR – In the post- survey, students were asked to explain which factors had influenced their choice of major. Responses were coded using inductive coding methods with the unit of analysis being each individual's response. Themes were allowed to emerge from the data, building a codebook that was then applied to the entire data set. "Math & Science" and "Impact on Society" were generally common codes for both male and female students (Table 17) and example quotes of these and other common codes are given in Table 18. See (Canney Dissertation, Appendix G) for a complete list of codes and sample responses.

**TABLE 17. TOP THREE CODES FREQUENCIES BY GENDER AND MAJOR IN RESPONSE TO FACTORS IN CHOOSING MAJOR**

| | Male | Female |
|---|---|---|
| **All** | 1. Math & Science (26%)<br>2. Build things (24%)<br>3. Impact on Society (16%) & Job Qualities (16%) | 1. Impact on Society (26%)<br>2. Math & Science (26%)<br>3. Help the Environment (16%) |
| **Civil** | 1. Impact on Society (24%)<br>2. Math & Science (21%)<br>3. Build things (20%) | 1. Math & Science (28%)<br>2. Impact on Society (27%)<br>3. Help People (13%) |
| **Environmental** | 1. Help the Environment (41%)<br>2. Impact on Society (23%)<br>3. Job Qualities (20%) | 1. Help the Environment (42%)<br>2. Impact on Society (36%)<br>3. Help People (22%) |
| **Mechanical** | 1. Math & Science (27%)<br>2. Build things (27%)<br>3. Broad field (15%) | 1. Math & Science (26%)<br>2. Broad field (21%)<br>3. Build things (18%) |

**TABLE 18. SAMPLE CODED RESPONSES FOR INFLUENCING FACTORS FOR CHOICE OF MAJOR**

| Code | Sample Response |
|---|---|
| **Build Things** | "My childhood of building things such as Lego and tinkering with toys. Desire to work with military vehicles. The interesting aspect of how everything comes together in machines, the electronics, gears, controls etc."<br>-Male Sophomore Mechanical Engineering Student |
| **Broad Field** | "I appreciated the fact that civil engineering is such a broad field where the impacts on the community are so apparent. I was attracted to the diversity of interest of my peers and the ability to study things on a large scale."<br>-Male Senior Civil Engineering Student |
| **Help People** | "I wanted to help people in a very fundamental and tangible way."<br>-Male Graduate Civil Engineering Student |
| **Help the Environment** | "I love math, science and the environment and environmental engineering put all those things together. Solve environmental problems seems like something I would interested in and not become easily bored with. Also engineers make a decent living and that is important in any job choice."<br>-Female First-year Environmental Engineering Student |
| **Impact on Society** | "I was interested in a career that built on my strengths in math and science and that had direct impacts on society"<br>-Female Graduate Civil Engineering Student |
| **Math & Science** | "I've always enjoyed math and science, and I like the challenge."<br>-Male Senior Civil Engineering Student |

Few differences were seen between different academic ranks by gender, so the complete data set from the post- survey was used here. The results showed that an affinity or aptitude in math and science was the most common response for both male and female students (26%). A desire to have an impact on society was tied as the most common code for female students, and was the third most common code for male students (16%), tied with discussions of positive job qualities such as salary and stability. A desire to help improve the environment was the third most common response for female students at 16%.

It is appropriate, at this point, to discuss the potentially confounding issue of major with respect to these results. Environmental Engineering had the highest proportion of female students in this data set, noticeably skewing the top response frequencies for females to include a desire to improve the environment. Table 17 summarizes the top three codes for male and female students for each major. Because codes were seen to be most similar between major rather than gender (i.e. male and female environmental engineers cited similar codes most frequently than male civil and environmental or female mechanical and civil), major was seen as a confounding factor for these data.

The Likert-item data were also examined by gender and major for the possibility of major as a confounding factor and it was found that, while there were differences between majors within each gender, the overall trend still held such that average scores for each of the three majors examined for female students were still higher than average scores for each of the three majors for male students. For example, the average scores for the highest category of male students (Environmental Engineers) were statistically similar to the lowest category for female students (Mechanical Engineers). Therefore, for the dimension average scores presented earlier, major was not a significant confounding factor. Refer to (Canney Dissertation, Chapter VI) for further information regarding differences in social responsibility by major.

From these data it was seen that a desire to have an impact on society was a common factor for choosing their major among female and male students in Civil and Environmental Engineering, but, within each major, female students cited this factor more often than male students. Also, a desire to help people was seen to be a more common code among female students in those majors, ranking third for each. An example of this code from a male Environmental Engineering student is "I wanted to work in a technical profession where I could help people, and make the world a better place to live in." This response would have been coded for both "Impact on Society" and "Help People." These results support findings from previous studies, that a desire to have an impact on society was more common among female students for choosing engineering, specifically Civil and Environmental Engineering, than male students.

IMPORTANCE OF JOB ATTRIBUTES – The third element from this data set that was examined were student responses to the job attributes question from the pre- data set. This question gave insight into how students looked ahead at their future careers with respect to the relative importance of different attributes. The average number of stones distributed to each of the eight bins, by gender, is shown in Figure 17. Women distributed statistically significantly more stones ($p<0.01$) into the 'Help People' bin than men, and men distributed statistically significantly more stones ($p<0.01$) into the 'Salary' bin. These two categories were the most common bins, with only 43 and 60 respondents putting no stones in the 'Salary' and 'Help People' bins, respectively. All other bins had from 237 (in 'Community Development Projects') up to 724 (in 'Living Internationally in a Developing Country') respondents who placeed no stones in them. These data show that, looking forward, the ability to help people is a more important career attribute than salary for female engineering students, and more important for female students than for male students.

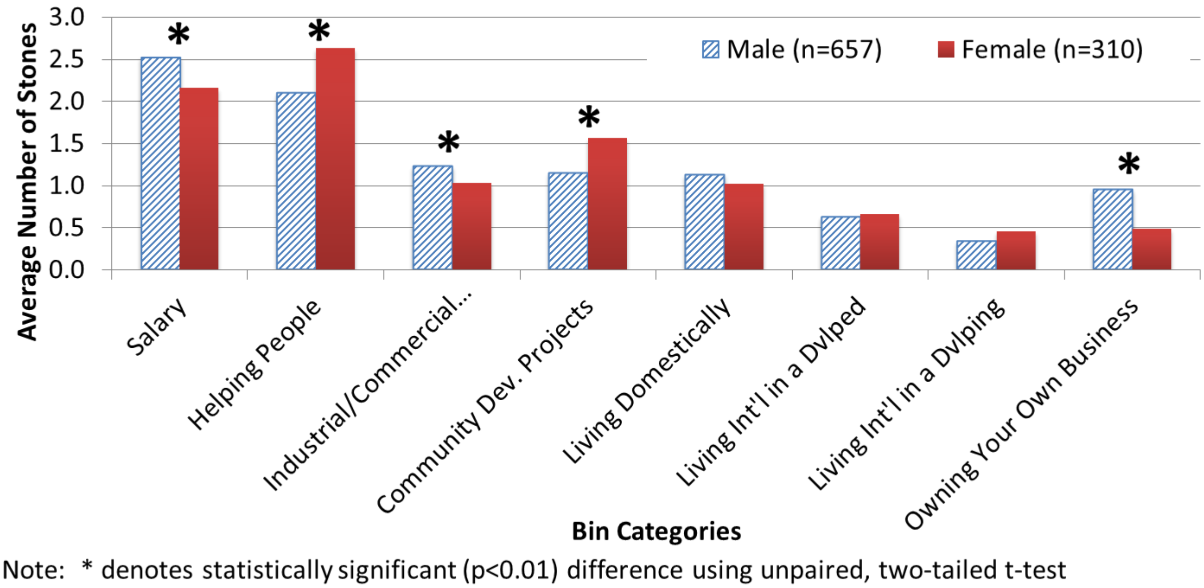



**FIGURE 17. STONE DISTRIBUTION FOR JOB ATTRIBUTES QUESTION BY GENDER**

Dimension averages were also examined based upon gender and the importance of salary and helping people as career attributes (Figure 18). Statistical significance ($p<0.01$) is denoted using labels "A" to "D." If a data point has a letter next to it, this means that averages for that population on that dimension are statistically significantly different from other populations with a different letter for that dimension. The black boxes are used to lump data points which are statistically similar to each other but statistically different from other groups. In the Personal Social Awareness and Professional Connectedness realms, male students who placed three or more stones in the 'Help People' bin (24% of the males) were more similar to female students who did the same (52% of females), than either female or male students who placed three or more stones in the 'Salary' bin (32% of females, 45% of males). In the Professional Development realm, males with three or more stones in the 'Help People' bin were statistically similar to females with three or more stones in the 'Salary' bin. Males who placed three or more stones in the 'Salary' bin had statistically significantly lower ($p<0.01$) scores for all dimensions except *Professional Ability* than males who placed more than three stones in the 'Help People' bin and females who place three or more stones in either. These results show an important bifurcation in male scores based upon the relative importance of salary or helping people in their future careers. There was also a significant separation between the female students based upon these two job attributes, but the differences were not as great and female students who placed more than three stones in ‘salary’ were still always statistically significantly higher than male students who did the same.

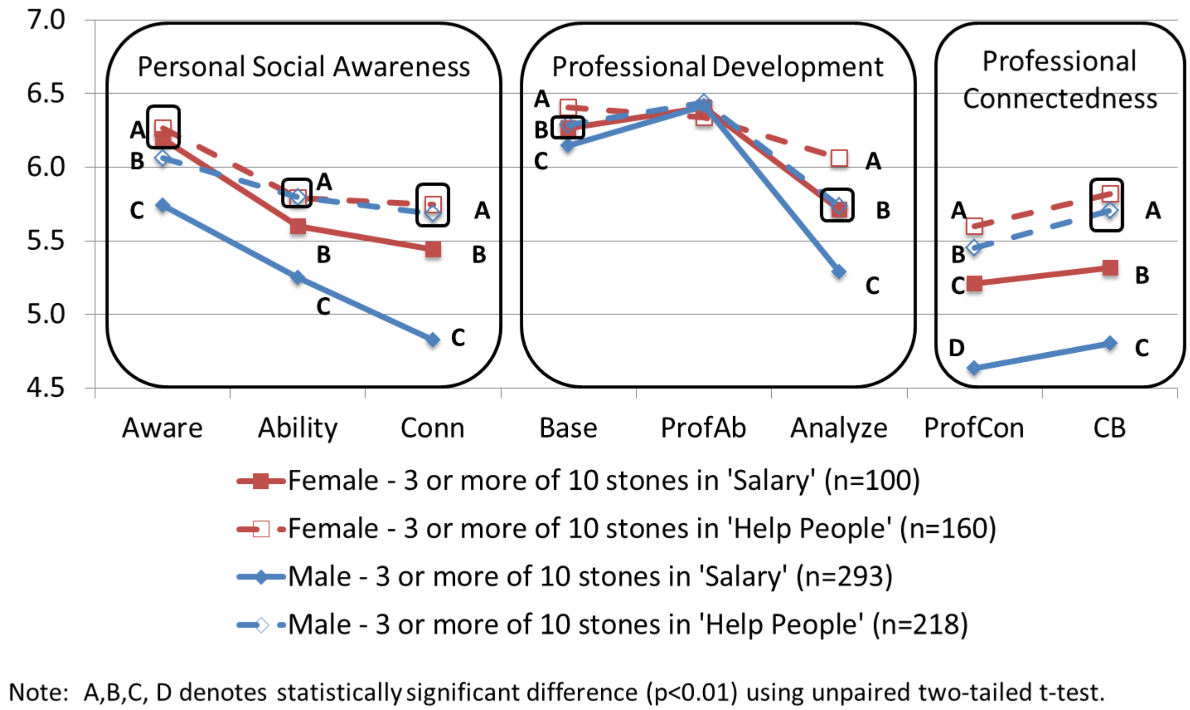



**FIGURE 18. PSRDM DIMENSION AVERAGE SCORES BY GENDER AND STONE DISTRIBUTION TO 'SALARY' AND 'HELP PEOPLE' BINS**

Overall, experiences and beliefs about the benefits of volunteering appeared to be higher with female engineering students than with male students. Entering first-year female students had more volunteer experiences and expressed a desire to have an impact on society and help people more frequently with respect to choosing their engineering major. Finally, when looking to the future about their engineering careers, female students placed, on average, the most importance on helping others, whereas male students, on average, placed the greatest importance on salary. For the male students who did place greater importance on helping others, however, their average dimension scores in the Professional Awareness and Professional Connectedness realms were similar to female students who also placed a greater importance on helping others. Male students who placed a greater importance on salary had the lowest scores on all dimensions, except in the *Professional Ability* dimension.

## CONCLUSIONS

This study focused on views of social responsibility in female and male engineering students, guided by results from previous studies which pointed to a desire to have a positive impact as a main motivation for women to enter STEM field. Results to the EPRA tool from 1000 engineering students were used in this assessment, and showed that there are differences in degrees of social responsibility between female and male engineering students, with female students having significantly higher averages for seven of the eight dimensions. The greatest differences were seen among first-year students, but looking across the engineering curriculum, averages for female students are generally lower for seniors and graduate students. Average scores for male engineering students were similar across academic ranks for most dimensions. Student awareness of the importance for social considerations in engineering design (*Analyze*) was higher for both male and female senior and graduate students compared to first-year students, however. These differences between first-year and senior and graduate female students, with scores being lower for students who are further in their academic careers, are alarming. Further research should conduct a full longitudinal study from first year though senior and attempt to identify why programmatic elements which may be negatively affecting these views in women, but not in men. The potential for selective attrition of female students with higher social responsibility should be explored.

Possible explanations for these differences could come from engagement in more volunteering activities and with more frequency for female students than male students, as well as female students holding stronger beliefs of the positive effects of volunteering on their lives and careers. Using a weighted frequency score showed that both men and women who engaged in more activities, more frequently also had higher social responsibility scores. Additionally, female students more frequently referenced a desire to have an impact on society and to help people than male students when explaining why they chose their major. These reasons were most common in Civil and Environmental Engineering students. Finally, when looking at their future careers, female students placed more importance on having a career that helped people than male students, who placed the most emphasis on salary. Male students who did place a greater importance on helping people, however, had similarly high social responsibility averages for most of the PSRDM dimensions as female students.

## Future Work

The results provided in this study point to several elements which should be investigated more closely towards both the development of social responsibility and as potential factors towards increasing the attraction and retention of women into engineering. Volunteer experiences before and during college could provide strong avenues for the development of social responsibility and as ways to connect engineering to social impact. Service learning may be a prime way to combine the two. Additionally, it would be important to examine whether the observed differences in social responsibility among female students between first year and senior year, with senior scores being lower, is due to attrition of females with high social responsibility or school experiences. There could be many factors that cause this, including decontextualized content prevalent in most engineering courses, stereotypes of the engineering culture in school and beyond, a divorce between personal beliefs and engineering practice, or a lack of opportunities to engage in activities, such as volunteering, which help develop beliefs of social responsibility. Examining this difference in social responsibility could provide new avenues to discuss curricular interventions to help attract and retain female students in engineering.

## Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 1158863. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. Additional funding was provided through an institutional fellowship for Excellence in STEM Education.

# CHAPTER VI

# EXAMINING BELIEFS OF SOCIAL RESPONSIBILITY AS A DIFFERENTIATING FACTOR BETWEEN CIVIL, ENVIRONMENTAL, AND MECHANICAL ENGINEERING STUDENTS

## ABSTRACT


BACKGROUND – The engineering profession needs to develop more holistic engineers in order to address complex social issues. Social responsibility is seen as one element which can contribute to the development of more holistic engineers.

PURPOSE/HYPOTHESIS – The purpose of this study is to examine differences in student views of social responsibility by discipline, looking at student reasons for their choice of discipline and online messaging as possible explanations for differences.

DESIGN/METHOD – A survey with strong evidence of reliability and validity was administered to first-year, senior, and graduate students in Civil, Environmental, and Mechanical Engineering at five universities. Responses were obtained at the beginning and end of the academic year and results were compared for differences between engineering disciplines. Online messaging at each university was also examined with respect to elements of social responsibility for the three disciplines.

RESULTS – Students from Environmental programs had higher degrees of social responsibility than students from Civil, who were higher than students from Mechanical. Moreover, the greatest differences were among first-year students, suggesting that *a priori* perceptions of the majors differentiated more than curricular content. This hypothesis was supported by student motivations for choosing each major, despite few apparent differences in online messaging between these disciplines with respect to elements of social responsibility.

CONCLUSIONS – Students entering into Environmental Engineering programs have higher degrees of social responsibility than those entering into Civil or Mechanical Engineering programs. Outwardly focused motivations among Environmental Engineering students, such as a desire to help the environment and have a positive impact on society, may partially explain these differences.

# INTRODUCTION

## PROBLEM STATEMENT

The National Academy of Engineering (NAE) report, *Changing the Conversation*, highlighted the need to develop a different view of the engineering profession, both from within and outside of the profession, in order to attract and retain a more diverse body of students (National Academy of Engineering, 2008). One of the main recommendations from the NAE report was a messaging campaign which focused on the positive impacts that engineers can have on society, suggesting language that emphasized how "engineering and engineers can make a difference in the world" (p. 11) in order to attract more students into engineering programs and careers. Student perspectives on the theme of engineering as a way to help society are examined in this study through the lens of social responsibility, using the Engineering Professional Responsibility Assessment (EPRA) tool (Canney Dissertation, Chapter IV). Students' views of personal and professional social responsibility were examined for incoming first-year, senior and graduate students in three main disciplines - Civil, Environmental, and Mechanical Engineering. Students from these engineering disciplines had differing degrees of social responsibility from the survey results; therefore the research team began to examine if perceptions of each major attracted students with inherently different degrees of social responsibility, or if curricular elements in each discipline possibly 'shaped' students differently with respect to social responsibility. The results from this study can help to inform how the different engineering disciplines are viewed with respect to social responsibility, and if those views affect how students decide which discipline to enter into as first-year students.

## Research Questions

The following research questions are addressed in this paper:

1. Are there differences in students' degrees of social responsibility by engineering discipline? If so, how do these differences compare at entry (first-year students) and completion (senior students) of the programs?
2. Do students indicate different reasons for choosing their discipline of study, specifically with respect to elements of social responsibility?
3. Does departmental messaging on websites and recruitment flyers differ with respect to social responsibility by discipline?

# Relevant Literature

The declining number of students pursuing engineering degrees and careers in the United States is concerning. In order for the United States to remain competitive in the rapidly progressing world economy, fields of education such as engineering and the sciences must remain strong; a connection highlighted in the national report *Rising Above the Gathering Storm* (NAS/NAE/IOM, 2007; Augustine, et al., 2010). The quantity and diversity of students choosing engineering, however, has continued to decline despite this recognition. Women comprise only 18.4% of the total degrees earned in engineering, and as low at 10% in some sub-disciplines (Yoder, 2012). Percentages for underrepresented minority students are similarly low. Some majors however, such as Environmental and Biomedical Engineering, have much higher percentages of women in them and are also the fastest growing engineering fields in the United States (U.S. Bureau of Labor Statistics, 2012). It is important to look at the many factors which contribute to students choosing to enter and continue in the various engineering disciplines.

A key step in increasing the number of engineers is clearly to increase the number of students choosing to study engineering. From this perspective, many studies have looked at how the public perceives engineering, why students choose engineering, and what factors aid in students staying in engineering both through school and into professional careers. The goals of these studies have been to build a body of knowledge that can be used to help improve the attraction and retention of students to and through engineering. Many studies have focused on these issues specifically with respect to women and underrepresented minority students in order to increase the diversity and capacity of the engineering field. Perhaps public perceptions of greater social responsibility in fields such as Environmental and Biomedical Engineering are a factor in their growth over other disciplines (Hill, Corbett, & St. Rose, 2010). Elements of these studies which relate to ideas of social responsibility are reviewed herein.

Study results on the public perception of engineers and engineering are mixed. One study reported that "the public believes that engineers are not as engaged in societal and community concerns as scientists" (National Academy of Engineering, 2008, p. 1). Another study, however, showed that college students outside of engineering generally believed that engineering was beneficial to society in that it helps to increase our quality of life and to create social wealth, but these students also believed that it took too much effort to gain an engineering degree and that a career in engineering was too demanding (Li, McCoach, Swaminathan, & Tang, 2008). Out-of-school media representations of engineering were examined, as shows like *Myth Busters* or magazines like *Motor Trend,* and it was found that these social influences gave mixed messages to high school students about the day-to-day work of engineers, causing students to falsely see engineering as fantastical, in opposition to their in-class experiences of math and science as dry and boring (Tang, 2013). No study was found that looked specifically at perceptions of the different engineering disciplines.

Many studies have looked at why current engineering students chose to study engineering in college. Across multiple studies using different methods, similar motivators emerged as to why students choose engineering, including the students' aptitude and enjoyment of math and science, an enjoyment of problem solving, a desire to impact the world, or because of financial or career benefits associated with engineering (Matusovich, Streveler, & Miller, 2010; Brawner, Lord, & Ohland, 2011; Atman, et al., 2010; Canney, Bowling, & Bielefeldt, 2013). The top three influential factors for first-year students found in one study were "interest in the field", "potential career opportunities", and "potential to impact society" (Palazolo, Ivey, & Camp, 2010). With respect to persistence, Seymour and Hewitt (1997) found that students were more likely to finish a science, engineering, or math degree when intrinsic interests were students' primary motivations (i.e. a passion for building things), rather than extrinsic elements (i.e. greater salary). For students who are motivated by a desire to have a positive impact on society, it would be important in helping increase persistence that their experiences within the engineering program align with that internal interest and motivating factor.

Other studies have looked more specifically at student perceptions of the different disciplines within engineering. One study found that first-year students who chose Civil Engineering cited the opportunity to work outdoors and working with their hands as the most common reasons, whereas students who chose Mechanical Engineering talked more about how they liked to work on mechanical things or perceived themselves as mechanically inclined (Ngambeki, Dalrymple, & Evangelou, 2008). Another study found that bettering the world was a more common reason, though not statistically different, for Civil Engineering students in their choice of major compared to other disciplines (Meyers & Mertz, 2011). Finally, when first-year students were asked to rate the capacity of different engineering disciplines to have an impact on society, students rated Civil Engineering with the highest capacity and Mechanical Engineering with the lowest capacity out of five engineering discipline, though, notably, all disciplines were rated quite highly by students in this study (Palazolo, Ivey, & Camp, 2010). No studies were found that looked specifically at Environmental Engineering.

In these studies, recommendations were made on how to use the results to improve the attraction and retention of students into engineering. Two of these recommendations were to help students "become more aware of the tremendous contributions engineering and technology have made on the society…" (Li, McCoach, Swaminathan, & Tang, 2008, p. 54) and to "help [students] associate a perceived engineering identity with their personal identity and demonstrating the value of the association" (Matusovich, Streveler, & Miller, 2010, p. 300). Both of these recommendations support the focus of this study towards an examination of the beliefs of personal and professional social responsibility of engineering students. Social responsibility refers to an individual's obligation to exercise care and objectivity towards the benefit of society, with special considerations for underrepresented populations (Canney & Bielefeldt, 2013). An examination of social responsibility embodies a view of engineering as having a positive impact on society, and as a career pathway which aligns an individual's personal views of obligation and desire to help others with her/his profession.

The tool used for this study was the Engineering Professional Responsibility Assessment (EPRA) tool, which is rooted in the Professional Social Responsibility Development Model (PSRDM). The PSRDM describes the development of both personal and professional social responsibility in engineering students (Canney & Bielefeldt, 2013). The development of social responsibility is partitioned into three realms, comprised of eight dimensions. The first realm is Personal Social Awareness which addresses an individual's awareness that there are others who need help, and that he/she has the ability and a moral or social obligation to help others. The second realm is Professional Development which addresses the attainment of engineering abilities, recognition that engineering can help solve social issues, and the development of awareness that the inclusion of social elements in the engineering design process is critical. Finally, the Professional Connectedness realm is a combination of the first two realms, and details how engaging in activities which help others increases the professional feeling of obligation to help improve society. The eight dimensions are named and summarized in Table 19. This framework is appropriate to examine how an emphasis on engineering's ability and obligation to improve society is seen by engineering students, and if there are differences in these views across disciplines.

Another critical element of the PSRDM framework is engagement in service as a primary mechanism for advancing personal and professional social responsibility. Several studies have suggested that an increased focus on service within engineering programs could be beneficial for increasing student attraction and retention, especially for women and underrepresented minority students (Carberry, 2010; Duffy, Barrington, & Heredia Munoz, 2011). From this perspective, examining differential perceptions of social responsibility, which includes service as a core element, could be useful for explaining and improving the attraction and retention of women and underrepresented minority students to different engineering disciplines. It could also partially explain why some engineering disciplines, such as Environmental Engineering, are approaching gender parity, while others, such as Mechanical Engineering, remain dramatically unbalanced (Yoder, 2012; Paterson & Jarvie, 2008). Service-learning is one pedagogical tool that has been suggested to better incorporate service into the engineering curriculum (Oakes, 2009; Titus, Zoltowski, & Oakes, 2011).

This study is guided by recommendations that, in order to increase attraction and retention of students, engineering should highlight the ability of the profession to have positive social impacts. Additionally, students seem to frequently voice a desire to have an impact society as a main motivator for choosing engineering. Finally, service may be an effective message and pedagogy for attracting more diversity into engineering. Social responsibility is an appropriate approach to examining engineering students' perceptions of engineering's ability to have positive impacts on society and the role of service in engineering. Additionally, this study will contribute to the body of knowledge regarding differences among engineering disciplines with respect to student motivations and student beliefs of social responsibility.

# METHODS

## SURVEY TOOL

The EPRA tool (Canney Dissertation, Chapter IV) was used in this study to examine degrees of social responsibility in engineering students. EPRA is a tool with strong evidence of validity and reliability. It was developed to operationalize the PSRDM through 50, seven-point Likert-items which focus on the eight developmental dimensions of the PSRDM. Many of these questions were used from previous surveys (Shiarella, McCarthy, & Tucker, 2000; Olney & Grande, 1995; Duffy & Raque-Bogdan, 2010). These eight dimensions, grouped into three realms, are given in Table 19, and form the unit of analysis for this study when comparing different disciplines. EPRA includes other elements, other than the Likert-items, but only student responses to an open response question asking them “What factors led you to choose your current major?” were used in this study.

**TABLE 19. DESCRIPTIONS OF THE EIGHT DIMENSIONS OF THE PSRDM**

| Realm | Dimension | Description |
|---|---|---|
| **Personal Social Awareness** | *Awareness* (Aware) | Recognition that others need help. |
| | *Ability* | Recognition that one has the ability to help others who are in need. |
| | *Connectedness* (Conn) | Feelings of moral or social obligation to help those who are in need. |
| **Professional Development** | *Base Skills* (Base) | Addresses the wide range of skills needed to be an effective engineer, but with particular focus on the role that professional skills play for a practicing engineer |
| | *Professional Ability* (ProfAb) | Recognition that engineers or the engineering profession have the ability to contribute to solutions of social issues. |
| | *Analyze* | Recognition of the importance of including social considerations in the engineering design process. |
| **Professional Connectedness** | *Professional Connectedness* (ProfCon) | Feelings of moral or social obligation to help others as engineers or the engineering profession. |
| | *Costs/Benefits* (CB) | Focuses on the costs and benefits of engaging in socially responsible behavior, such as service. For an engineer, costs may be time, salary, or prestige, and benefits may include personal satisfaction, travel, or innovation. |

For the analysis of the EPRA data, Likert-items were considered ordinal. Average scores for each dimension were compared using two-tailed t-tests, consistent with (Sarle, 1995) and (Baker, Hardyck, & Petrinovich, 1966). Responses to the open questions were analyzed using an inductive methodology, employing emergent coding to identify themes (Creswell, 2005). Normalized frequencies of the various themes were compared by discipline and academic rank.

## Participants

The data set for this study came from a pre-post distribution of EPRA to first-year, senior, and graduate students in Civil, Environmental, and Mechanical Engineering programs at five different universities in the 2012-2013 academic year. The institutions used in this study included one private, three public, and one military schools of differing sizes. The largest university had more than 30,000 students, whereas the smallest had less than 4,800. Engineering was the predominate field at one of the universities. The pre- distribution was conducted in August and September and the post- distribution was conducted in late March and April. These disciplines were chosen because they represent nearly half of all engineering degrees awarded from American universities (National Science Board, 2012), and many of the project types central to these disciplines are generally perceived as having more social elements than projects from other engineering disciplines. Future studies will examine other engineering disciplines using the approach presented here. First-year and senior students were targeted to bracket the standard four-year curriculum and because evidence from pilot studies using EPRA suggested that degrees of social responsibility in Sophomore students was lower than First-year, and that Junior student perceptions were similarly lower than Sophomores (Canney & Bielefeldt, 2012b). Additionally, researchers felt that these two years were where students were most likely to engage in engineering projects which could include elements of social responsibility, as opposed to purely technical courses which traditionally fill the middle two years. Graduate students were selected as the continuation of the academic pathway. They also represented students who were selecting their given majors with significantly more knowledge about the various fields.

Students were recruited for the pre- survey via departmental email lists at each institution for each of the three targeted departments within the first month of the Fall 2012 semester. Students were given a link to the instrument in SurveyMonkey. In total, 1000 students checked the necessary Institutional Review Board (IRB) consent form and completed at least 90% of the survey. These responses represent about 28% of the potential student respondents. For the post- distribution, only these 1000 students were solicited, also via email. Of those 1000, 698 completed the post-survey using the same requirements for completion. The demographic breakdowns for respondents to both the pre- and post-surveys are shown in Table 20. The percentage of female students responding was higher than their overall representation within the majors at each institution, as has been commonly found in other studies (Smith, 2008). Students were given a $5 gift card for completing the pre-survey and another

$10 gift card for completing the post- survey, except at one of the universities where students were not allowed to receive incentives because of institutional policies.

**TABLE 20. PARTICIPANT DEMOGRAPHICS**

| Major | Fall 2012 Pre- | | | Spring 2013 Post- | | |
|---|---|---|---|---|---|---|
| | # of Students | Year* 1stYr/Sr/Grad | Gender % Female | # of Students | Year* 1stYr/Sr/Grad | Gender % Female |
| **Civil** | 262 | 45/109/87 | 32% | 180 | 33/63/71 | 34% |
| **Environmental** | 182 | 36/62/70 | 54% | 131 | 18/44/59 | 57% |
| **Mechanical** | 474 | 113/167/146 | 22% | 340 | 69/109/133 | 23% |
| **Other/Undeclared** | 82 | 42/6/12 | 29% | 47 | 27/6/10 | 47% |
| **Total** | **1000** | **236/344/315** | **31%** | **698** | **147/222/273** | **34%** |

*Note that some students self-identified as a sophomore or junior, despite being on first-year or senior email lists. These surveys were kept in the data set, except when reporting for specific academic ranks.

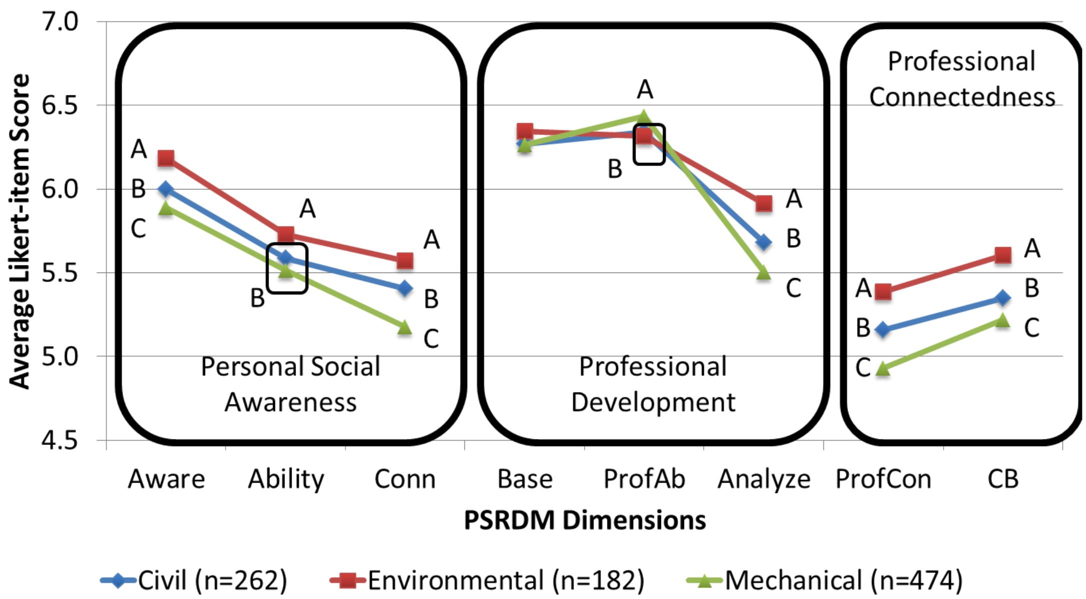
## Online Messaging Artifact Analysis

In addition to results from the EPRA tool, an artifact analysis of online messaging was conducted. The websites chosen for the study included the College of Engineering homepages at each of the five universities, as well as departmental homepages, mission statements and 'prospective student' pages for each of the three disciplines at each university. These pages were chosen to represent what an incoming student who would be uncertain about the different disciplines may research at a glance to aid in their decision. Images were coded based upon the activity and location shown in them and for broad descriptions of individuals also present. Code frequencies for images were normalized by the percentage of images which contained a given code. Text was analyzed using emergent coding with individual sentences or headings as the unit of analysis. Similar to the images, code frequencies for text were normalized by the total number of individual codes assigned, which are described with the results in this paper. Results were examined for each of the three disciplines combined from the five universities. Two of the universities had departments which combined two disciplines, one being Civil and Environmental and the other being Civil and Mechanical. Image and text coding from these pages were assigned to both disciplines and any language specifically addressing one or the other discipline was assigned solely to that discipline.

## Results

### Research Question 1: Differences in Social Responsibility by Engineering Discipline

Our first research question asked if there were any differences in degrees of social responsibility between students in Civil, Environmental, and Mechanical Engineering programs. Figure 19 shows the average Likert-item scores for each of the eight dimensions for all Civil, Environmental, and Mechanical Engineering students from the Fall 2012 pre- distribution. Few students responded negatively on average to the items, so the y-axis only presents the upper portion of the 1 to 7 scale. Two-tailed t-tests showed that Environmental students had statistically significantly ($p<0.01$) higher scores than Mechanical Engineering students on all of the dimensions of the Personal Social Awareness and the Professional Connectedness realms as well as the *Analyze* dimension, with the largest differences in means for the *Professional Connectedness* dimension. They also had higher scores than Civil Engineering students for the *Awareness*, *Analyze, Professional Connectedness,* and *Costs/Benefits* dimensions. Civil Engineering students had statistically significantly higher scores on the *Awareness, Connectedness, Analyze, Professional Connectedness*, and *Costs/Benefits* dimensions than Mechanical Engineering students. Minimal changes were observed in the post- data, which showed similar trends as seen here, therefore that data is not shown.




Note: A,B,C denotes statistically significant difference (p<0.01) using unpaired two-tailed t-test

**FIGURE 19. DIMENSION AVERAGE SCORES BY MAJOR**

The dimensions where Environmental Engineers had the highest scores all pertain to views of personal and professional obligations to help others. Examples of questions from these dimensions include "It is important to me personally to have a career that involves helping people" (*Professional Connectedness*) and "It is important to incorporate societal constraints into engineering decisions" (*Analyze*). This suggests that Environmental Engineering students had stronger beliefs than Civil or Mechanical Engineering students about their personal obligation to help others, as well as their obligations as engineers to help society. Similarly, Civil Engineering students had stronger beliefs with respect to these elements than Mechanical Engineering students.

To ensure that these differences by discipline were not due to correlation with higher percentages of female respondents in Environmental (54%) compared to Civil (32%) and Mechanical (22%), analysis of the results based on gender was conducted (Figure 20). The same trends by major are evident among both female students and male students, with Environmental above Civil above Mechanical for dimensions in the Personal Social Awareness and Professional Connectedness realms and the *Analyze* dimension. Additional gender effects are examined explicitly in another paper (Canney Dissertation, Chapter V).

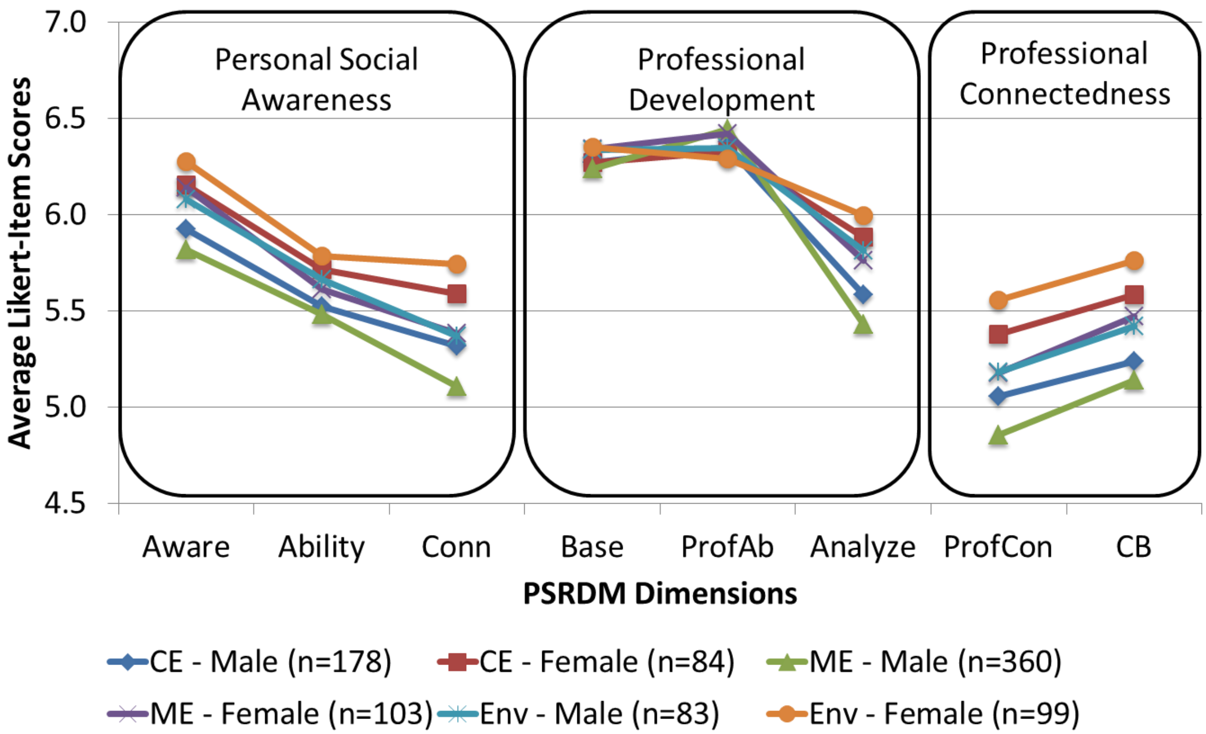



**FIGURE 20. PSRDM DIMENSION AVERAGE SCORES BY DISCIPLINE AND GENDER**

After concluding that the degrees of social responsibility were different between the three disciplines, the research team was interested to see if the differences existed at the beginning of students' academic career, or if they existed predominately at the end, suggesting programmatic effects. Figure 21 shows dimension averages for each of the eight dimensions for first-year students, again using the Fall 2012 pre- data set. These students were surveyed within the first month of their first semester; therefore it is reasonable to assume that there had been minimal influence from university courses within their specific discipline on their views. Similar to the results from Figure 19, Environmental Engineering students had statistically significantly higher scores than Mechanical Engineering students for all the dimensions of the Personal Social Awareness and Professional Connectedness realms and the *Analyze* dimension. Civil Engineering students also had higher scores than Mechanical Engineering students for the same dimensions except *Awareness.* Scores for Civil and Environmental Engineering students were more similar among first-year students then they were for the aggregated scores. Therefore, differences in beliefs of social responsibility between the disciplines existed from the beginning, where students with higher degrees of social responsibility self-selected into Environmental or Civil Engineering over Mechanical Engineering. The largest differences were in the *Connectedness* dimension of the Personal Social Awareness realm, with questions such as "It is my responsibility to take some real measures to help others in need" (Canney Dissertation, Chapter IV).

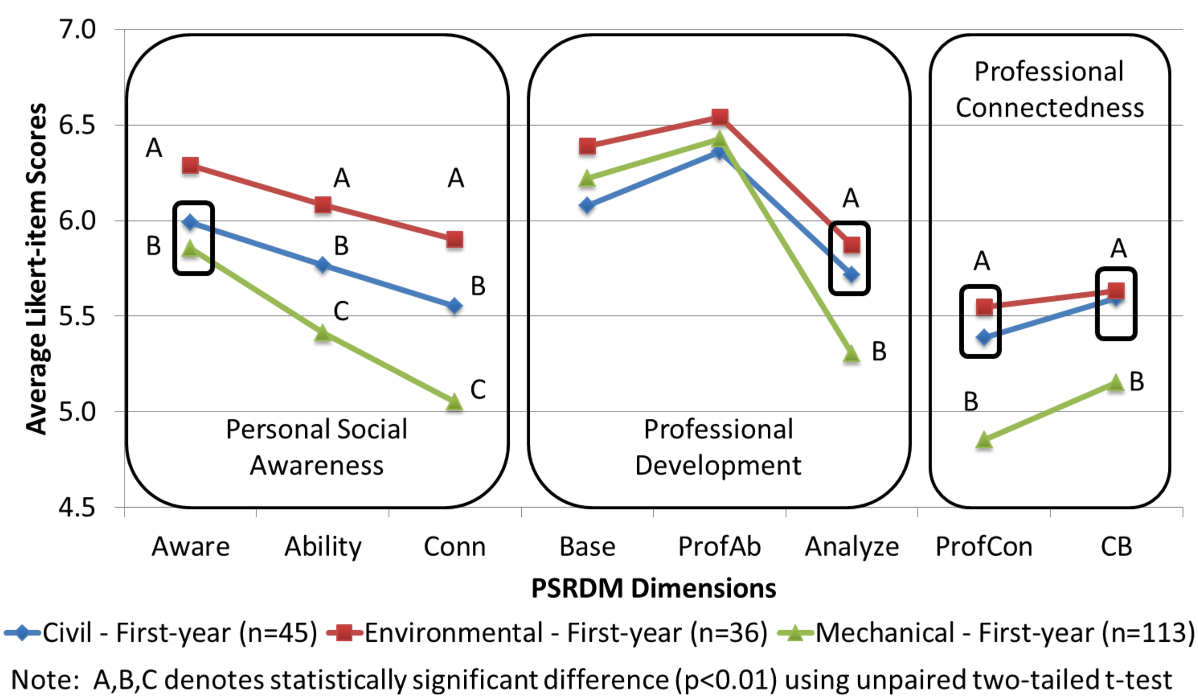



**FIGURE 21. DIMENSION AVERAGE SCORES BY MAJOR FOR FIRST-YEAR STUDENTS**

Beliefs of social responsibility for senior students were examined next in order to view possible differences through each engineering program. Figure 22 shows dimension average scores for senior engineering students in each of the three disciplines from the Fall 2012 pre- data set. Differences between majors were less than in the aggregate or for first-year students, though the general ordering was retained. Environmental Engineering seniors had statistically significantly higher scores than Mechanical Engineering students for the *Awareness, Analyze,* and *Professional Connectedness* dimensions, and higher than the Civil Engineering seniors for the *Analyze* and *Professional Connectedness* dimensions. Scores for each discipline were generally lower for the senior students than for the first-year students, suggesting that beliefs of personal and professional social responsibility generally decrease as students move through the engineering curriculum. These results suggest that differences in social responsibility between Civil, Environmental, and Mechanical Engineering students are not caused primarily by the programs themselves, but by students with differing degrees of social responsibility self-selecting into each discipline. The following research questions examine this issue of self-selection by looking at students' motivations for choosing their major related to elements of social responsibility and by looking at differences in departmental messaging for each discipline.

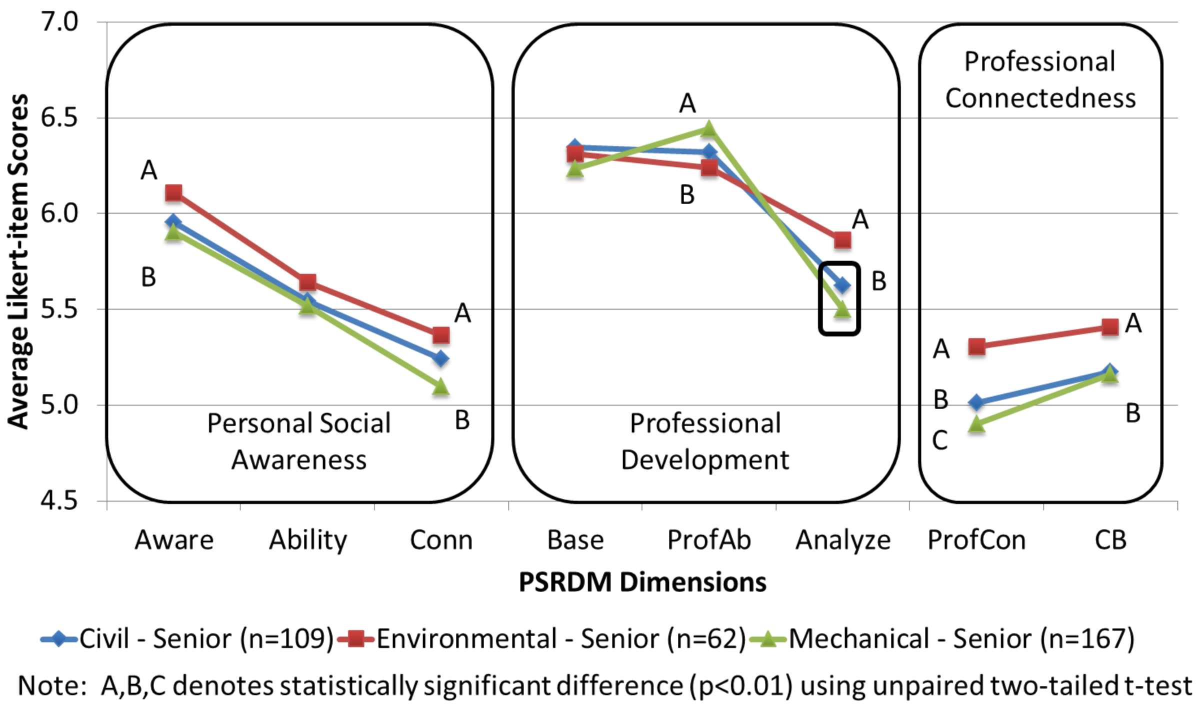



**FIGURE 22. DIMENSION AVERAGE SCORES BY MAJOR FOR SENIOR STUDENTS**

Graduate student results were similar to senior student results, except that they had slightly higher averages in the Professional Connectedness realm. The same trend, however, with Environmental Engineering students having higher averages than Civil Engineering students, who were higher than Mechanical Engineering students still held. It is important to note that graduate students come from a wide variety of undergraduate programs, and therefore there is a greater chance of confounding factors from what they studied prior to graduate school.

## RESEARCH QUESTION 2: DIFFERENCES IN REASONS FOR CHOOSING EACH DISCIPLINE

In order to investigate why students with higher degrees of social responsibility self-selected into Environmental Engineering over Civil and Mechanical Engineering, we asked students to share why they chose their discipline. From the Spring 2013 post- survey, 601 students responded to an open response question asking "What factors led you to choose your current major?" Representative quotes for each of the common codes are shown in Table 21 and the top three coded reasons for each academic rank and discipline are shown in Table 22.

In general, the reasons that students gave for choosing their majors were consistent with results from previous studies (Atman, et al., 2010; Ngambeki, Dalrymple, & Evangelou, 2008; Meyers & Mertz, 2011). An aptitude or enjoyment of math and science was a common factor for each discipline and academic rank subgroup. Environmental and Civil Engineering students cited a desire to have a positive impact on society as a top factor, 30% and 28% respectively, but this was not a top factor for Mechanical Engineering students (10%). Additionally, a desire to help the environment was a significant influence for Environmental Engineering students, not surprisingly. Students in Mechanical Engineering spoke most often about how they liked to build things or that they were interested in learning how things worked. They also referenced that Mechanical Engineering was a broad field which opened up a greater variety of career pathways for them.

**TABLE 21. SAMPLE QUOTES FOR FACTORS INFLUENCING STUDENT CHOICE OF DISCIPLINE**

| Code | Sample Quotes |
|---|---|
| **Broad field** | "I have always been interested in engineering and civil engineering is a broad field where I can do many different types of projects." – First-year Civil<br><br>"It allows a broad range of opportunities for future careers. I was told if I was good at math and science I should try engineering" – Senior Mechanical |
| **Build things** | "My skill set is geared towards tinkering and experimenting. I love building things and testing their limits. That's why I am a mechanical engineer." – Graduate Mechanical<br><br>"I am civil, I mainly want to do it because the fact I will get to work hands on and outdoors." – First-year Civil |
| **Help the Environment** | "I'm very passionate about the environment, and I feel that even the small impact I have from being an environmental engineer is one small but important step to fixing our problems" – First-year Environmental<br><br>"I have always wanted to help people as well as the environment in which we live; thus, environmental engineering seemed the perfect choice." – Graduate Environmental |
| **Impact on Society** | "I wanted to work in a technical profession where I could help people, and make the world a better place to live in." – Senior Environmental<br><br>"I wanted to influence the world positively, and engineering is the best way to do that with the skills and talents I have." – First-year Mechanical<br><br>"I like Civil engineering because it is a field that helps better society and the community around me. While it doesn't get quite as much attention and appreciation from the public as other fields of engineering, it plays a crucial role to everyone's lives and makes general life possible - this makes civil engineering all the more satisfying to me." – Senior Civil |
| **Math & Science** | "I was good at math and science in high school." – Graduate Mechanical<br><br>"Was adept in math and science early on and always had a curiosity of the way things work and are made." – Senior Civil |

These results may explain why Environmental Engineering students have higher degrees of social responsibility than Mechanical Engineering students, with Civil Engineering students in the middle. Two of the top three factors for Environmental Engineering students were outward focused, concerned about the health of the environment and a desire to have a positive impact on society. Mechanical Engineering students, on the other hand, predominately cited inward focused factors, including a personal appreciation for math and science, enjoyment or interest in building things, and the affordances that a broad field gave them. Civil Engineering students gave a mixture of the two, with the top factor being outward focused (impact on society) and the next two being inward focused (math & science and build things).

**TABLE 22. TOP MOTIVATING FACTORS FOR STUDENT CHOICE OF DISCIPLINE**

| | Civil | | Environmental | | Mechanical | |
|---|---|---|---|---|---|---|
| | **n** | **Top Codes** | **n** | **Top Codes** | **n** | **Top Codes** |
| **First-year** | 34 | 1. Build things (27%)<br>2. Math & Science (24%)<br>3. Family member is an engineer (18%) | 18 | 1. Help the Environment (56%)<br>2. Math & Science (28%)<br>3. Impact on Society (17%) | 70 | 1. Build things (23%)<br>2. Math & Science (23%)<br>3. Family member is an engineer (17%) |
| **Senior** | 62 | 1. Impact on Society (31%)<br>2. Math & Science (23%)<br>3. Build things (11%) | 45 | 1. Help the Environment (64%)<br>2. Impact on Society (33%)<br>3. Help People (20%) | 110 | 1. Build things (33%)<br>2. Math & Science (29%)<br>3. Broad field (22%) |
| **Graduate** | 76 | 1. Impact on Society (27%)<br>2. Math & Science (26%)<br>3. Job Qualities (15%) | 55 | 1. Impact on Society (35%)<br>2. Help the Environment (20%)<br>3. Math & Science (20%) | 131 | 1. Math & Science (29%)<br>2. Build things (18%)<br>3. Broad field (15%) |
| **Total** | **172** | **1. Impact on Society (28%)<br>2. Math & Science (26%)<br>3. Build things (14%)** | **118** | **1. Help the Environment (41%)<br>2. Impact on Society (30%)<br>3. Math & Science (20%)** | **311** | **1. Math & Science (26%)<br>2. Build things (23%)<br>3. Broad field (16%)** |

Higher degrees of personal and professional social responsibility embrace a wider view of the engineering profession to include many social elements in the decision process as well as notions of social obligation to help society. The outward focus evident in many of the Environmental Engineering students' motivation statements embodies these characteristics of higher social responsibility, supporting the differences seen through the EPRA tool. This raises important questions about the image and capacity of the different disciplines. Is it that Environmental Engineering is advertised as having more of an outward focus than Mechanical Engineering and students hear that message and choose based upon their interests and goals? Or are there inherent differences in the focus of each discipline, where Environmental Engineering projects are more directly outward focused in their objectives and Mechanical Engineering projects are more inward? The first possibility is examined by the third research question of this study. The second possibility is a larger issue for future studies.

## Research Question 3: Differences in Departmental Messaging

The third research question for this study focused on how online messaging differed between Civil, Environmental, and Mechanical Engineering with respect to elements of social responsibility. The websites, mission statements, and 'prospective student' pages for each discipline at the five universities were examined, coding both images and text. Seven codes emerged relating to activities portrayed in website images and Table 23 shows the percentage of images for each discipline which pertain to these codes. 'Green Energy' and 'Service' were two codes which seemed to align most clearly with ideas of social responsibility, both of which were fairly infrequent for this data set. Despite the infrequency, the majority of images portraying some form of engineering service resided in Civil or Environmental Engineering websites. Most of these images showed students engaging in water, shelter or other infrastructure projects in developing communities. Surprisingly, more images from Civil and Environmental Engineering websites featured some form of green energy, usually solar arrays or wind turbines, than Mechanical websites. From images alone, though not predominate, the ability for engineering to have positive impacts on society through service and green energy were more present on Civil and Environmental Engineering websites than Mechanical Engineering websites.

**TABLE 23. DISTRIBUTION OF ACTIVITIES SHOWN IN ENGINEERING WEBSITES BY DISCIPLINE**

| | Civil | Environmental | Mechanical | College of Engineering |
|---|---|---|---|---|
| **Total # of Images** | 42 | 41 | 61 | 35 |
| **Code** | | | | |
| **Classroom** | 0% | 0% | 8% | 6% |
| **Lab Work** | 24% | 7% | 34% | 26% |
| **Outside** | 57% | 68% | 23% | 34% |
| **Project/Research** | 50% | 46% | 54% | 57% |
| **Green Energy** | 5% | 5% | 2% | 3% |
| **Industry** | 14% | 10% | 8% | 11% |
| **Service** | 12% | 12% | 2% | 3% |

Similar to website images, text was analyzed and coded using emergent coding. Twenty-two codes emerged from the data. Only 10 of those codes had representation for any discipline above 6%, and those codes and distributions are shown in Table 24. Text relating to the environment or sustainability (excluding ‘environment’ in ‘environmental engineering’) were more common on Civil and Environmental websites than Mechanical websites. Civil and Environmental websites also seemed to write more about what graduates with that degree could do, explaining the range of professional opportunities that are available in that field. Language focusing on current research and research opportunities were more common on Mechanical and the general School of Engineering websites than Civil or Environmental websites. Similarly, the ability to contribute to the medical field was a more common message on Mechanical Engineering websites than Civil and Environmental, voicing another way in which that discipline can contribute to improving quality of life for society. Some of the codes which did not reach a 6% threshold, but are of interest included references the educational quality or classroom experiences, departmental or school rankings, service, a personal fit or satisfaction with a given discipline, and the opportunity to work on “real world” projects in that program.

**TABLE 24. CODES OF TEXT DATA FROM ENGINEERING WEBSITES BY DISCIPLINE**

| | Civil | Environmental | Mechanical | College of Engineering |
|---|---|---|---|---|
| **Total # of Coded items** | 276 | 271 | 279 | 79 |
| **Code** | | | | |
| **Social Impact** | 13% | 13% | 11% | 13% |
| **Medical** | 1% | 1% | 7% | 6% |
| **Environment/Sustainability** | 11% | 15% | 3% | 4% |
| **ABET Professional Skills** | 7% | 6% | 4% | 6% |
| **As an engineer you…** | 12% | 9% | 3% | 1% |
| **Broad field** | 5% | 4% | 6% | 0% |
| **Financial Benefits, Career Stability, Career Opportunities** | 7% | 6% | 8% | 1% |
| **"Meet Challenges"** | 3% | 2% | 4% | 6% |
| **Research** | 6% | 6% | 12% | 15% |
| **Technical Skills** | 13% | 12% | 10% | 6% |

Reflecting the suggestions from *Changing the Conversation*, the ability to have an impact on society was one of the most common codes across all disciplines. One Civil Engineering website had as a heading on the homepage, "Global Engineering with a Human Touch: Engineering a better world through service to developing communities" (Large Public U Website, 2013). Another website geared at prospective students for a Mechanical Engineering department said,

> "Our society is becoming increasingly complex. We must provide more food, water, and energy for a rapidly growing population, and we must limit damage to the environment in the process. Mechanical engineering will play a key role in meeting these challenges. So can you." (Engineering U Website, 2013)

With respect to elements of social responsibility, there were few differences in messaging between the three disciplines from these data that would explain an outside perspective that one discipline is more able to make an impact on society over another. Future work into messaging differences should examine many more websites from a greater variety of schools and programs, but this evidence shows, preliminarily, that there are few differences with respect to social responsibility. Additionally, other sources which inform the public perception of each discipline should be examined. College and departmental websites are only one source of information that students may use to inform their decisions about what to study in college, as Tang (2013) highlighted with the examination of out-of-school media as representations of engineering.

## CONCLUSIONS

This study examined differences in beliefs of personal and professional social responsibility between Civil, Environmental, and Mechanical Engineering students. The EPRA tool was administered to first-year, senior, and graduate students in these programs at five universities pre-post in the 2012-2013 academic year. Results from the survey showed that Environmental Engineering students had higher degrees of social responsibility than Civil Engineering students, who had higher degrees than Mechanical Engineering students. Partitioning the student population by academic rank showed that there was a greater difference among incoming first-year students for each discipline than senior students, suggesting that, for some reason, more students with higher degrees of social responsibility chose to study Environmental Engineering than Civil or Mechanical Engineering. Similarly, more students with higher degrees of social responsibility chose to study Civil Engineering than Mechanical Engineering.

In order to explore the differences in beliefs of social responsibility among incoming first-year students, all students were asked in the post- survey to describe the factors which influenced their choice of discipline. The results were similar to previous studies about choosing engineering more broadly, but, through the lens of social responsibility, they revealed an interesting pattern where the most common motivating factors for Environmental Engineering students were more outwardly focused than those of Mechanical Engineering students. Environmental Engineering students most commonly cited a desire to help the environment and to have a positive impact on society, whereas Mechanical Engineering students cited math and science abilities, an interest in building things, and the broad nature of the Mechanical Engineering field. Civil Engineering students were in between, citing a desire to have a positive impact on society as well as math and science abilities and an interest in building things. These results suggested that students who held outwardly focused objectives towards improving society saw Environmental Engineering as a discipline which aligned more with those goals, leading to higher degrees of social responsibility from the EPRA tool for incoming first-year students in that discipline over the other two.

Finally, departmental messaging was examined to see if the public voice of these disciplines focused more on elements of social responsibility or not. From departmental websites at five universities, there were few differences in messaging around elements of social responsibility, including service and the ability of each discipline to have a positive impact on society. From these results, it does not seem that Environmental Engineering departments advertise that profession as more connected to helping society than either Civil or Mechanical Engineering, therefore not explaining the difference in first-year student perspective.

## FUTURE WORK

This exploratory study has presented new evidence regarding different degrees of social responsibility among students in Civil, Environmental, and Mechanical Engineering programs, but little evidence was found to explain why there are differences. While this paper focused on differences among incoming first-year students, curricular differences should also be explored to see how students are shaped over their years of undergraduate education. More research should also be conducted with respect to the public perception of each discipline towards elements of social responsibility and the root causes of those perceptions. Insider and outsider perspective should be examined, including high-school students, engineering college students, and engineering professionals. Finally, other engineering disciplines should be examined through the lens of social responsibility to see if elements of social responsibility are affecting the attraction and retention of students to each.

## ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1158863. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. Additional funding was provided through an institutional fellowship for Excellence in STEM Education. This research was possible because of the institutional support to distribute the survey and the students who took time to honestly complete the survey.

# CHAPTER VII

# CONCLUSIONS AND FUTURE WORK

In order for the engineering profession to be able to address the complex social issues facing the planet, there need to be adjustments to the way engineering is taught and how social elements play into the engineering design process. Over the last twenty years, there has been significant movement towards educating engineers to have a greater breadth of skills, including both technical and professional skills. The ABET criteria, which guide the U.S. engineering educational system, includes ethical and professional responsibility, and an understanding of the social impacts of engineering as paramount skills to be gained by engineering students (ABET, 2008). Furthermore, the ASCE BOK2 draws attention to the importance of not only the need for specific knowledge and skills to be a successful engineer, but also a wide range of attitudes, such as the consideration of others and sensitivity, recognizing that attitudes are central to how knowledge and skills are used (American Society for Civil Engineering, 2008). Ethics, views of social impact, and many of these attitudes build from a foundation of social responsibility, guiding how engineering students and professionals perceive their roles in society. Learning Through Service (LTS) is one approach that is being used to incorporate these elements into the engineering educational system, working towards training future generations of engineers who are adept at working across cultural and social divides to solve complex problems.

This thesis has focused on defining and developing models and instruments able to assess beliefs of personal and professional social responsibility among engineering students. The purpose of this has been to provide tools which are useful at gauging the effects of educational interventions, such as LTS, geared at positively affecting these base dispositions in students. Several hypotheses were put forth about the relative agreeability of different aspects of social responsibility such as awareness and obligation, about the potential for disconnects between students' views of personal and professional social responsibility, about relative degrees of social responsibility between genders, academic ranks and majors, and about possible sources of those differences such as previous volunteer histories. Most of these hypotheses were supported by the results presented in this thesis and much of the evidence provides good trajectories to guide future research.

In Chapter III, the theoretical grounding for our approach to social responsibility was presented, rooted in the Ethic of Care framework. This new framework for describing students' attitudes about the importance of social responsibility in engineers combined ideas about the development of altruistic behavior, the inclusion of social elements into the scientific process, and the effects of volunteering on views of social responsibility to explain the development of social responsibility in engineers. Each of the eight PSRDM dimensions was discussed and qualitative data was used to exemplify experiences which had influenced different students' development of beliefs within each of the three realms of the PSRDM. This framework provides theoretical grounding for future work to study personal and professional social responsibility, including designing and assessing educational interventions aimed at developing positive dispositions of each in engineers.

Chapter IV presented the development of the Engineering Professional Responsibility Assessment tool, based upon the PSRDM. This tool is intended to measure engineering student degrees of social responsibility for each of the eight dimensions of the PSRDM. Other elements of EPRA provide supporting evidence which correlate with social responsibility, including the importance of future careers attributes, previous volunteer involvement, motivations and limitations for volunteering, and open ended questions related to life experiences, people, or classes which may had influenced social responsibility, and reasons for choosing one's major. Evidence of reliability using Ordinal Alpha and validity using Multidimensional Item Response Theory and agreement with interview data were presented. Results from these analyses support that the EPRA tool measures beliefs of social responsibility and is able to differentiate between individuals with differing perspectives, as seen from interview data. Agreement between volunteer frequencies and social responsibility also supported the connection between the two. Future applications of this instrument could include pre- and post- assessment of individual courses, extracurricular experiences (such as participation in EWB projects), or engineering curriculum in order to identify practices that successfully increase social responsibility among students. Plans are currently underway at Virginia Technological University to apply this instrument to an engineering ethics course.

Chapter V examined results from a multi-institution distribution of EPRA that explored differences in the views of social responsibility between women and men. Female engineering students consistently had higher degrees of social responsibility than male engineering students, with the largest difference among first-year students as they entered college. Engineering discipline was seen to be a confounding element for responses to why they chose their major because a majority of the Environmental Engineering respondents were women. Gender, however, was seen to be the more dominant element, where the male students in the major with the highest social responsibility (Environmental) were statistically similar to the female students in the major with the lowest social responsibility (Mechanical). Looking across academic ranks showed that, for women, views of social responsibility were lower for higher academic ranks in most of the PSRDM dimensions, but were similar or higher for men. This could be due to women with higher degrees of social responsibility leaving engineering, or that something in the engineering curriculum negatively affects women's views of social responsibility. A longitudinal study should be conducted explore curricular, extracurricular, or outside effects on students' views on engineering professional responsibility as they progress through engineering. This could also determine if there is differential attrition of students with high social responsibility out of engineering and/or particular engineering majors.

In open responses, students overwhelming cited previous volunteer activities as influencing factors for their views of social responsibility, therefore differences in prior volunteer experiences were examined between male and female first-year students. It was found that female students generally volunteered with more activities, and did so more frequently than male students. Consistent with the underlying theory about the development of social responsibility, it was seen that for both male and female students, social responsibility scores increased with the amount of volunteering that individuals did. This could point to service-learning courses and the incorporation of service activities into student professional societies as a method to increase social responsibility among engineering students. Finally, consistent with previous research, it was seen that female students more frequently cited a desire to have an impact on society as motivation for them choosing their engineering major, specifically Civil and Environmental engineering. Therefore, engineering curricula should reinforce these social benefits of engineering early and often throughout courses to help motivate and retain these students.

In Chapter VI, the same Tier 1 data set was used to examine differences in social responsibility among Civil, Environmental, and Mechanical Engineering students. It was found that, consistent across gender and academic rank, Environmental Engineering students had higher scores than Civil Engineering students, who had higher scores than Mechanical Engineering students. Students in Environmental Engineering more often cited outwardly focused motivations for choosing that discipline, mainly a desire to have a positive impact on society, and to help the environment, whereas students in Mechanical Engineering more often cited inwardly focused motivations: enjoyment in building things, an aptitude for math and science, and the broad nature of the field. Civil Engineering students also fell between the other two with respect to motivations, citing most often a desire to have an impact on society, an aptitude for math and science, and enjoyment in building things. Departmental websites were examined at the five Tier 1 institutions for each discipline, searching for messaging differences which may attract students differently based upon perceived alignment with beliefs of social responsibility. It was found, however, that there were few differences between the disciplines in terms of messaging around elements of social responsibility, including the ability to have a positive impact on society, and an ability to contribute to medical technology or environmentally health. Future studies should expand to an exploration of additional engineering disciplines.

In general, this dissertation presented evidence of correlations between elements of gender, academic rank, engineering discipline, and volunteer activity. These results provide a solid starting point for future research. The following are some ideas about future directions of research, inspired by the results presented in this thesis.

- Examining changes in social responsibility in students longitudinally, through an entire undergraduate program. Comparing men and women pseudo-longitudinally showed lower scores for women at higher academic ranks, but not for men. True longitudinal data from EPRA, accompanied by interview data could shed light on how social responsibility plays into the retention of women through the engineering curriculum. It would be interesting to examine how classroom experiences influence, or don't influence views of social responsibility in this context, as well as extracurricular activities. EPRA scores could be used to quantify the change, but qualitative methods would be need to isolate potential causes for any changes that were seen. This study is on-going with 30 first-year students, having acquired both pre- and post- EPRA surveys from their first-year and interviews with each which were conducted near the end of their first year by Greg Rulifson. Two more years of follow-up interviews with these students are planned as part of the current NSF grant.
- First-year engineering students enter college with many of their views of personal social responsibility having already been formed. It would be worthwhile to extend this study of the development of social responsibility to students throughout the elementary and secondary educational system. For those first-year students who discussed a desire to have an impact on society as their reason for choosing engineering,

where did they get that idea? What exposed them to engineering as the pathway for them to achieve those personal goals, as opposed to medicine, law, social work, and many other professions which could be used to do the same? How many of these influences are within the educational system and could possibly be influenced by teachers and how many are simply out of anyone's control? This research could be coupled with an active GK-12 program with local schools, which introduces engineering starting in $2^{nd}$ grade classrooms and builds to a STEM academy in high school or with the new Next Generation Science Standards that encourage the integration of engineering and engineering design into the K-12 science education (Next Generation Science Standards, 2013)

- In addition to looking at social responsibility in prospective engineering students, it would also be critical to look at social responsibility in engineers post-graduation. Preliminary research has been conducted regarding the professional experiences of students who were active in engineering service opportunities in college, using interviews with 14 alumni, to-date. How do college experiences influence the professional trajectories of engineering students? In what ways does the engineering profession develop and support ideas of social responsibility? Do student views align with or conflict with professional realities? Is social responsibility an element of retention issues in the professional realm as it may be for the educational realm? This is particularly important in light of the very low percentage of females in the engineering workforce, which significantly lags the percentage of female students earning Bachelor's degrees (Corbett & Hill, 2012).
- EPRA is a tool which measures self-reported beliefs regarding personal and professional social responsibility, but it would be interesting to approach social responsibility from a behavioral perspective. It would be worthwhile to see how beliefs of social responsibility manifest themselves in the behavior of engineering students, both as students and later as professionals. Qualitative and quantitative methods could be used in the design of studies which take a behavioral approach to social responsibility as opposed to a cognitive development approach as was done in this study. Instead of looking at student beliefs about social responsibility (as was done with Likert-items), engineering students could be observed in classrooms, group projects, or on service experiences to see how they enact their role in social settings. When and how do they incorporate social considerations into their designs? How much are they willing to

change a design to fit with community needs and beliefs? How do personal values play into the way in which they talk with and about their teammates, project partners, or beneficiaries?

- In this study, correlations were examined, but causal relationships were much more difficult to discuss due to the majority of data coming from a qualitative instrument. The student interview data could be used to shed some light on causal relationships, though, it seems that one-time interviews can only go so deep into personal histories. Moreover, views of social responsibility are engrained in each person, and perhaps many engineering students haven't been given or taken the time to really think about their views. For this reason, a series of interviews would be useful to allow students to process and for a relationship to develop where, perhaps, deeper beliefs and causes could be discussed. Fuzzy set Qualitative Comparative Analysis (Ragin, 2006) may be a useful tool to examine data from a set of interviews like this, as a way to discuss non-linear relationships between life experiences as influences to views of social responsibility.
- The PSRDM framework provides a foundation for examining the development of personal and professional social responsibility and has been applied to engineering in this study. It would be interesting to try to apply this framework to other professions to examine how social responsibility is viewed and how it develops for those professions. In business, for example, Corporate Social Responsibility is a common term, but may hold vastly different meanings than how social responsibility is used in this study. Moreover, the manifestation of Corporate Social Responsibility may be very different from the manifestation of social responsibility in engineering. Advancing the PSRDM to other professions and developing tools similar to EPRA would be very interesting. Net Impact is an organization of businesses and business students that focuses on "creating positive social and environmental change in the workplace and the world" (Net Impact, 2013). This organization could be studied from the lens of professional social responsibility using the PSRDM, similar to how EWB would be studied in engineering.
- Volunteer activity and frequency are one way to look at service involvement, but even the same activity can be experienced differently by two different people. Therefore, a deeper examination of student involvement in service activities across institutions could provide more insight into how service influences social responsibility. On this note, more work could be done to tie the five levels of the Service Learning Model (Delve, Mintz, & Stewart, 1990) into how service experiences are viewed with respect to the

development of social responsibility, going further into the cyclical nature of the Professional Connectedness Realm of the PSRDM.

- Finally, continuing the research presented here, a wider distribution of EPRA to other engineering majors and a wider variety of institutions would be informative. How do other majors compare to the three sampled here? How much does institutional character influence the development of social responsibility? Does curricular variation between majors and institutions, such as the amount of humanities classes that an engineer takes, influence their development of social responsibility?

In conclusion, this thesis presents a perspective on personal and professional social responsibility as one way in which the engineering profession can address the need for change. Social responsibility is seen as a fundamental disposition which guides the ways in which an engineer and the engineering profession relate to society and social issues. Studying social responsibility, including ways to measure it and educational interventions designed to affect its development, allows researchers, educators, and professionals to work towards developing more holistic engineers on a foundational level. It is believed that an engineer with strong social responsibility will hold the values, ethics, and awareness desired in the engineer of the future, able to work across social and cultural lines to solve many of the complex social issues our society faces.

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# APPENDIX A

# THE ENGINEERING PROFESSIONAL RESPONSIBILITY ASSESSMENT (EPRA) TOOL

**Engineering Professional Responsibility Assessment**

**Definitions:**

*Community Service* is voluntary work intended to help people in a particular community.

*Social Responsibility* is 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.

*Social Justice* relates to the distribution of the advantages and disadvantages in society, including the way in which they are allocated.

*pro bono* - Work done without compensation (pay) for the public good

**Please rate how important the following skills are for a professional engineer using the following scale:**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Very Unimportant | Unimportant | Slightly Unimportant | Neutral | Slightly Important | Important | Very Important |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Fundamental Skills *(i.e. Math & Science)*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Technical Skills *(i.e. Conducting Experiments, Data Analysis, Design, Engineering Tools, & Problem Solving)*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Business Skills *(i.e. Business Knowledge, Management Skills & Professionalism)*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Professional Skills *(i.e. Communication, Contemporary Issues, Creativity, Leadership, Life-Long Learning, & Teamwork)*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Cultural Awareness/Understanding *(i.e. of your culture, and those of others)*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Ethics *(i.e. ensuring all of your work follows professional codes of conduct)*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Societal Context *(i.e. how your work connects to society and vice versa)*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Volunteerism *(for professional and personal reasons)*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Future Job Qualities:** Below there are 8 bins with different job qualities on them. You have 10 stones to distribute among the bins to mark which qualities are important to you when thinking of your future engineering job. You may place multiple stones in any bin, but you must place exactly 10 stones in total and no fractional stone distributions are allowed. Write your number of stones in the square on each bin.

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**Rate the level to which you agree/disagree with the following statements using the following scale:**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Disagree | Disagree | Slightly Disagree | Neutral | Slightly Agree | Agree | Strongly Agree |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Engineers have contributed greatly to fixing problems in the world** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I would *not* change my engineering design because it conflicted with community feedback** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Volunteer experience(s) have changed the way I think about spending money** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **It is important to me personally to have a career that involves helping people** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Engineering skills are *not* useful in making the community a better place** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **It is important for engineers to consider the potential broader impacts of technical solutions to problems** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Service should *not* be an expected part of the engineering profession** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I would be willing to have a career that earns less money if I were serving society** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I will use engineering to help others** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I view engineering and community service work as unconnected** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I feel called to serve others through engineering** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **The needs of society have no affect on my choice to pursue engineering as a career** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **It is important to incorporate societal constraints into engineering decisions** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Technology does *not* play an important role in solving society's problems** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **My engineering skills are strengthened through participation in engineering service opportunities** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I feel called by the needs of society to pursue a career in engineering** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Engineering firms should take on some *pro bono* work** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I doubt that volunteer work will ever have much affect on my career** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I think it is important to use my engineering to serve others** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Engineers can have a positive impact on society** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Engineers should use their skills to solve social problems** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **It is important to use my engineering abilities to provide a useful service to the community** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I believe that I will be involved in social justice issues for the rest of my life** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Rate the level to which you agree/disagree with the following statements using the following scale:**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Strongly Disagree | Disagree | Slightly Disagree | Neutral | Slightly Agree | Agree | Strongly Agree |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **I do *not* think it is important to use engineering to serve the greater community** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I believe my life will be positively affected by the volunteering that I do** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I think people who are more fortunate in life should help less fortunate people with their needs and problems** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I believe that extra time spent on community service is worthwhile** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **It is *not* my responsibility to do something about improving society** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I believe it takes more than time, money, and community efforts to change social problems: we also need to work for change at a national or global level** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Community groups need our help** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **There are *not* people in the community who need help** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I can have an impact on solving problems that face my local community** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **It is important to me to have a sense of contribution and helpfulness through participating in community service** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Please mark "3" if you are reading this question** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **It is my responsibility to take some real measures to help others in need** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I feel an obligation to contribute to society** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **There are people who have needs which are not being met** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **My contribution to society will make a real difference** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I think I should help people who are less fortunate with their needs and problems** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **I *cannot* have an impact on solving problems that face underserved communities internationally** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **There are needs in the community** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Rate the frequency that you have engaged in any of the following community service activities since the beginning of this school year, using the following rating scale:**

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Have not Participated | Once | Twice | More than Twice but not routinely | Monthly | Weekly |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Habitat for Humanity Build** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Tutoring elementary or secondary children** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Tutoring college students (unpaid)** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Donated Blood** | 0 | 1 | 2 | 3 | 4 | 5 |
| **In Class Service Learning Project (i.e. service oriented capstone project)** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Engineers without Borders (EWB), Engineers for a Sustainable World (ESW), or Bridges 2 Prosperity Project** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Short term on-site service project (i.e. Spring Break Service trip, EWB/ESW in-country work)** | 0 | 1 | 2 | 3 | | |
| **Disaster Relief Volunteer** | 0 | 1 | 2 | 3 | | |
| **International Humanitarian Volunteer: (Specify)_________________________** | 0 | 1 | 2 | 3 | | |
| **Food Bank Volunteer** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Meals on Wheels Volunteer** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Nursing Home Volunteer** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Political Campaign Volunteer** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Big Brother/Big Sister, Boys & Girls Club, Boy/Girl Scouts** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Soup Kitchen Volunteer** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Sports Camp, Coaching, etc. (unpaid)** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Professional Society (ASCE, ASME, AAEE, etc.)** | 0 | 1 | 2 | 3 | 4 | 5 |
| **Other:_____________________________** | 0 | 1 | 2 | 3 | 4 | 5 |

**If you were to volunteer, or have volunteered with an organization since coming to college, please specify why you would/did (check all that apply):**

- ☐ Required for class
- ☐ I went with a friend
- ☐ Because of my religious beliefs
- ☐ Makes me feel good
- ☐ To help others
- ☐ With my Fraternity/Sorority
- ☐ To gain new skills
- ☐ To meet new people
- ☐ To build my resume
- ☐ For an international experience (to travel)
- ☐ Other:________________________________

**Are there factors that currently or have previously limited/inhibited your participation in volunteer activities (check all that apply):**

- ☐ Lack of time due to course work
- ☐ Lack of time due to extracurricular activities
- ☐ Lack of time due to work obligations
- ☐ Family obligations
- ☐ Health restrictions
- ☐ Don't know where to volunteer/how to be connected with a volunteer opportunity
- ☐ Not interested in volunteering
- ☐ My friends do not participate in volunteer activities
- ☐ Previous negative experience(s) with volunteering
- ☐ Financial limitations
- ☐ None
- ☐ Other:________________________________

**Briefly describe any events that have influenced your views of community service and social responsibility**.

| |
|---|
| |

## Demographic Information

| | |
|---|---|
| **Name:** | |
| **Email:** | |
| **Gender** | Male     Female |
| **Age:** | <18    18-20    21-23    24-28    >28 |
| **Major:** | Civil    Environmental    Mechanical<br>Open<br>Other:______________________________ |
| **College rank:** | Freshman    Sophomore    Junior    Senior    Graduate |
| **Cumulative GPA:** | <2.5    2.5-3.0    3.0-3.5    3.5-4.0 |
| **Race:** | African American    Hispanic    Asian<br>Native American    Non-Hispanic White    Multiracial<br>Other:______________________________ |
| **Previous Engineering Work Experience:** | None    Summer or Part Time Internship/Co-term    Full Time Employment: For _______ year(s) |
| **Are you in the first generation of your family to attend college?** | Yes    No |
| **How would you describe your religious preference?** | Religious, affiliated with an organized religion (i.e. Christian, Muslim, Jewish, Hindu, Buddhist, etc.)    Spiritual but not affiliated with an organized religion (i.e. Humanist, Agnostic, etc.)    Atheist    Indifferent or not religious |
| **If religious, how active do you consider yourself in the practice of your religious preference?** | Very active    Somewhat active    Not very active    Not active    Does not apply/Prefer not to say |

# APPENDIX B

# EPRA DEVELOPMENT

The following table presents items which were removed or added to the EPRA tool through its development in the Pilot and Tier 1 surveys. If items came from another survey, the original sources for those items are given, as well as when it was added or removed. This appendix is supplemental to Chapter IV, which discussed the development process in more completely.

| | Action | When? | Item | Source |
|---|---|---|---|---|
| **Awareness** | Original | | There are not people in the community who need help | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original, Removed | Pilot, 2nd iteration | Cultural differences are less important than the fact that people have the same needs, interests, and goals in life | (IDI, LLC, 2011) |
| | Original, Removed | Pilot, 2nd iteration | It is appropriate that people do not care what happens outside their country | (IDI, LLC, 2011) |
| | Original, Removed | Pilot, 2nd iteration | People in other cultures are more interested than we are in improving themselves | (IDI, LLC, 2011) |
| | Added | Pilot, 3rd iteration | There are needs in the community | (Shiarella, McCarthy, & Tucker, 2000) |
| | Added | Pilot, 3rd iteration | Community groups need our help | (Shiarella, McCarthy, & Tucker, 2000) |
| | Added | Pilot, 3rd iteration | There are people who have needs which are not being met | (Shiarella, McCarthy, & Tucker, 2000) |
| | Added | Pilot, 3rd iteration | There are not communities in America that need help | |
| **Ability** | Original, edited | Pilot, 2nd iteration | I can make a difference in ~~the~~ my community | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original | | I can have an impact on solving problems that face my local community | (Duffy, Barrington, & Heredia Munoz, 2011) |
| | Original | | My contribution to society will make a real difference | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original | | I cannot have an impact on solving problems that face underserved communities internationally | (Duffy, Barrington, & Heredia Munoz, 2011) |
| **Connec** | Original, Removed | Pilot, 3rd iteration | Rate how important the following is to you personally: Helping others who are in difficulty | (Center of Inquiry in the Liberal Arts at Wabash Colledge, 2007) |

| | | | | |
|---|---|---|---|---|
| | Original, Removed | Pilot, 3rd iteration | Rate how important the following is to you personally: Volunteering in a community | (Center of Inquiry in the Liberal Arts at Wabash Colledge, 2007) |
| | Original | | I am responsible for doing something about improving society | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original, negatively worded | Pilot, 3rd iteration | It is *not* my responsibility to take some real measures to help others in need | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original, positively worded | Pilot, 2nd iteration | I feel any obligations to contribute to society | (Shiarella, McCarthy, & Tucker, 2000) |
| | Added | Pilot, 2nd iteration | I think I should help people who are less fortunate with their needs and problems | |
| **Base Skills** | Original, Consolidated | Pilot, 3rd iteration | How important is Business Knowledge to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Communication to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Conducting Experiments to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Creativity to a professional engineer? | |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Data Analysis to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Design to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Engineering Tools to a professional engineer? | (Atman, et al., 2010) |
| | Original | | How important is Ethics to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Leadership to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Life-Long Learning to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Management Skills to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Math to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Problem Solving to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Professionalism to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Science to a professional engineer? | (Atman, et al., 2010) |
| | Original, Consolidated | Pilot, 3rd iteration | How important is Teamwork to a professional engineer? | (Atman, et al., 2010) |
| | Added, Expanded | Pilot, 3rd iteration, Tier 1 pre- | How important are Technical Skills (i.e. Math, Conducting Experiments, Data Analysis, Design, Engineering Tools, Problem Solving, & Science) for a professional engineer | |
| | Added, Expanded | Pilot, 3rd iteration, Tier 1 pre- | How important are Professional Skills (i.e. Business Knowledge, Communication, Contemporary Issues, Creativity, Leadership, Life-Long Learning, Management Skills, | |

| | | | | |
|---|---|---|---|---|
| | | | Professionalism, & Teamwork) for a professional engineer | |
| | Added | Tier 1 pre- | How important are Technical Skills (*i.e. Conducting Experiments, Data Analysis, Design, Engineering Tools, & Problem Solving*) for a professional engineer | |
| | Added | Tier 1 pre- | How important are Professional Skills (*i.e. Communication, Contemporary Issues, Creativity, Leadership, Life-Long Learning, & Teamwork*) for a professional engineer | |
| | Added | Tier 1 pre- | How important are Fundamental Skills ((*i.e. Math & Science*) for a professional engineer | |
| | Added | Tier 1 pre- | How important are Business Skills (.*e. Business Knowledge, Management Skills & Professionalism*) for a professional engineer | |
| **Professional Ability** | Original | | Engineers have contributed greatly to fixing problems in the world | (Besterfied-Sacre, Atman, & Shuman, 2000) |
| | Original | | My engineering skills are *not* useful in making the community a better place | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original | | Technology does *not* play a role in solving society's problems | (Besterfied-Sacre, Atman, & Shuman, 2000) |
| | Original | | Engineers can have a positive impact on society | |
| **Analyze** | Original, Consolidated | Pilot, 3rd iteration | How important are Contemporary Issues for a professional engineer? | (Atman, et al., 2010) |
| | Original | | How important are Cultural Awareness/Understanding for a professional engineer? | (ABET, 2008) |
| | Original, Removed | Pilot, 3rd iteration | How important are Global Context for a professional engineer? | (Atman, et al., 2010) |
| | Original | | How important are Societal Context for a professional engineer? | (Atman, et al., 2010) |
| | Original, Removed | Pilot, 3rd iteration | Courses have *not* helped me see the connections between engineering and how it affects society | (Center of Inquiry in the Liberal Arts at Wabash Colledge, 2007) |
| | Original, Removed | Pilot, 3rd iteration | Rate how motivated you would be to: Incorporate societal constraints into engineering decisions | (McCormick, et al., 2010) |
| | Added | Pilot, 3rd iteration | It is important for engineers to consider the broader potential impacts of technical solutions to problems | |
| | Added | Pilot, 3rd iteration | I would *not* change my design if it conflicted with community feedback | |
| | Added | Pilot, 3rd iteration | It is important to incorporate societal constraints into engineering decisions | Adapted from (McCormick, et al., 2010) |
| **Professional** | Original | | How important is Volunteerism for a professional engineer? | |
| | Original (with *Activation* dimension) | | Volunteer experience(s) have changed the way I think about spending money | (Olney & Grande, 1995) |
| | Original (with *Internalization* | | It is important to me personally to have a career that involves helping people | (Duffy, Barrington, & Heredia Munoz, |

| | | | | |
|---|---|---|---|---|
| | dimension) | | | 2011) |
| | Original | | Service should *not* be an expected part of the engineering profession | (Duffy, Barrington, & Heredia Munoz, 2011) |
| | Original (with *Internalization* dimension) | | I doubt that volunteer work will ever have much affect on my career | (Olney & Grande, 1995) |
| | Original | | Engineers should use their skills to solve social problems | (Duffy, Barrington, & Heredia Munoz, 2011) |
| | Original (with *Internalization* dimension) | | I believe that I will be involved in social justice issues for the rest of my life | (Olney & Grande, 1995) |
| | Original, Removed | Pilot, 3rd iteration | Rate how motivated you would be to: Use Engineering to help society or solve a societal need | (McCormick, et al., 2010) |
| | Original, Removed | Pilot, 3rd iteration | Rate how motivated you would be to: Use engineering to benefit your community | (McCormick, et al., 2010) |
| | Original, Removed | Pilot, 3rd iteration | Rate how motivated you would be to: Act responsibly as a citizen and professional | (McCormick, et al., 2010) |
| | Original (with *Activation* dimension), Removed | Pilot, 3rd iteration | Rate how important the following is to you personally: Influencing social values | (Center of Inquiry in the Liberal Arts at Wabash Colledge, 2007) |
| | Original (with *Realization* dimension), Removed | Pilot, 3rd iteration | Rate how important the following is to you personally: Influencing politics | |
| | Original (with *Realization* dimension), Removed | Pilot, 3rd iteration | It is *not* important to me to gain a sense of responsibility by participating in community service | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original (with *Internalization* dimension), edited | Pilot, 2nd iteration | I think people ~~like me~~ who are more fortunate in life ~~need to~~ should help less fortunate people with their needs and problems | (Olney & Grande, 1995) |
| | Original (with *Internalization* dimension) | | I believe it takes more than time, money, and community efforts to change social problems: we also need to work for change at a national or global level | (Olney & Grande, 1995) |
| | Original (with *Realization* dimension) | | It is important to me to have a sense of contribution and helpfulness through participating in community service | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original (with *Activation* dimension), Removed | Tier 1 post- | The people who benefit from my volunteer activities do *not* have anything to offer me | (Olney & Grande, 1995) |
| | Original (with *Realization* dimension), edited | Pilot, 3rd iteration | It is important to use my engineering abilities to provide a useful service to the community ~~through community service~~ | (Shiarella, McCarthy, & Tucker, 2000) |
| | Original (with *Activation* dimension), Removed | Tier 1 post- | I believe that the causes of most social issues are simple | (Olney & Grande, 1995) |
| | Original (with | Tier 1 post- | I am starting to realize that many volunteer | (Olney & Grande, |

| | | | | |
|---|---|---|---|---|
| | *Activation* dimension), Removed | | organizations simply put “band aids” over social problems, rather than change them | 1995) |
| | Added | Pilot, 3rd iteration | I will use engineering to help others | (Duffy & Raque-Bogdan, 2010) |
| | Added | Pilot, 3rd iteration | I think it is important to use my engineering to serve others | (Duffy & Raque-Bogdan, 2010) |
| | Added | Pilot, 3rd iteration | I do not think it is important to use engineering to serve the greater community | (Duffy & Raque-Bogdan, 2010) |
| | Added | Pilot, 3rd iteration | I view engineering and community service work as unconnected | (Duffy & Raque-Bogdan, 2010) |
| | Added | Pilot, 3rd iteration | I feel called by the needs of society to pursue a career in engineering | (Duffy & Raque-Bogdan, 2010) |
| | Added | Pilot, 3rd iteration | I feel called to serve others through engineering | (Duffy & Raque-Bogdan, 2010) |
| | Added | Pilot, 3rd iteration | The needs of society have no effect on my choice to pursue engineering as a career | (Duffy & Raque-Bogdan, 2010) |
| **Action** | Original, Removed | Pilot, 3rd iteration | My department helps facilitate community service | |
| | Original, Added to Professional Connectedness | Pilot, 3rd iteration | Engineering Firms should take on some *pro bono* work | |
| **Costs/Benefits** | Original, Removed | Pilot, 3rd iteration | Engineering is more concerned with improving the welfare of society than most other professions | (Besterfied-Sacre, Atman, & Shuman, 2000) |
| | Original, Removed | Pilot, 2nd iteration | Engineers can have a negative impact on society | |
| | Original, Removed | Pilot, 3rd iteration | People in most other occupations contribute more to making the world a better place than engineers | (Besterfied-Sacre, Atman, & Shuman, 2000) |
| | Added | Pilot, 3rd iteration | I would be willing to have a career that earns less money if I were serving society | |
| | Added | Pilot, 3rd iteration | I believe that extra time spent on community service is worthwhile | |
| | Added, Removed | Pilot, 3rd iteration, Tier 1 post- | Knowing that my engineering career is helping others would *not* increase my personal satisfaction | (Shiarella, McCarthy, & Tucker, 2000) |
| | Added, Removed | Pilot, 3rd iteration, Tier 1 pre- | I believe that there are risks associated with doing community service | |
| | Added | Pilot, 3rd iteration | My engineering skills are strengthened through participation in engineering service opportunities | |
| | Added | Tier 1 pre- | I believe my life will be positively affected by the volunteering that I do | |

The following shows the evolution of the career attributes question:

**Fall 2011 pre- version:**
Briefly describe your ideal engineering career (types of projects, clients, firm, field work, etc.)

| |
|---|
| |

**Fall 2011 post- version:**
Rank which job description you would Most Prefer (6) to Least Prefer (1) as a career

| **Job Description** | **Rank**<br>1=Least Prefer → 6=Most Prefer |
|---|---|
| Engineering design on **domestic** public works projects - $55,000/year | |
| Engineering design on **domestic** private projects - $60,000/year | |
| Engineering design on **international** projects in **developed** countries, **living domestically** - $60,000/year | |
| Engineering design on **international** projects in **developed** countries, **living internationally** - $70,000/year | |
| Engineering design on **international** projects in **developing** countries, **living domestically** - $40,000/year | |
| Engineering design on **international** projects in **developing** countries, **living internationally** - $35,000/year | |

Explain what factors most influenced your job ranking choices

| |
|---|
| |

**Spring 2012 pre- version:**

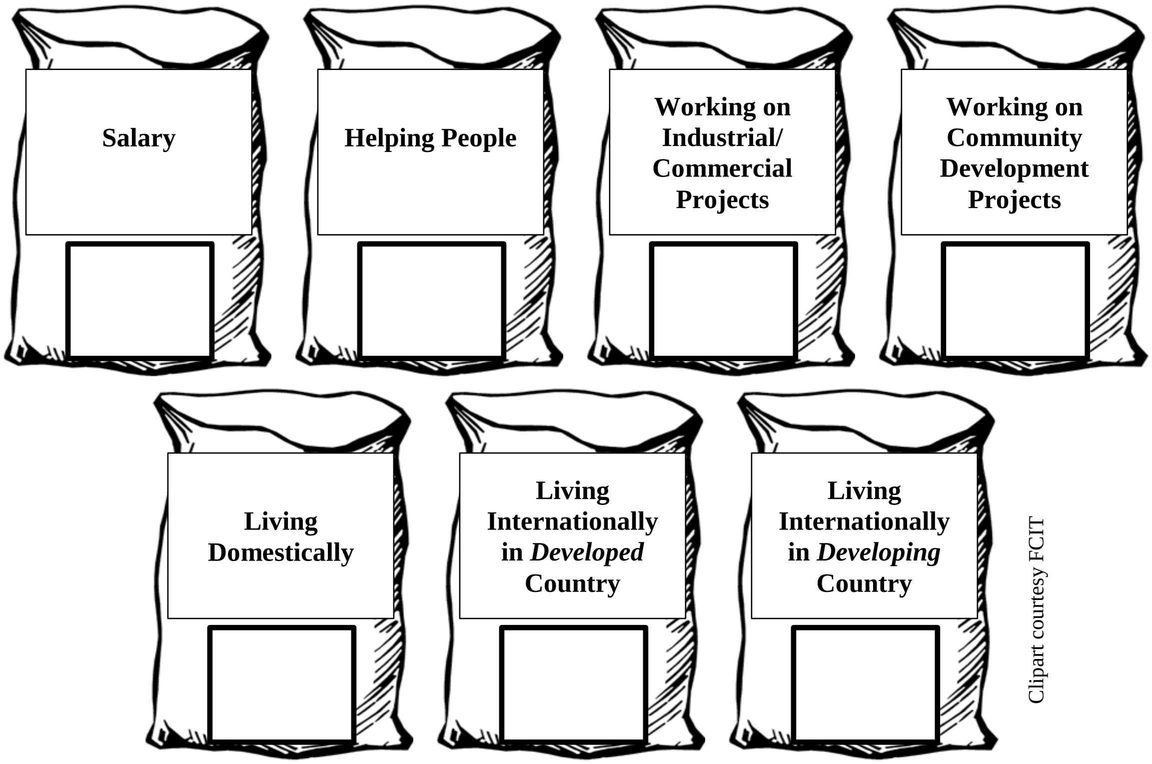
Rank which job description you would Most Prefer (1) to Least Prefer (6) as a career

| **Job Description** | **Rank**<br>1=Most Prefer→ 6=Least Prefer |
|---|---|
| Engineering design on **community development** projects in **developed** countries (including the US), **living domestically** - $55,000/year | |
| Engineering design on **community development** projects in **developed** countries, **living internationally** - $60,000/year | |
| Engineering design on **industrial/commercial** projects in **developed** countries (including the US), **living domestically** - $60,000/year | |
| Engineering design on **industrial/commercial** projects in **developed** countries, **living internationally** - $70,000/year | |
| Engineering design on **community development** projects in **developing** countries **living domestically** - $40,000/year | |
| Engineering design on **community development** projects in **developing** countries **living internationally** - $35,000/year | |

Explain what factors most influenced your job ranking choices

**Spring 2012 post- version:**

**Future Job Qualities:** Below **t**here are 7 bins with different job qualities on them. You have 10 stones to distribute among the bins to mark which qualities are important to you when thinking of your future engineering job. You may place multiple stones in any bin, but you must place exactly **10** stones in total. Write your number of stones in the square on each bin.




Clipart courtesy FCIT

**Current version:**

**Future Job Qualities:** Below there are 8 bins with different job qualities on them. You have 10 stones to distribute among the bins to mark which qualities are important to you when thinking of your future engineering job. You may place multiple stones in any bin, but you must place exactly 10 stones in total and no fractional stone distributions are allowed. Write your number of stones in the square on each bin.


Clipart courtesy FCIT

# APPENDIX C

# IRB APPROVAL LETTER

University of Colorado Boulder

Institutional Review Board
563 UCB
Boulder, CO 80309
Phone: 303.735.3702
Fax: 303.735.5185
FWA: 00003492

12-Dec-2011

**Initial Approval - Expedited**

Canney, Nathan
**Protocol #:** 11-0414
**Title:** Assessing Engineering Studentsâ€™ Understanding of Social Responsibility from Undergraduate and Graduate Education into Professional Life

Dear Nathan Canney,

The Institutional Review Board (IRB) has approved this protocol in accordance with Federal Regulations at 45 CFR 46. You must use the IRB approved informed consent form when obtaining consent from subjects participating in this protocol.

**Initial Approval Date:** 12-Dec-2011
**Expiration Date:** 11-Dec-2012
**Associated Documents:** * 11-0414 Protocol (12Dec11); 11-0414 Student Survey Consent (12Dec11); Student Interview Informed Consent; Student Post-Survey; Student Interview Questions for Gender Study; Alumni Interview Questions; Alumni Interview Informed Consent; Student Interview Questions; Student Pre-Survey; Updated Protocol; Student Survey Informed Consent; Alumni Survey Informed Consent; 11-0414 Alumni Survey Consent (12Dec11); 11-0414 Student Interview Consent (12Dec11); 11-0414 Alumni Interview Consent (12Dec11); Responses to Modification Request; Amendment - eForm;
**Number of subjects approved:** 3532
**Review Cycle:** 12 months
**Expedited Category:** 7

* Approved documents can be found by logging into the eRA system, opening this protocol, and navigating to the "Versions" folder.

A waiver of documentation of consent was granted in accordance with 45 CFR 46.117(c)(2): Research presenting no more than minimal risk of harm to subjects and involving no procedures for which written consent is normally required outside of the research context.

**Regulations require that this protocol be renewed prior to the above expiration date. The IRB will provide a reminder prior to the expiration date, but it is your responsibility to ensure that the continuing review form is received in sufficient time to be reviewed prior to the expiration date.**

Changes to your protocol must be submitted to the IRB for review and approval prior to their implementation. This includes changes to the consent form, principal investigator, protocol, etc.

All events that meet reporting criteria must be submitted within 10 business days from notification of the event. Any study-related death must be reported immediately (within 24 hours) upon learning of the death.

The IRB has approved this protocol in accordance with federal regulations, university policies and ethical standards for the protection of human subjects. In accordance with federal regulation at 45 CFR 46.112, research that has been approved by the IRB may be subject to further appropriate review and approval or disapproval by officials of the institution. The investigator is responsible for knowing and complying with all applicable research regulations and policies including, but not limited to, Environmental Health and Safety, Scientific Advisory and Review Committee, Clinical and Translational Research Center, and Wardenburg Health Center and Pharmacy policies. Approval by the IRB does not imply approval by any other entity.

Please contact the IRB office at 303-735-3702 if you have any questions about this letter or about IRB procedures.

Douglas Grafel
IRB Admin Review Coordinator
Institutional Review Board

# APPENDIX D

# MULTIDIMENSIONAL ITEM RESPONSE THEORY RESULTS

This appendix is a continuation of the discussion in Chapter IV about interpreting results from the Rasch Models used as evidence of construct validity. The key tool used for interpreting these results is the Wright Map The Wright Map is a diagram used to assess the relationships between item difficulty and participant abilities. Figure 23 shows the Wright Map for the Personal Social Awareness Realm, Figure 24 and Figure 25 show the Wright Maps for the Professional Development and Professional Connectedness realms, respectively. The measure shown on the left side of the Wright Map is logits, which is a measure of relative probability, with each row of Figure 23 representing 0.17 logits. The rows of "X"s represent the relative amount of the measured trait that participants have, in this case Personal Social Awareness, with each X standing for approximately 5 students. This column represents a histogram of the respondents' relative degrees of Personal Social Awareness. On the right hand side of the Wright Map are the locations of the Thrustonian Thresholds for each item and for each Likert answer on the 7-point scale. Near the top of the Wright Map, "co3.7" marks the location where there is a 50% probability of answering a 7 rather than a 6 or lower for question Conn3 (Refer to Table 10 for item codes). Because co3.7 is located two rows below aw2.7, it requires less of the trait to answer than item aw2.7. Looking at this another way, a person who is located in the same row as co3.7 has a 50% probability of crossing the threshold between a 6 and a 7 on the Likert scale, and a lower than 50% probability of doing so for aw2.7, but a greater than 50% probability of doing so for co1.7, which is located 3 rows below co3.7. The equation for translating logits to probability is given by,

$$Probability(Xi = Below\ Upper\ Threshold|\theta, \delta) = \frac{1}{1 + e^{(\theta - \delta)}}$$

Where θ is the individual's ability in logits and δ is the item difficulty in logits. Therefore, in the case given above, since aw2.7 is located 0.34 logits above co3.7, the individual located at the same logits as co3.7 has a 42% likelihood of crossing the 7 threshold for Aware2, and a 62% likelihood of crossing the 7 threshold for Conn1 which is located 0.51 logits lower. By examining the Wright Map in this way, we can see the relative difficulties between items, and test this against the developmental progressions hypothesized by the PSRDM. It is important to note that, in this case, it is inaccurate to compare between the three different Wright Maps because they were developed separately. Wright Maps are built upon the relationships between items, therefore there is no universal anchor point of difficulty, on an arbitrary anchor point set for that given set of data. In Chapter IV, an analysis was performed with all items from the EPRA tool, thereby allowing for relative difficulties to be examined between each realm. The Wright Map from this analysis is too messy and not worth showing in the traditional way, therefore the Wright Maps from each individual analysis are given here. See (Wilson M. , 2005) for a more detail discussion on how to read and interpret Wright Maps.

```
                        Wright Map (EAP)     Variable: psa
                                    Raw Scores
       Map of person estimates and response model parameter estimates
============================================================================
   raw       students                          Thurstonian Thresholds
----------------------------------------------------------------------------
4   |                       |
    |74                   XX|
    |68                    X|
    |73                   XX|
    |72                   XX|aw2.7 co2.7
    |66                    X|ab2.7 ab3.7 ab4.7 co4.7
3   |71                   XX|co3.7
    |                  XXXXX|
    |                  XXXXX|
    |                  XXXXX|co1.7
    |                   XXXX|ab1.7
    |                 XXXXXX|
2   |               XXXXXXXX|
    |       XXXXXXXXXXXXXXXX|aw4.7 aw5.7
    |           XXXXXXXXXXXX|aw3.7
    |            XXXXXXXXXXX|co2.6
    |   -----XXXXXXXXXXXXXXX|
    |             XXXXXXXXXX|aw2.6 ab3.6 ab4.6 co3.6 co4.6
1   |   XXXXXXXXXXXXXXXXXXXX|co1.6
    |     XXXXXXXXXXXXXXXXXX|ab2.6
    |        XXXXXXXXXXXXXXX|aw1.7
    |             XXXXXXXXXX|
    |          XXXXXXXXXXXXX|aw3.6 ab4.5 co1.5 co3.5
0   |            XXXXXXXXXXX|aw2.5 co2.5
    |                XXXXXXX|aw1.6 aw4.6 ab1.6 ab3.5 co4.5
    |                  XXXXX|aw1.5 aw3.5 aw5.6 ab4.4 co1.4 co3.4
    |                      X|aw1.3 aw1.4 aw3.4 aw4.5 ab2.5 co2.4
    |                       |aw3.3 aw4.3 aw4.4 aw5.5 ab4.3 co1.3
    |25                    X|aw5.4 co3.3 co4.4
-1  |                       |aw2.4 aw4.2 aw5.3 ab1.5 co2.3
    |                       |aw1.2 aw5.2 co1.2 co4.3
    |                       |ab2.4 ab3.4 ab4.2
    |                       |aw2.3 aw3.2
    |                       |co2.2 co3.2
    |                       |aw2.2 co4.2
-2  |                       |ab1.4
    |                       |ab2.3 ab3.3
    |                       |
    |                       |
    |                       |
    |                       |
-3  |                       |
    |                       |
    |                       |ab1.3
    |                       |
    |                       |
    |                       |
-4  |                       |
============================================================================
           Each X represents 5 students, each row is 0.170 logits
Model Specifications:
Measurement Model                    = Partial Credit
Proficiency Estimation Method        = EAP
Maximum Logit                        = 6.00
Minimum Logit                        = -6.00
Integration Method                   = Monte Carlo
Quadrature Nodes                     = 2000
EM convergence criteria              = 0.001
```

**FIGURE 23. PERSONAL SOCIAL AWARENESS REALM WRIGHT MAP**

```
--------------------------------------------------------------------------------
wright_map[13].txt
Jun 10, 2013  4:07:35 PM
Item Set: base
                   Wright Map (EAP)     Variable: profdev
                                 Raw Scores
       Map of person estimates and response model parameter estimates
================================================================================
   raw      students                         Thurstonian Thresholds
--------------------------------------------------------------------------------
6   |                       |
    |                       |
    |                       |
    |                       |
5   |                       |
    |                       |
    |                       |
    |                       |
4   |                       |
    |                       |
    |                       |
    |                       |
3   |                       |an3.7
    |                     XX|ba3.7 an5.7
    |77                    X|an1.7
    |                  XXXXX|an2.7
2   |                XXXXXXX|
    |        XXXXXXXXXXXXXXX|an4.7
    |   -----XXXXXXXXXXXXXXX|pa3.7
    |    XXXXXXXXXXXXXXXXXXX|ba4.7 ba5.7 pa2.7 an1.6 an3.6
1   |      XXXXXXXXXXXXXXXXX|ba1.7 pa1.7 pa4.7 an5.6
    |               XXXXXXXX|ba2.7 ba3.6 an2.6 an3.5
    |                    XXX|an1.5 an3.4
0   |                      X|ba4.6 ba5.6 pa2.5 pa2.6 pa3.6 an2.5 an4.6 an5.5
    |                     XX|ba1.6 ba2.2 ba2.3 ba2.4 ba2.5 ba2.6 ba3.5 ba4.3 .
    |24                    X|ba1.3 ba1.4 ba1.5 ba3.3 ba3.4 ba4.2 ba5.2 ba5.3 .
    |                       |pa1.5 pa2.2 pa3.3 pa4.6 an1.2 an2.2 an3.2 an4.3 .
-1  |                       |ba3.2
    |                       |an4.2
    |                       |pa4.5
    |                       |pa1.4 an5.2
-2  |                       |
    |                       |
    |                       |
    |                       |
-3  |                       |
    |                       |
    |                       |
    |                       |pa1.3 pa4.4
-4  |                       |
    |                       |
    |                       |
    |                       |
-5  |                       |
    |                       |
    |                       |
    |                       |
-6  |                       |
================================================================================
          Each X represents 11 students, each row is 0.255 logits
Model Specifications:
Measurement Model                = Partial Credit
Proficiency Estimation Method    = EAP
Maximum Logit                    = 6.00
Minimum Logit                    = -6.00
Integration Method               = Monte Carlo
Quadrature Nodes                 = 2000
EM convergence criteria          = 0.001
```

**FIGURE 24. PROFESSIONAL DEVELOPMENT REALM WRIGHT MAP**

```
---------------------------------------------------------------------------
wright_map[16].txt
Jun 10, 2013  4:26:06 PM
Item Set: base
                   Wright Map (EAP)     Variable: profcon
                                 Raw Scores
       Map of person estimates and response model parameter estimates
===========================================================================
   raw      students                     Thurstonian Thresholds
---------------------------------------------------------------------------
6   |                       |
    |                       |
    |                       |
    |                       |
5   |                       |
    |                       |
    |                       |
    |                       |
4   |                       |
    |                       |
    |137                   X|
    |                      X|
3   |                      X|
    |                     XX|pc1.7 pc2.7 pc4.7 pc6.7 pc7.7 pc9.7 pc10.7 cb1.7
    |                     XX|pc8.7 pc11.7 pc13.7 pc15.7 pc19.7 cb2.7
    |                  XXXXX|pc12.7 pc14.7 pc18.7 cb4.7
2   |                  XXXXX|pc17.7
    |               XXXXXXXX|pc3.7 pc5.7 pc9.6 pc15.6 pc16.7 cb3.7
    |             XXXXXXXXXX|pc4.6 pc7.6 pc10.6 cb1.6
    |         XXXXXXXXXXXXXX|pc1.6 pc2.6 pc6.6 pc8.6
1   |   ----XXXXXXXXXXXXXXXX|pc9.5 pc11.6 pc15.5 pc19.6 cb2.6
    |    XXXXXXXXXXXXXXXXXXX|pc4.5 pc7.5 pc8.5 pc10.5 pc12.6 pc13.6 pc14.6 ...
    |              XXXXXXXXX|pc2.5 pc3.6 pc6.5 pc9.4 pc16.6 pc17.6 cb3.6
0   |           XXXXXXXXXXXX|pc1.5 pc8.4 pc11.5 pc15.4 cb1.4 cb2.5 cb4.6
    |                XXXXXXX|pc4.4 pc5.6 pc6.4 pc7.4 pc8.3 pc9.3 pc12.5 ...
    |                   XXXX|pc1.4 pc2.4 pc3.5 pc7.3 pc10.4 pc11.4 pc14.5 ...
    |                     XX|pc2.3 pc4.3 pc6.3 pc10.3 pc13.4 pc16.4 pc17.4 ...
-1  |                      X|pc1.3 pc3.4 pc5.5 pc11.3 pc12.4 pc16.3 cb2.4
    |                      X|pc9.2 pc12.3 pc13.3 pc14.4 pc17.3 pc18.3 pc19.3 .
    |24                    X|pc3.3 pc14.3 pc15.2 cb1.2 cb2.3 cb4.4
    |18                    X|pc1.2 pc2.2 pc4.2 pc5.4 pc8.2 pc10.2 pc12.2 ...
-2  |                       |pc5.3 pc6.2 pc7.2 pc11.2 pc13.2 pc18.2 pc19.2
    |12                    X|pc5.2 pc14.2 pc17.2 cb2.2
    |                       |pc16.2
    |                       |pc3.2 cb4.2
-3  |                       |
    |                       |
    |                       |
    |                       |
-4  |                       |
    |                       |
    |                       |
    |                       |
-5  |                       |
    |                       |
    |                       |
    |                       |
-6  |                       |
===========================================================================
           Each X represents 9 students, each row is 0.255 logits
Model Specifications:
Measurement Model                = Partial Credit
Proficiency Estimation Method    = EAP
Maximum Logit                    = 6.00
Minimum Logit                    = -6.00
Integration Method               = Monte Carlo
Quadrature Nodes                 = 2000
EM convergence criteria          = 0.001
```

**FIGURE 25. PROFESSIONAL CONNECTEDNESS REALM WRIGHT MAP**

# APPENDIX E

# RUBRIC FOR DEGREES OF SOCIAL RESPONSIBILITY BASED UPON PSRDM DIMENSIONS

As part of this study, student interviews were coded using an a priori coding system with respect to each of the eight dimensions of the PSRDM. This was done in order to examine agreement between the more detailed information and insights gathered from an hour long interview with the dimension average scores obtained from the EPRA tool. The results from this are given in Chapter IV, but this appendix provides the rubric that was used and describes its development. The purpose of the rubric was to assign degrees or levels for each dimension which would correspond to average scores from the Likert-items.

Initial definitions for each construct and a rubric from 0 to 5 was developed by the author based upon his experiences having conducted, transcribed, and coded the interviews, and familiarity with the average Likert scores for the Tier 1 population. Because averages were generally skewed toward the positive side of the scale, the rubric was also developed to be asymmetric, where a degree of “2” was associated with a ‘neutral’ disposition, “1” captured all degrees of negative views or disagreement, and “3” through “5” corresponded to “slightly agree”, “agree”, and “strongly agree” from the Likert-scale. “0” was used to designate that there was no evidence from the interview to speak to that student’s views for that specific dimension.

The preliminary definitions and rubric were then sent to two engineering faculty members who conduct engineering education research, two staff members who conducted engineering education research in their doctoral programs, and three doctoral students engaged in engineering education research. A focus group was conducted with these seven experts, where each of the five levels for the eight dimensions was discussed, and wording was adjusted based upon the focus group comments. The researcher and another doctoral student (one of the students from the focus group) worked together to address the focus group’s comments.

Next, the researcher and that same doctoral student used the rubric to independently code 20 of the student interviews, assigning a level to each student for each dimension. After they had completed this process individually, the two students compared scores. Wherever there was disagreement, the two students worked together to come to consensus on an appropriate score. The rubric presented here is the result of this collaboration, including slight wording adjustments that occurred when the reviewers were developing consensus. Because it was never the intention to use this rubric beyond these two reviewers, intra-rater reliability was not examined between the two reviewers.

| Score | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **Awareness** | No Evidence | Use language that distances themselves from those in need, or recognizes some groups that may need help, but denies others (i.e. “Maybe there are people in Africa that need help, but certainly not here in the US.”) | Express both positive and negative statements about people needing help. Seem to be waffling on the issue (i.e. “Maybe there are people who need help, but maybe there aren’t”) | No direct comments about people in need, but peripherally discusses issues of people in need. (i.e. they volunteer at a soup kitchen, but never talk about the needs of the people they volunteer for) | Gives specific examples of people or groups that need help, but speaks about social issues as isolated events. Does not speak about social issues as interconnected. (i.e. “there are hungry people in many parts of the world” but no discussion of causes) | Fully aware that people need help and speaks to the interconnection between social issues and how that affects people in need. Evidence of complexity include: discussing systemic roots of problems, or cross disciplinary issues. |
| **Ability** | No Evidence | Speaks about an inability to help others in a meaningful way, or are averse to helping others. | Impersonal or distance acknowledgement of one’s ability to help, speak about possibly ‘yes’, possibly ‘no’ that they have the ability to help, or speak about not ever having opportunities to help. | Expresses that they have the ability to help others, but limiting themselves to small acts, helping individuals more than causes. | Expresses a strong belief in their ability to help people on systemic levels. They may also tend to recognize how the complexity of these systems may limit their ability to help. | Superman – they surely have an ability to help on any front – perhaps a seemingly naïve perspective that they can do anything. |
| **Connectedness** | No Evidence | Speaks about not feeling any moral/ethical responsibility or obligation to help others. | Impersonal, indirect, or vague acknowledgment that “people in general”, or companies or countries should help others. | An acknowledgement that they, personally, should help, but with little or no further discussions about why. Motivations of past experiences are surficial, such as ability to travel, or simply ‘fun’. | Talk about how they should help others, explaining why they feel that way either because of external or internal motivations (i.e. church, privilege, wealth, ability, morals, etc.). | Talks a sense of personal obligation to help others. It’s more than a ‘should’ but a ‘will’ or a personal mission. They talk about taking action as a critical component. |

| Score | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **Basic Skills** | No Evidence | Speaks against professional skills (communication, cultural awareness, teamwork, etc.) as being important | No direct discussion of the importance of professional skills, but speaks peripherally about how these types of skills might be important or useful for an engineer. | Acknowledges the need for both technical and professional skills, but does not go into depth, nor give examples of why. Also, does not talk about degrees of importance. | Talks about the importance of a balanced range of skills for an engineer, including technical and professional skills, and/or gives examples of using professional skills in engineering applications. | Talks about how professional skills are central to the work of an engineer and also gives examples or previous experiences to support this. |
| **Professional Ability** | No Evidence | Talks about how engineering cannot help those who are in need | Talks about how engineering helps generally just by the projects that we do. Uses examples of roads and buildings (i.e. the status quo) as ways in which engineering helps | Talks more about the potential for engineering to help solve social/ environmental problems that face society. This is a step beyond "just doing what engineers do", making a mild connection between engineering projects and improving people's livelihood. | Talks about engineering as a crucial element towards finding solutions to social problems. May express that engineering could be highly effective in solving these problems, but recognizes that engineering may not be the entire solution. | Hands down, engineering is the central source of solutions for social problems and that human (social, political, personal) development has been possible because of engineers. |
| **Analyze** | No Evidence | Talks about how it is not important to consider any social elements of engineering design, but that an engineer only needs to focus on technical issues | Does not speak directly about how social elements should be tied into the engineering process, but they may peripherally talk about how social issues may sometimes play a part (i.e. a narrow view of project stakeholder to include boss and client.) | Agrees on case-by-case basis that social considerations are important in the engineering process, though not primary to the engineering design process (i.e. if the project causes pollution, it will affect the whole community). Includes a recognition of a broader group impacted by engineering, but does not include a wider group in the decision making process | Talks about how it is good to incorporate social elements, and gives examples of how social considerations were positive for successful projects. Hold a wider definition of stakeholders to include the community or potentially affected groups, and includes them in aspects of the decision making process. These stakeholders have input. | Talks about how it is critical to incorporate social issues into the engineering design process, throughout the entire process and that projects cannot be successful without it. Prioritizes consideration of social issues over technical issues in terms of importance to project success. |

| Score | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **Professional Connectedness** | No Evidence | Speaks against any ideas of responsibility or obligation in the engineering profession to help others | Talks solely about professional minimal expectations as sources or levels of responsibility, including ethics, public safety, and cost (i.e. "to avoid lawsuits, you should follow the engineering code of ethics.") | Talks about the responsibility of an engineer extending beyond professional minimums, perhaps open to ideas of pro bono work, service, sustainability, or environmentalism | Talks about how engineers should do service, but are not required to. There is also an belief that it should be incorporated into their professional career, not just something that they individually do on the side – supported by the profession. | Expresses a strong connection between their personal moral obligation and having a professional responsibility to help others. They express their identity as an engineer being tied to service, more than just the profession in general. |
| **Costs/Benefits** | No Evidence | The costs of doing service seem to dominate the conversation, with few references to any benefits. Service is not worthwhile because the costs outweigh the benefits. | Equal discussion of costs and benefits, but no leaning one way or another. Conversation of costs/benefits is dominated by generalizations. | Acknowledges both costs and benefits, but emphasizes the benefits that are gained through doing service. Emphasis resides in vague or shallow examples of benefits, such as "it was fun", "it makes me feel good", "got to travel", or "met new people." | Talks positively about the benefits of doing service and draws from personal experiences or examples of how engaging in service has benefitted them and their personal development. Examples of benefits would be "opened my eyes", expansion of cultural understanding | In spite of acknowledgements of the costs of doing service, they are willing to make personal or professional sacrifices to do engineering service long-term and with regularity. Benefits are worth the acknowledged costs. |

# APPENDIX F

# EPRA VOLUNTEER FREQUENCY RESULTS

This appendix presents a more detailed analysis of student responses to the Tier 1 pre- distribution volunteer frequency question and relating those responses to dimension averages on the Likert-items. The elements discussed include frequency distribution of how many activities students engaged in and how frequently they engaged in them, EPRA scores based upon the weighted system discussed in Chapter V, and EPRA scores based upon volunteer frequencies within different activities.

Figure 26 shows how many people volunteered in how many of the 16 different activities and how frequently they did so. The majority of students participated in one to five different activities at least once. Only 46 people reported never participating in any activities, including the ‘other’ category for write-ins, seen by the number of people with 16 activities in the “Have not participated” category. Five hundred and eighty five people

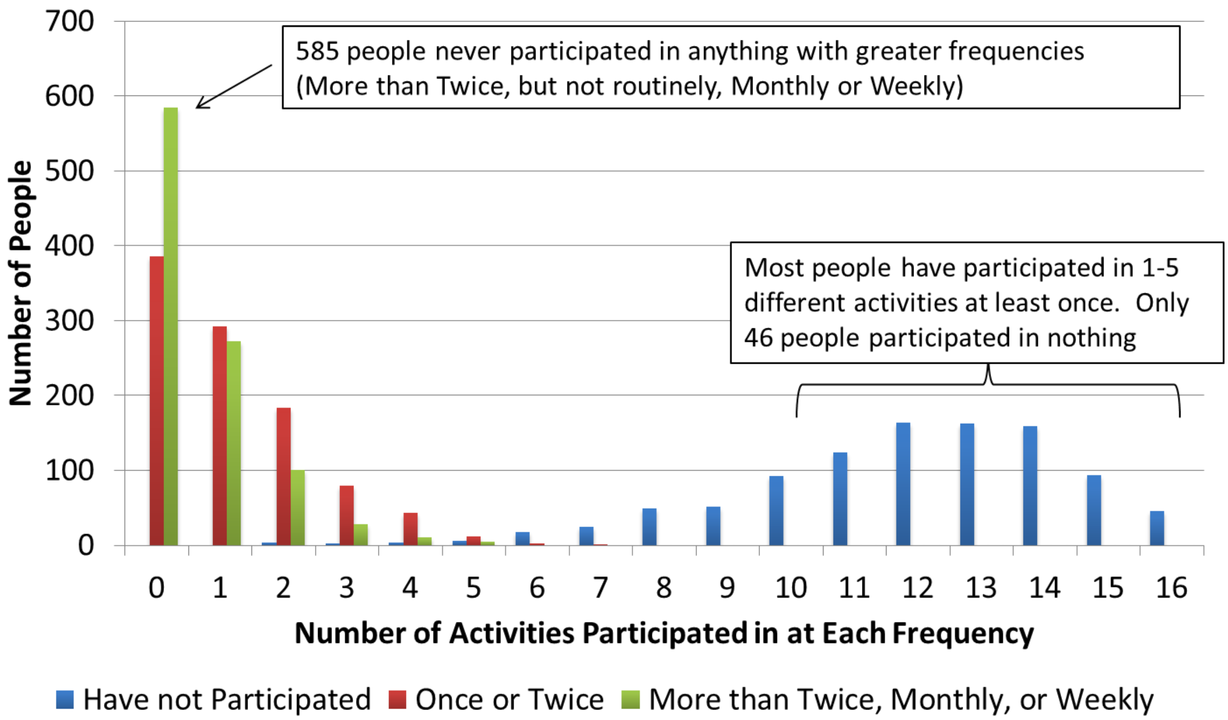



**FIGURE 26. FREQUENCY DISTRIBUTIONS OF NUMBER OF VOLUNTEER ACTIVITIES PARTICIPATED IN (N=1000)**

never participated in anything more than twice, or on a routine basis (monthly or weekly). These 585 respondents only participated in any activity once or twice.

Seeing that the majority of people engaged in up to five activities, we examined what the frequency of involvement was for those individuals to see if fewer activities correlated with doing them less frequently. First we looked at all of the students who had only engaged in one volunteer activity (n=93), shown in Figure 27. The most common frequency of engagement for that group was "More than twice but not routinely", though a significant number of students, mostly seniors, also only did their one activity once. Nearly 20% of the students who had only engaged in one activity did so on a monthly or weekly basis, which was surprising to see because we expected that students who did one activity routinely would have possibly experimented with other volunteering along the way. This perspective matched Delve et al.'s Service Learning Model, where an individual would tend to initially experiment with a variety of service activities before committing to a single activity with higher frequency (Delve, Mintz, & Stewart, 1990). At first it was thought that this could be a factor simply of the busyness of college, especially in engineering, since the questions asked senior and graduate students to report volunteer activities since entering college, but distributions were seen to be fairly even across the academic ranks.

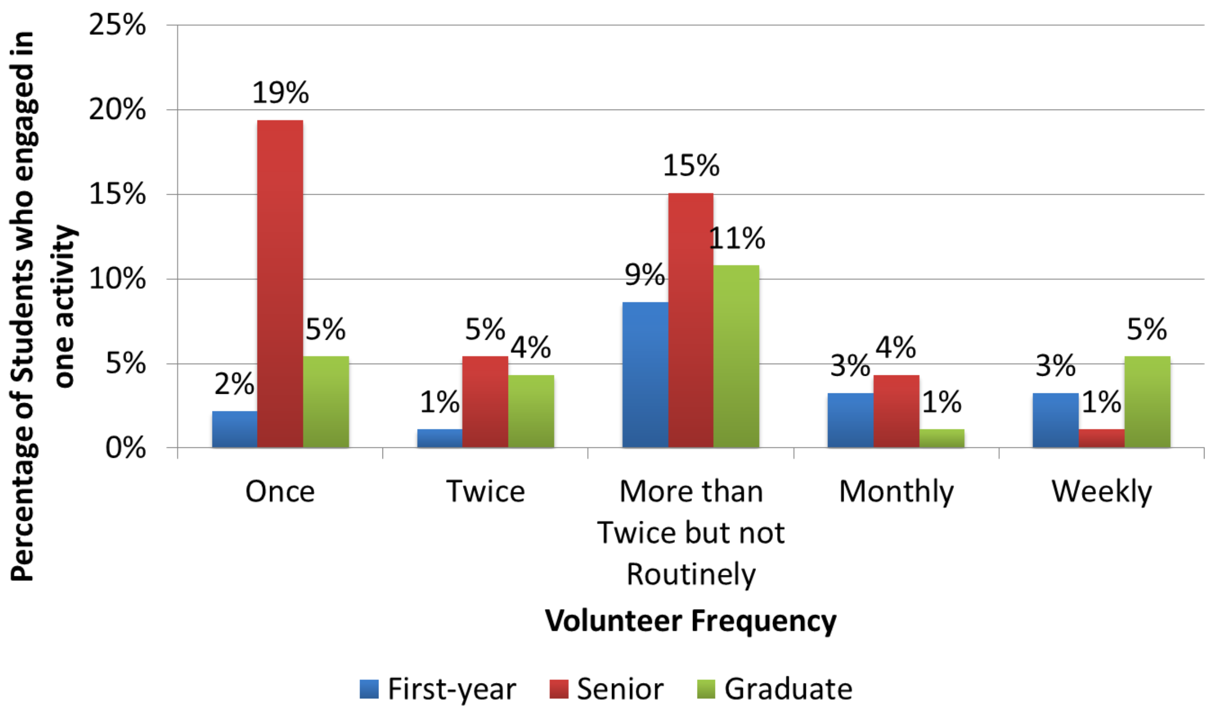



**FIGURE 27. VOLUNTEER FREQUENCY DISTRIBUTIONS OF STUDENTS WHO ENGAGED IN ONLY ONE ACTIVITY**

Figure 28 shows similar distributions for those students who engaged in 2, 3, 4, or 5 different activities, though not separated by academic rank. For simplicity, volunteer frequencies were grouped as “Once or Twice” and “More than Twice but not Routinely, Monthly or Weekly”. For each graph, the number of possible combinations is the number of activities plus 1. For example, a student who had engaged in two activities could have done both of them “Once or Twice”, both of them “More than Twice but not routinely, Monthly or Weekly” or one of each. No clear patterns emerged from these results such as students with less variety of activities did so with less frequency or that students who engaged in more activities did so with more frequency. There seemed to be a fairly consistent distribution where the majority of students had a mix of activities within each frequency group. Fewer students were at the extremes where they did all of their activities either “Once or Twice” or “More than Twice, Monthly, or Weekly”.

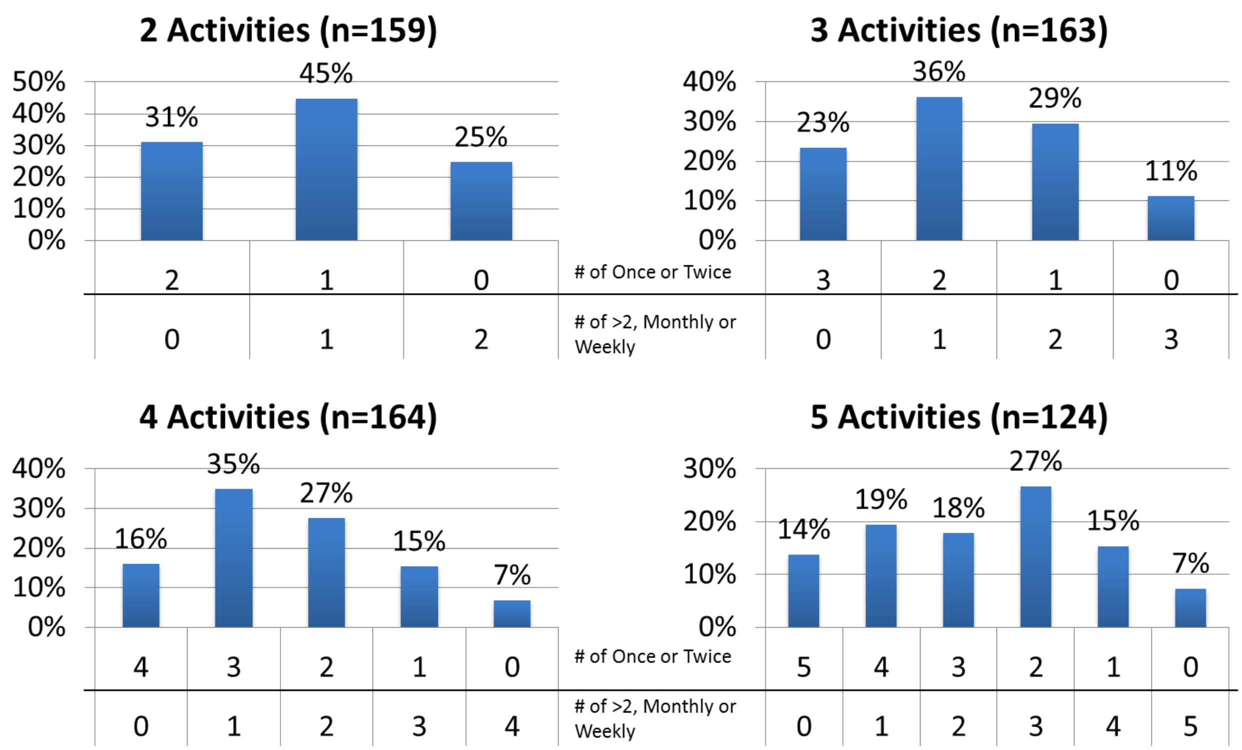



**FIGURE 28. VOLUNTEER FREQUENCY DISTRIBUTIONS FOR STUDENTS WHO ENGAGED IN 2, 3, 4, OR 5 DIFFERENT ACTIVITIES**

Having gained a better understanding of how many activities most students participated in and how frequently they did so, we wanted to look at how the number of activities that students engaged in related to their social responsibility scores, irrespective of what the volunteer activities were. This approach tests whether any possible correlations with social responsibility come from what you do, or simply that you do. At first correlation coefficients (Pearson's r) were examined between averages scores on each dimension and the number of activities that students engaged in and how many they engaged in at each frequency. Additionally, a weighted system for volunteer frequencies was examined, recognizing that there is a non-linear relationship between engaging in an activity once or twice versus engaging routinely. The weighting system used is shown in Table 16 in Chapter V. The weighting system used was the sum of the weighted frequencies, so that if an individual volunteered with a soup kitchen once and tutoring weekly, their score would be 1+50= 51. These correlations are shown in Figure 29. Correlations between volunteering and the PSRDM dimensions were highest in the Personal Social Awareness and Professional Connectedness realms, which aligns well with the theoretical grounding of the PSRDM, which holds that engaging in action is how views in both of these realms are advanced. The strongest correlations for most of the dimensions in these realms were with the number of activities that students engaged in, rather than the number of activities at any given frequency. There were, however, generally increasing correlations based upon the number of activities with increasing frequencies. In other words, the weakest correlations were with the number of activities engaged in only once, and progressively stronger correlations were with the number of activities engaged in twice,

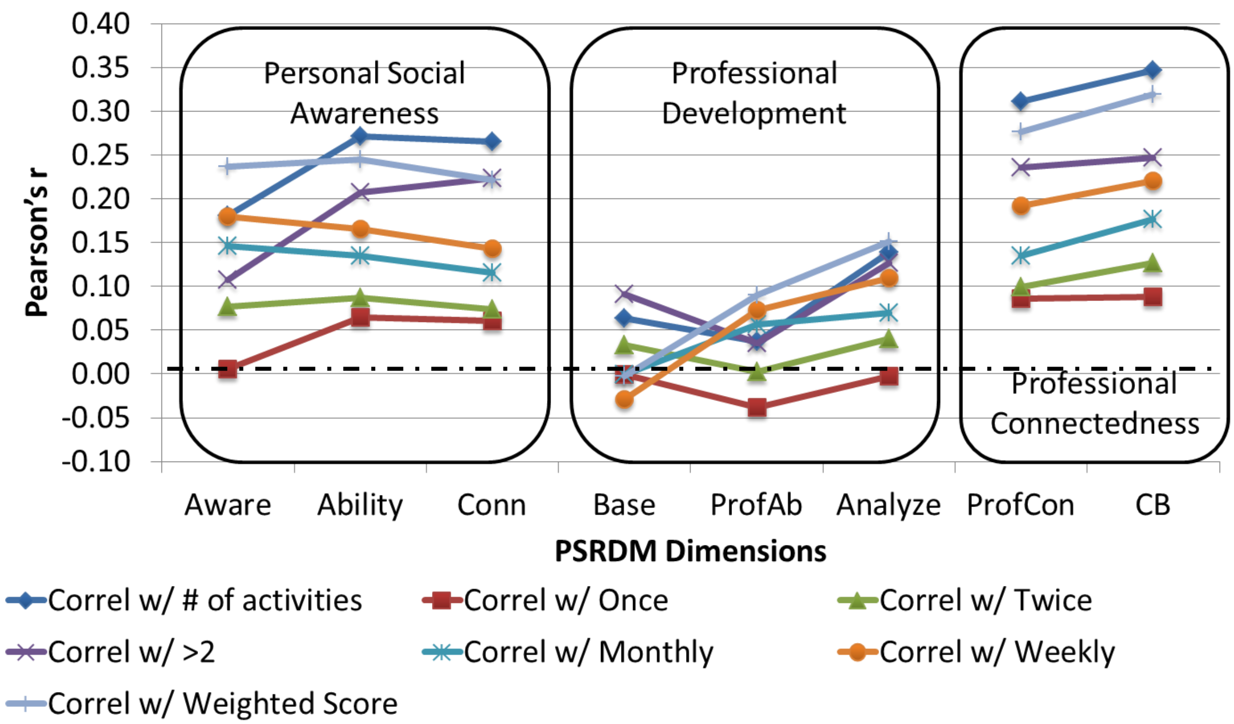



**FIGURE 29. CORRELATION COEFFICIENTS BETWEEN PSRDM DIMENSION AVERAGE SCORES AND VOLUNTEER FREQUENCIES**

monthly or weekly. Correlations with the "More than Twice, but not Routinely" were outside of this pattern, and generally higher than the others. This measure, however, is not completely accurate since individuals tended to engage in many activities with different frequencies, as seen in Figure 28. Therefore the weighted score is one way to account for how students engage in different activities with differing frequencies. Correlations between social responsibility scores and the weighted volunteer scores were similar to the number of activities that students engaged in, but were not higher in most dimensions, suggesting that, at least with the weighting system chosen, frequency was not such a controlling element. A sensitivity analysis of the weighting structure should be examined for future work. The trends seen in Figure 29 were similarly seen when correlations by gender were examined, though correlations were slightly higher across the board for women than men.

Since correlations were highest between dimension averages and the number of activities engaged in, those relationships were examined more closely. This time, because correlations were slightly higher for female than male students, data for each gender were examined. Figure 30 and Figure 31 show the average dimension scores for female and male student, respectively, based upon the number of activities they had engaged in. Table 27 presents results of statistical significance using unpaired, two-tail t-tests. Relationships where scores were not statistically significantly different ($p<0.05$) for any dimensions were omitted from the table.

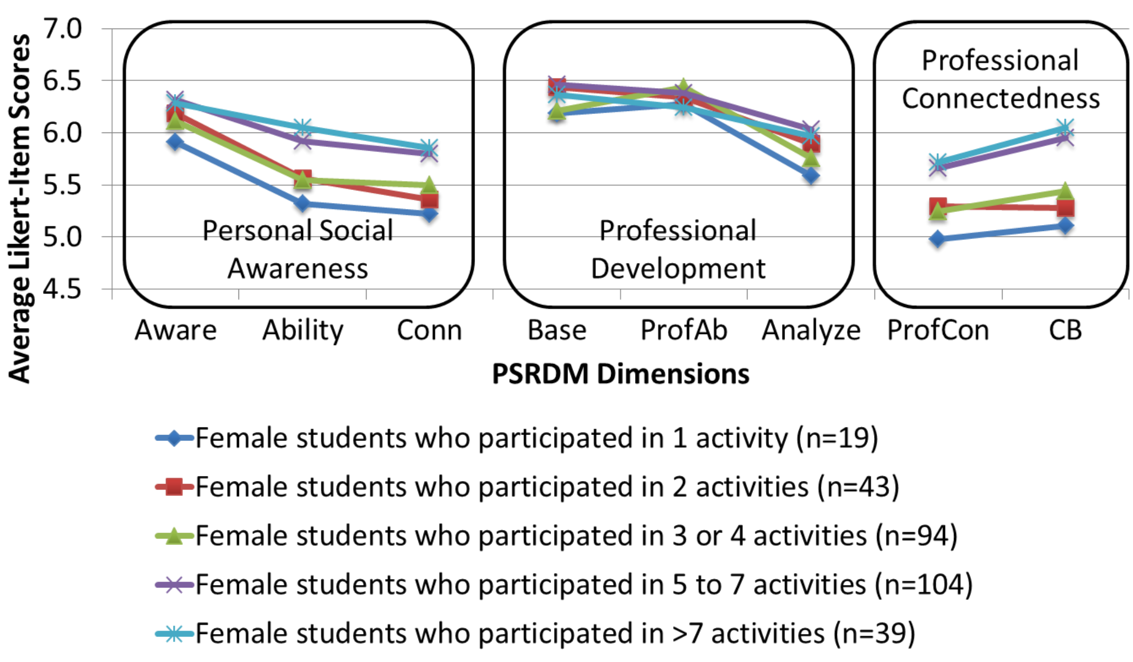



**FIGURE 30. AVERAGE LIKERT-ITEM SCORES FOR FEMALE STUDENTS BASED UPON NUMBER OF ACTIVITIES ENGAGED IN**

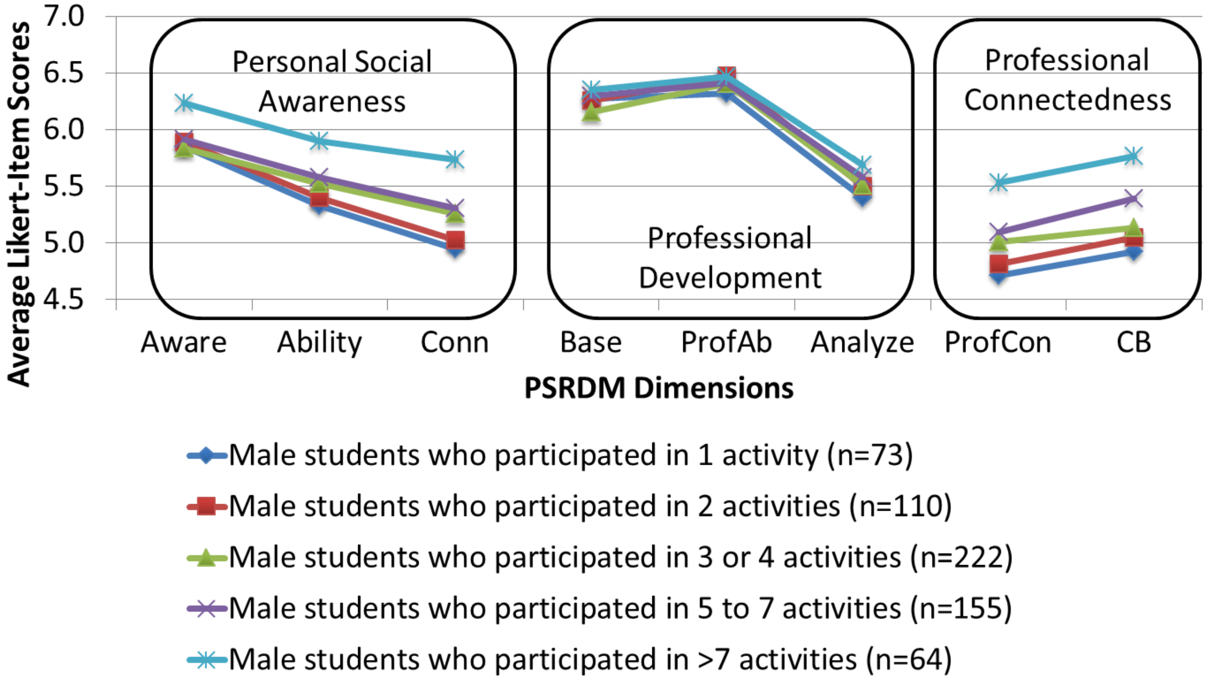



**FIGURE 31. AVERAGE LIKERT-ITEM SCORES FOR MALE STUDENTS BASED UPON NUMBER OF ACTIVITIES ENGAGED IN**

These results showed that, for both female and male students, those students who had engaged in more activities had higher dimension averages in the Personal Social Awareness and Professional Connectedness realms than students who engaged in fewer. Females who engaged in five or more activities and males who engaged in seven or more activities were noticeably higher the other groups within their gender, most notably the *Ability*, *Professional Connectedness*, and *Costs/Benefits* dimensions. Scores for females who volunteered with five activities or more were statistically significantly higher for most dimensions than all male student averages except for those who volunteered with more than seven activities. Scores for male and female students who participated in only one activity were not statistically significantly different from each other for any dimension, which could be partially due to the low number of females in this category (n=19). In general, these results support a positive relationship between beliefs of social responsibility and how many different activities an individual volunteers with, supporting the idea that either volunteering more increases social responsibility, or higher social responsibility leads individuals to volunteer with more things, or both, creating a cyclical relationship.

**TABLE 25. STATISTICAL SIGNIFICANCE FOR FEMALE AND MALE STUDENTS BASED UPON NUMBER OF ACTIVITIES ENGAGED IN (P VALUES SHOWN)**

| | With respect to | Aware | Ability | Conn | Base | ProfAb | Analyze | ProfCon | CB |
|---|---|---|---|---|---|---|---|---|---|
| **Female – > 7 Activities** | **Female – 3 or 4 Activities** | | 0.007 | | | | | 0.026 | 0.001 |
| | **Female – 2 Activities** | | 0.001 | | | | | 0.015 | 0.000 |
| | **Female – 1 Activity** | | 0.031 | | | | | 0.045 | 0.000 |
| | **Male – > 7 Activities** | | | | | 0.003 | | | 0.025 |
| | **Male – 5 to 7 Activities** | 0.000 | 0.003 | | | 0.031 | 0.011 | 0.004 | 0.000 |
| | **Male – 3 or 4 Activities** | 0.000 | 0.001 | 0.034 | | 0.006 | 0.000 | 0.000 | 0.000 |
| | **Male – 2 Activities** | 0.004 | 0.001 | 0.010 | | 0.001 | 0.001 | 0.000 | 0.000 |
| | **Male – 1 Activity** | 0.007 | 0.000 | 0.003 | | | 0.009 | 0.000 | 0.000 |
| **Female – 5 to 7 Activities** | **Female – 3 or 4 Activities** | | 0.012 | | | | | | 0.000 |
| | **Female – 2 Activities** | | 0.003 | 0.022 | | | | 0.036 | 0.000 |
| | **Female – 1 Activity** | | | | | | | | 0.000 |
| | **Male – > 7 Activities** | | | | | 0.005 | | | 0.000 |
| | **Male – 5 to 7 Activities** | 0.001 | 0.003 | 0.007 | | | 0.000 | 0.000 | 0.000 |
| | **Male – 3 or 4 Activities** | 0.000 | 0.000 | 0.001 | | 0.007 | 0.000 | 0.000 | 0.000 |
| | **Male – 2 Activities** | 0.010 | 0.001 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.000 |
| | **Male – 1 Activity** | 0.016 | 0.001 | 0.000 | | | 0.001 | 0.000 | 0.008 |
| **Female – 3 or 4 Activities** | **Female – 1 Activity** | | | | | | | | 0.041 |
| | **Male – > 7 Activities** | | 0.002 | | | | | | |
| | **Male – 5 to 7 Activities** | 0.010 | | | | | | | |
| | **Male – 3 or 4 Activities** | 0.000 | | 0.033 | | | 0.001 | | 0.006 |
| | **Male – 2 Activities** | | | 0.006 | | 0.009 | 0.017 | 0.019 | 0.007 |
| | **Male – 1 Activity** | | | 0.002 | | | | 0.015 | 0.005 |
| **Female – 2 Activities** | **Male – > 7 Activities** | | 0.001 | | | | | | |
| | **Male – 5 to 7 Activities** | 0.046 | | | | | 0.032 | | |
| | **Male – 3 or 4 Activities** | 0.004 | | | 0.027 | | 0.000 | | |
| | **Male – 2 Activities** | | | | | 0.034 | 0.003 | | |
| | **Male – 1 Activity** | | | | | | 0.024 | | |
| **Female – 1 Activity** | Male – **> 7 Activities** | | 0.026 | | | | | | 0.028 |
| | | | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Male – > 7 Activities** | **Male – 5 to 7 Activities** | 0.032 | 0.000 | | | | | | |
| | **Male – 3 or 4 Activities** | 0.001 | 0.000 | | | | 0.002 | 0.009 | 0.013 |
| | **Male – 2 Activities** | | 0.000 | 0.020 | | | 0.023 | 0.002 | 0.011 |
| | **Male – 1 Activity** | | 0.000 | 0.007 | | | | 0.002 | 0.006 |
| **Male – 5 to 7 Activities** | **Male – 3 or 4 Activities** | | | | | | 0.043 | | 0.035 |
| | **Male – 2 Activities** | | | | | 0.019 | | 0.049 | 0.032 |
| | **Male – 1 Activity** | | | | | | | 0.036 | 0.019 |
| **Male – 3 or 4 Activities** | **Male – 1 Activity** | | | | 0.026 | | | | |

Next, social responsibility scores were examined based upon the weighted frequency scores, which had the second highest correlations with dimension average scores. As expected, students who had higher volunteer frequency scores also had higher dimension averages in the Personal Social Awareness and Professional Connectedness realms (Figure 32). It is interesting how much lower the scores are for individuals who engaged in no volunteer activities (n=46) were for the Personal Social Awareness and Professional Connectedness realms than all other groups. Their scores were statistically significantly lower ($p<0.01$) than every other group for the *Connectedness*, *Professional Connectedness,* and *Costs/Benefits* realms and lower than every group but those with scores of 1 to 4 on the *Awareness* and *Ability* dimensions.

Looking closer at each dimension, scores for the *Costs/Benefits* dimension, separated by gender and for first-year students only, was shown in Figure 15 in Chapter V, showing more clearly the positive relationship between volunteer frequencies and average scores for that dimension. Similar graphs for the *Awareness* (Figure 33), *Ability* (Figure 34), *Connectedness* (Figure 35), *Professional Connectedness* (Figure 36), and *Costs/Benefits* (Figure 37) dimensions are provided here, also separated by gender but for all academic ranks. The distribution between each volunteer frequency scores by gender are shown in Figure 38. For each dimension, it was interesting to see that for the highest weighted frequency scores, both men and women had similar averages, suggesting that engaging in volunteer activities extensively overcomes the gender differences that were seen throughout this study.

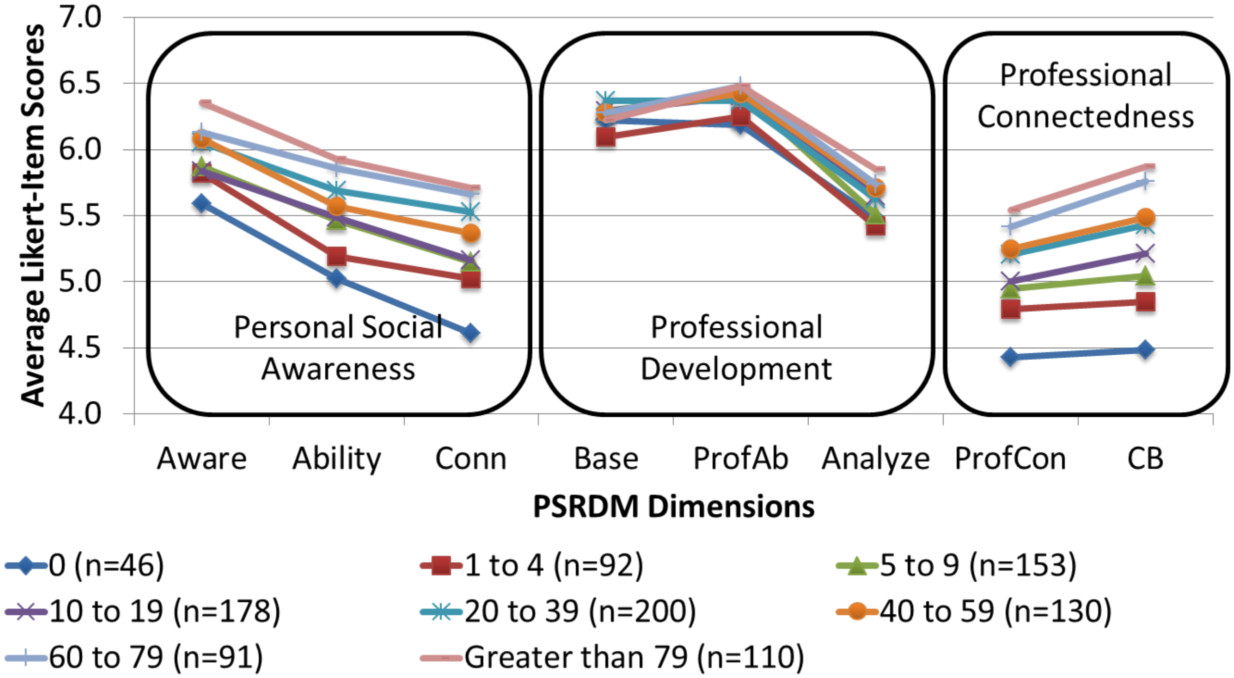



FIGURE 32. PSRDM DIMENSION AVERAGE SCORES BASED UPON WEIGHTED VOLUNTEER FREQUENCY SCORES

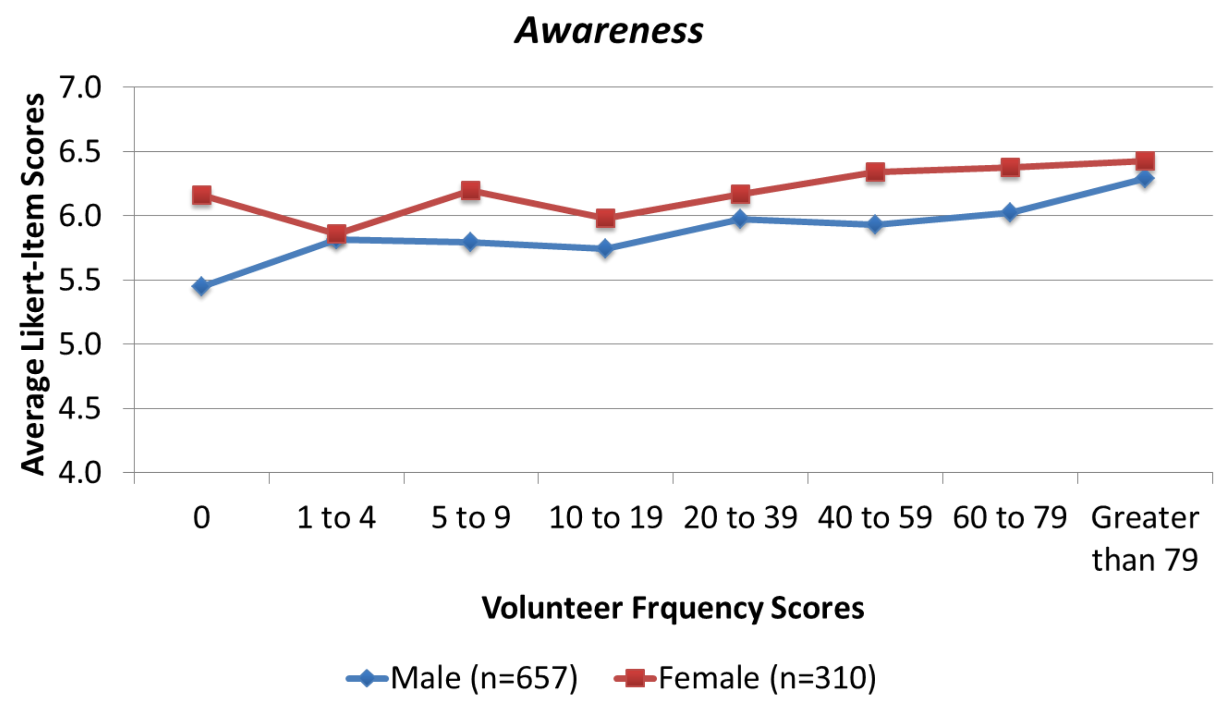



FIGURE 33. *AWARENESS* DIMENSION AVERAGE SCORES BY GENDER AND VOLUNTEER FREQUENCY SCORE

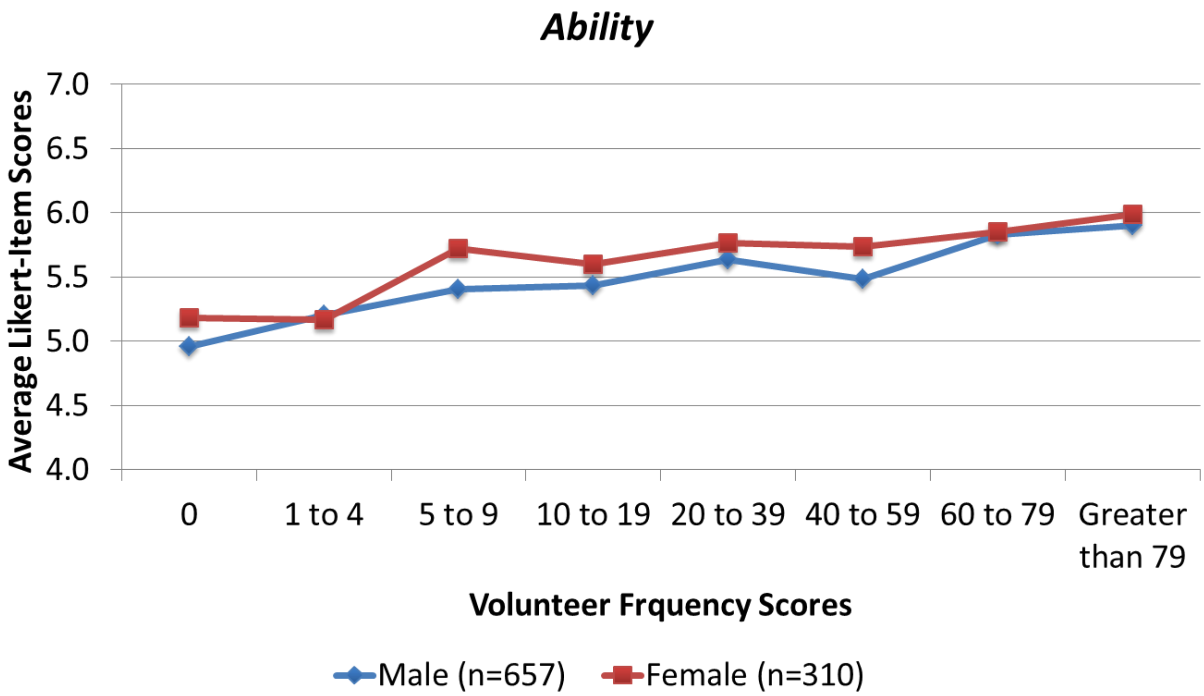



**FIGURE 34.** ***ABILITY*** **DIMENSION AVERAGE SCORE BY GENDER AND VOLUNTEER FREQUENCY SCORE**

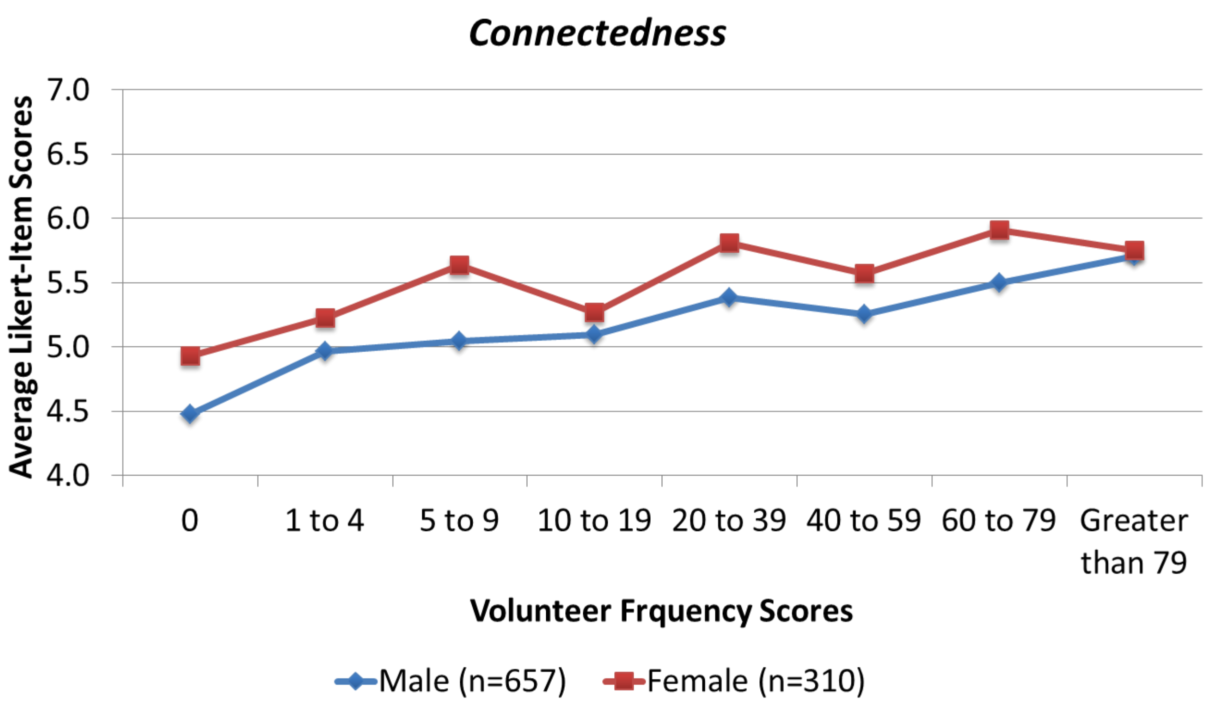



**FIGURE 35.** ***CONNECTEDNESS*** **DIMENSION AVERAGE SCORES BY GENDER AND VOLUNTEER FREQUENCY SCORE**

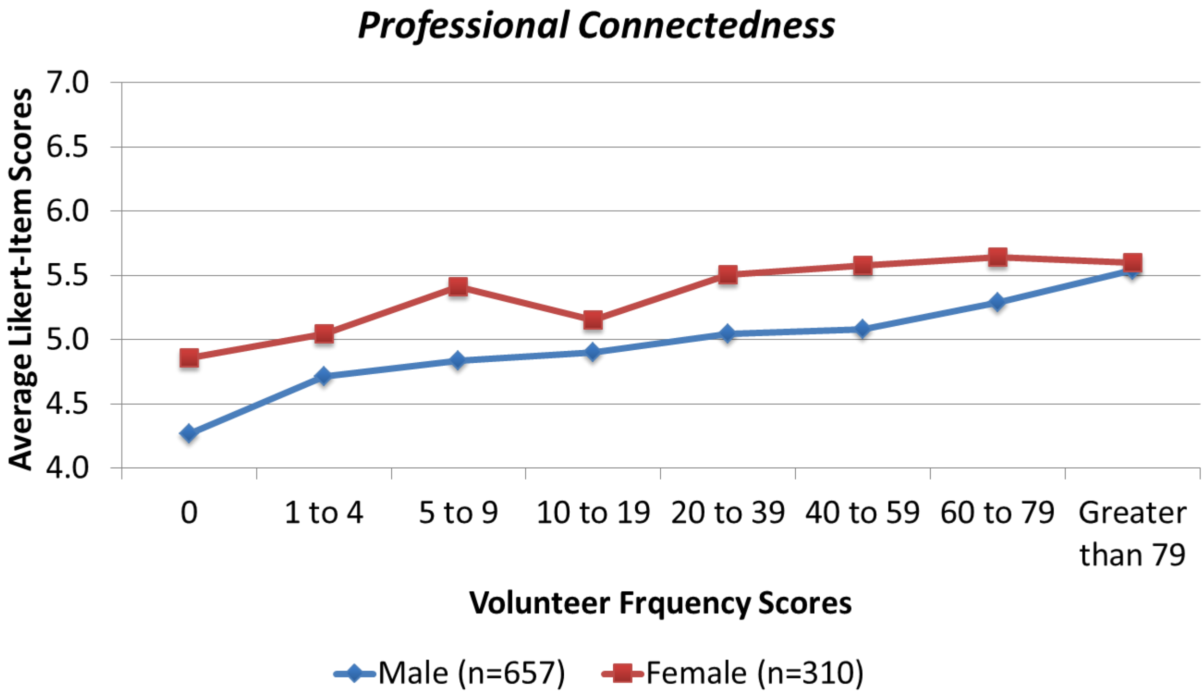



**FIGURE 36. *PROFESSIONAL CONNECTEDNESS* DIMENSION AVERAGE SCORES BY GENDER AND VOLUNTEER FREQUENCY SCORE**

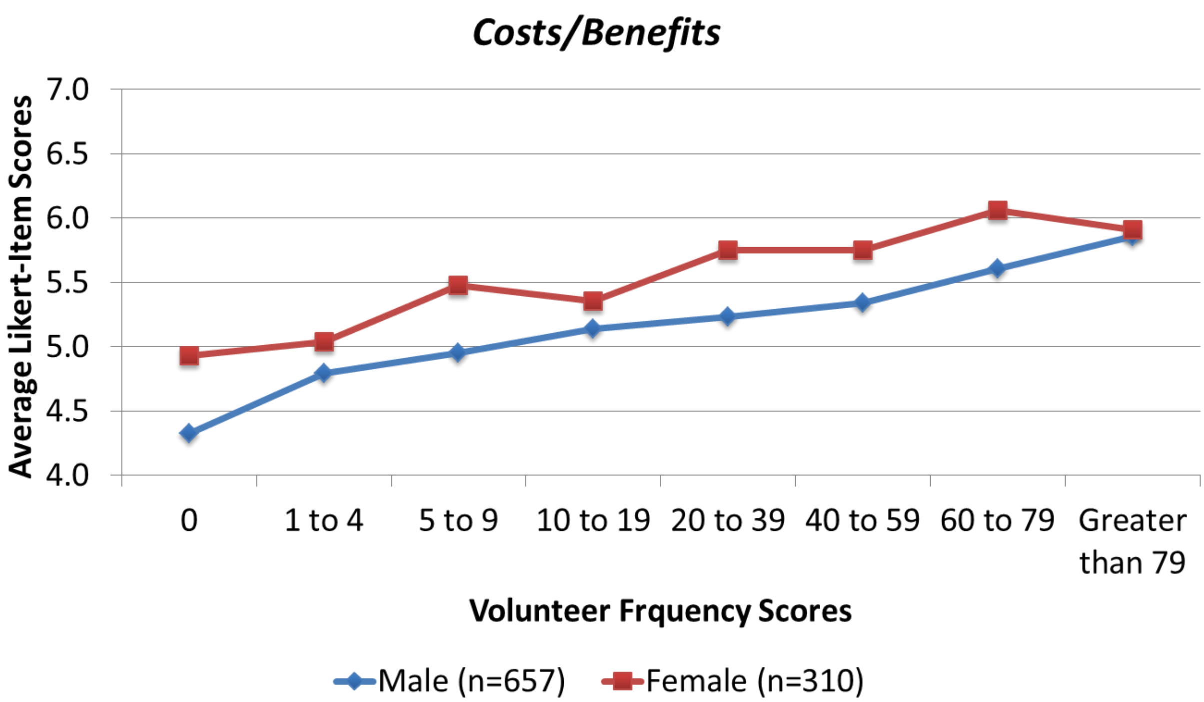



**FIGURE 37. *COSTS/BENEFITS* DIMENSION AVERAGE SCORES BY GENDER AND VOLUNTEER FREQUENCY SCORE**

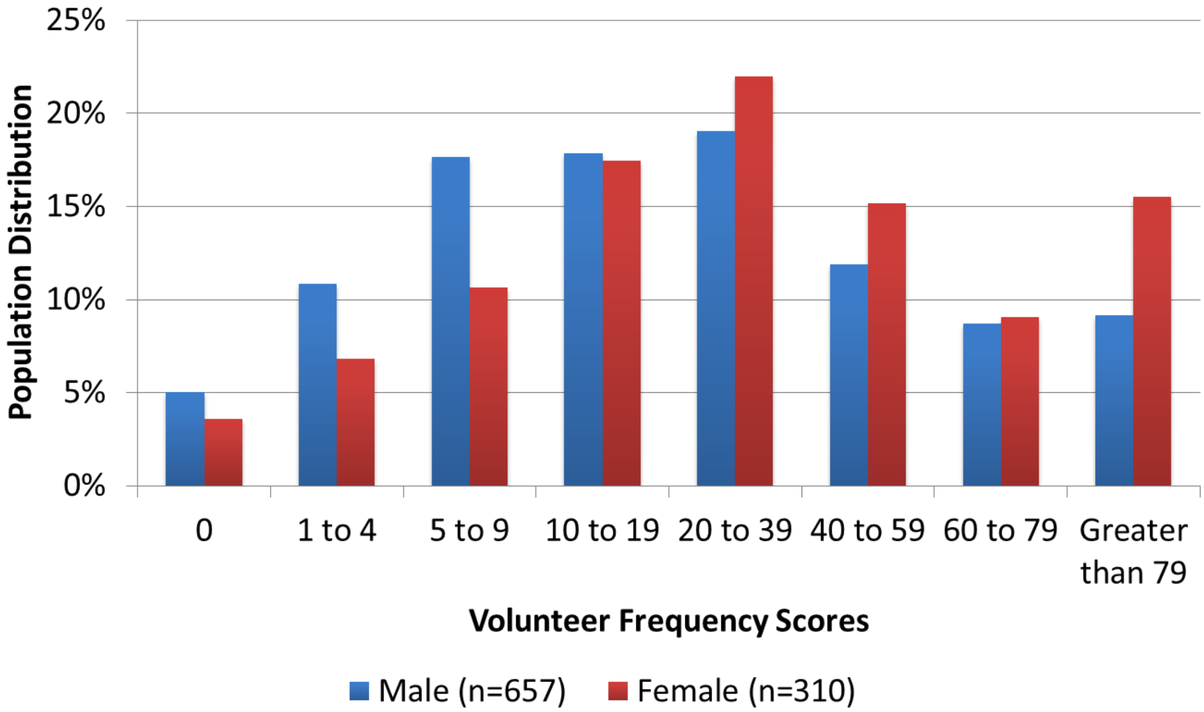
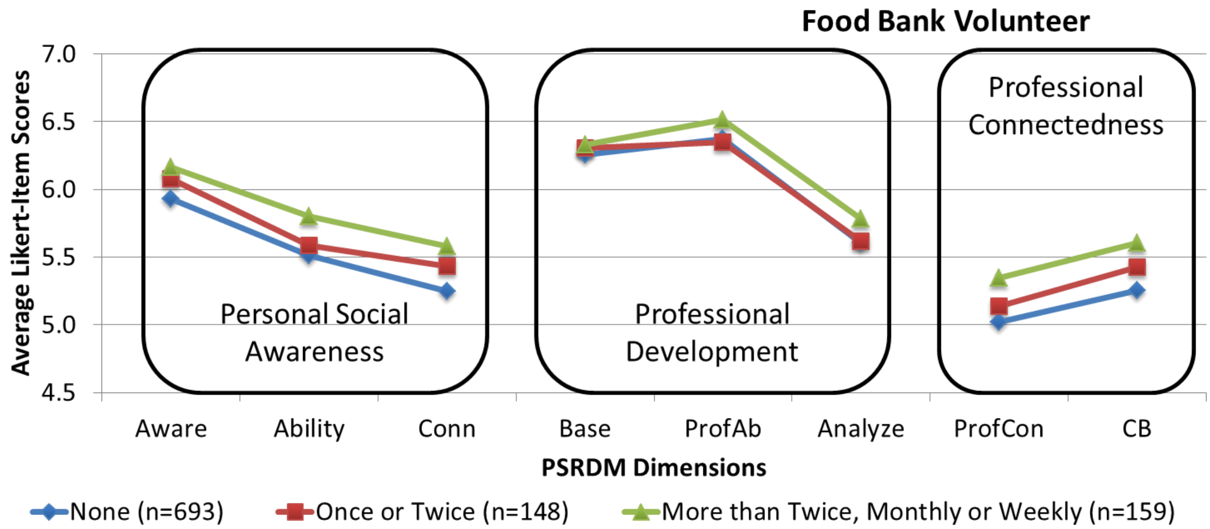



**FIGURE 38. DISTRIBUTION OF MALE AND FEMALE STUDENTS BY VOLUNTEER FREQUENCY SCORES**

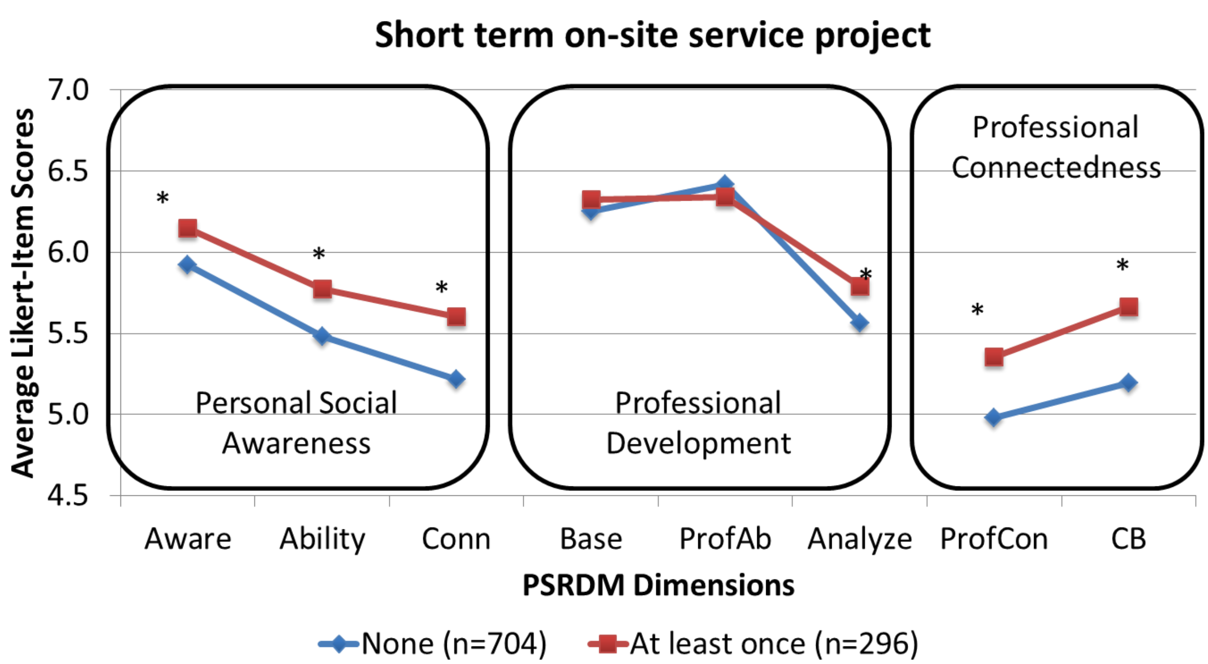
Finally, each activity individually was examined to see if volunteering more frequently within the same activity correlated with higher degrees of social responsibility. It was found that, across all activities except donating blood, people who volunteered more frequently with that activity generally had higher averages on the dimensions in the Personal Social Awareness and Professional Connectedness realms. As examples, graphs showing dimension averages based upon volunteering frequency at food banks and with short-term on-site service project, such as EWB or service Spring Break trips, are shown (Figure 39 and Figure 40, respectively).

With respect to volunteering at food banks, students who volunteered more than twice, monthly or weekly had statistically significantly higher averages ($p<0.05$) for every dimension except *Base Skills* thank students who had never volunteered at a food back and higher than those who had volunteered once or twice in the *Ability*, *Professional Ability*, *Analyze*, and *Professional Connectedness* dimensions. Students who volunteered once or twice had statistically significantly higher scores for the *Awareness*, *Connectedness*, and *Costs/Benefits* dimensions over students who had never volunteered at a food bank.




| T.Tests (p value shown) | | Aware | Ability | Conn | ProfAb | Analyze | ProfCon | CB |
|---|---|---|---|---|---|---|---|---|
| None | Once or Twice | 0.018 | | 0.026 | | | | 0.03 |
| | More than Twice | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.0 | 0.0 |
| Once or Twice | More than Twice | | 0.010 | | 0.006 | 0.039 | 0.010 | |

**FIGURE 39. PSRDM DIMENSION AVERAGE SCORES BASED UPON VOLUNTEER FREQUENCIES AT FOOD BANKS**




* Denotes statistical significance (p<0.05) using unpaired, two-tailed t-tests

**FIGURE 40. PSRDM DIMENSION AVERAGE SCORES BASED UPON VOLUNTEER FREQUENCIES ON SHORT TERM ON-SITE SERVICE PROJECTS**

With the short term volunteer activity, frequency options did not include monthly or weekly, simply given the nature of this form of volunteering. It was seen that students who had engaged in at least one short term on-site service experience had statistically significantly higher averages ($p<0.05$) for every dimension except *Base Skills* and *Professional Ability* over students who had not.

When taken together, all of these results show strong correlation between engaging in service activities and beliefs of social responsibility, particularly one's awareness of the needs of others, one's belief in her/his ability to help, one's feeling of obligation to help, and connecting those beliefs to a professional view that includes obligations to help others as a professional. Since these activities seem so strongly tied to these virtues, it seems critical to find ways to include them in the engineering curriculum towards forming stronger connections between engineering and an ability to have a positive impact on society. There is much more work that could be done in this realm, including closer examinations of the quality of individual service engagements, elements of reflection after engaging in service, and if/how service experiences can be tied to academic goals.

# APPENDIX G

# EPRA SHORT ANSWER CODES AND SAMPLES

This appendix presents coded results from two of the short answer items that were part of the EPRA tool in the Tier 1 distributions. Results from these short answer questions were used in both Chapters V and VI, where only the top three most common codes were discussed. Below is a more complete account of the codes which emerged from the data as well as a few examples of each.

On the Tier 1 pre- survey, students were asked to "Briefly describe any events that have influenced your views of community service and social responsibility." There were 729 responses to this question. Nineteen codes emerged from the data and 403 of the responses were coded with more than one code. Table 26 gives each code, samples, and how common each code was. Codes are arranged in the table in descending order by how frequently they arose. Codes which were mentioned by less than 5% of the respondents are not included in the table and were "Engineering Service", "Military", "Received Aid", "Required", and "Work".

**TABLE 26. CODES AND SAMPLES FOR "OTHER INFLUENCES" OPEN QUESTION**

| Code | % of responses with that code assigned | Sample Response |
|---|---|---|
| **Doing Service** | 50% | "I spent a few months tutoring inner city children in an after school program. The kids needed supervision in addition to some basic homework help, and it was really convenient for me to help. Seeing the kids' smiles on those afternoons, and hearing them speak so highly of all the volunteers made me realize it takes so little to make a difference in someone's life."<br>-Female Graduate Civil Engineering Student at Mid-Private U<br><br>"On a service trip to Honduras through United Catholic Fellowship at [Military U], I was able to positively contribute to a poorer community by helping them repaint/refurbish their community center. It was an awesome experience that confirmed no matter how big or how small the impact; I can still make some difference if I can gather the tools and the people. The intent is for that one act to spur on other acts and create the snowball effect."<br>-Male Senior Civil Engineering Student at Military U |

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|---|---|---|
| **Impact** | 18% | "Going on a mission completely changed my motivation for helping people, by realizing how much you can affect someone's life"<br>-Female Senior Mechanical Engineering Student at Large Public U<br><br>"Going out and simply being out volunteering shows you as a role model to somebody in your presence, and this is a pretty awe inspiring thing because it is so easy to do."<br>-Male Civil Engineering Student at Military U |
| **General** | 17% | "Church, Poverty, Injustice , Corruption."<br>– Male Graduate Mechanical Engineering Student at Engineering U<br><br>"Disaster relief of Katrina and Haiti show how shockingly slow work can be done when there is little exposure by the media."<br>– Male Graduate Mechanical Engineering Student at Large Public U |
| **Personal Benefits** | 14% | "In my community service efforts I have connected with the people that I helped and leave feeling happier than when I began."<br>-Female First-year Civil Engineering Student at Small Research U<br><br>"I worked on a house with my youth group one summer. It was just an eye opener to how little I have to do to make people happy, which makes me feel good."<br>-Male First-year Mechanical Engineering Student at Engineering U |
| **Religion** | 11% | "My religious background is Catholic and I have been in Catholic schooling my whole life (until now) so that has been the basis for my view of community service and social responsibility."<br>-Female First-year undecided Student at Mid-Private U<br><br>"I am a practicing Christian and have been for several years now. I feel that because I am privileged it is the least I can do to help others whether it be through the church or through some other organization."<br>-Male First-year Mechanical Engineering Students at Engineering U |
| **Negative** | 9% | "I have had multiple cases where I have felt unappreciated as a volunteer by the people I was helping. Either because they were unaware that the work I was doing to help them was volunteer, they just didn't care, or they thought I was doing it because I was forced to be there."<br>-Male Graduate Mechanical Engineering Student at Engineering U<br><br>"When volunteering previously I saw that the needs of society were just being covered up instead of actually fixed."<br>-Male Senior Mechanical Engineering Student at Large Public U |
| **Empathy** | 8% | "Working with disadvantaged students in a downtown school made me better understand the size of the education gap and realize how important it is to narrow that gap."<br>-Male Senior Mechanical Engineering Student at Mid-Private U<br><br>"Serve food to homeless about 3 times a year has made me realize that those in need are real, genuine people and simply need help just getting back on their feet."<br>-Male Senior Civil Engineering Student at Large Public U |

| | | |
|---|---|---|
| **Travel** | 8% | “living in a couple of developing countries shows that images of poverty aren't just images but people's lives”<br>-Female Sophomore Environmental Engineering Student at Military U<br><br>“During High School, I traveled on four mission trips to John's Island in South Carolina. There I worked with a group of people and the community to help repair old houses. The people living on the land didn't own the land because of a government clause that was enacted generations ago. It has had a large impact on me and opened my eyes to the difficulties of inherited poverty and large scale development.”<br>-Female First-year Civil Engineering Student at Small Research U |
| **Example** | 7% | “I have a friend volunteering in the peace corps right now in Senegal. It sounds like it has been a pretty valuable experience so far and I really admire him for it.”<br>-Male Senior Environmental Engineering Student at Large Public U<br><br>“When people I look up to have spoken about the importance of volunteer work. Parents and Professors.”<br>-Male Graduate Civil Engineering Student at Mid-Private U |
| **Family** | 5% | “One of my uncles is homeless so I have a mixed feeling about doing community service for the homeless. Sometimes I believe it is their own fault for being homeless, but then other times I feel bad for their situation.”<br>-Female Senior Environmental Engineering Student at Large Public U<br><br>“My family has always been aware of the needs of the community, and they instilled in me a heart to serve.”<br>-Male Graduate Mechanical Engineering Student at Large Public U |
| **Limitations** | 5% | “As a lifelong member of the Boy Scouts of America, I am well acquainted with doing service work. However in recent years I have been exceptionally busy putting myself through school, limiting the amount of volunteering I can do.”<br>-Male Senior Environmental Engineering Student at Engineering U |
| **None** | 5% | Responses saying simply that no life experiences had affected their views, usually just wrote “none” |
| **Obligation** | 5% | “It is my belief that it is one's civic duty to give back to one's community. Especially when that community lays the groundwork for one's lifetime success. That is the case with my community and why I feel a social responsibility to volunteer.”<br>-Male First-year Engineering Student at Military U |
| **School** | 5% | “I did a semester term program that was a service-learning experience. Even though I anticipated many of the challenges I encountered, it was another thing to experience them and have to interact with real people.”<br>-Female Graduate Civil Engineering Student at Engineering U |

On the Tier 1 post- survey, students were asked "What factors led you to choose your current major?" Of the 727 responses, 650 were complete enough to be assigned a code and 259 of those received more than one code. An example of a response which was not coded is "professional experience." Twenty-one codes emerged from the data, 11 of which had 5% or more of the responses receive that code. These 11 codes, frequencies, and samples are given in Table 27 and are arranged by how frequently they appeared.

**TABLE 27. CODES AND SAMPLES FOR "WHY MAJOR" OPEN QUESTION**

| Code | % of responses with that code assigned | Sample Response |
|---|---|---|
| **Enjoy Math and Science** | 26% | "I've always enjoyed math and science, and I like the challenge." -Male Senior Civil Engineering Student at Large Public U<br><br>"I love math, I love analysis problems, I love a more practical major than a theory one and My major will provide me more job opportunity than others. Mechanical engineering is more visual than other engineering major, for example EE. That's the reason why I choose ME as my major." -Male Graduate Mechanical Engineering Student at Engineering U |
| **Impact on Society** | 19% | "A desire to do work that is meaningful to me and perhaps have a hand in improving society" -Male Graduate Civil Engineering Student at Small Research U<br><br>"I was interested in a career that built on my strengths in math and science and that had direct impacts on society" -Female Graduate Civil Engineering Student at Mid-Private U |
| **Build things** | 18% | "My interest in building things and creative mechanical design" -Male Senior Mechanical Engineering Student at Engineering U<br><br>"My childhood of building things such as Lego and tinkering with toys. Desire to work with military vehicles. The interesting aspect of how everything comes together in machines, the electronics, gears, controls etc." -Male Sophomore Mechanical Engineering Student at Military U |
| **Job qualities** | 14% | "I wanted a technical major that offered good job prospects, and engineering of some sort fit the bill. I chose environmental engineering because I thought that it would give me a chance to work outdoors and preserve the land/water quality that I have always enjoyed for recreation." -Male Graduate Environmental Engineering Student at Large Public U<br><br>"My dad is an engineer and he persuaded me to do engineering because of the available jobs after graduation." -Female Senior Civil Engineering Student at Large Public U |

| | | |
|---|---|---|
| **Broad field** | 10% | "I appreciated the fact that civil engineering is such a broad field where the impacts on the community are so apparent. I was attracted to the diversity of interest of my peers and the ability to study things on a large scale."<br>-Male Senior Civil Engineering Student at Mid-Private U<br><br>"I chose to study engineering in order to open many options and career possibilities."<br>-Male Graduate Mechanical Engineering Student at Small Research U |
| **Help the environment** | 10% | "I love math, science and the environment and environmental engineering put all those things together. Solve environmental problems seems like something I would interested in and not become easily bored with. Also engineers make a decent living and that is important in any job choice."<br>-Female First-year Environmental Engineering Student at Engineering U<br><br>"I started in chemical engineering but really did not like my the students in the program or what I was learning. After looking around for a while I found environmental engineering and I have loved it ever since. I have always been environmentally conscious and this seemed like a good fit. The further into the program I go, the more I love it. I'm currently looking to going into remediation to attempt to correct some of the wrong actions of the past."<br>-Male Senior Environmental Engineering Student at Large Public U |
| **Technical** | 10% | "I enjoy figuring out how things work together and why they don't work if they break."<br>-Male Sophomore Mechanical Engineering Student at Military U<br><br>"A desire to delve deeper into how things work.  A hope to help solve those aspects of society's problems that need engineered solutions."<br>-Male Junior Environmental Engineering Student at Small Research U |
| **Help people** | 9% | "I wanted to help people in a very fundamental and tangible way."<br>-Male Graduate Civil Engineering Student at Large Public U<br><br>"It is something I enjoy and it is something I can use to help people less fortunate than me."<br>-Female First-year Environmental Engineering Student at Engineering U |
| **Family** | 8% | "My parent were both engineering majors and I got to see what engineering was all about through them. I also have great math, science an critical thinking skills that I was told would be great for engineering. One final factor is the job market for engineering is a good one and most engineers do well in life."<br>-Male First-year Mechanical Engineering Student at Engineering U |
| **Financial** | 7% | "Interest in math and science. Desire for a reliable and financially sound career."<br>-Male Graduate Civil Engineering Student at Large Public U |
| **Machines** | 7% | "Being from a country where girls normally don't opt Mechanical Engineering, I wanted to achieve remarkable level of expertise. Also, with my passion to work with machines and combining medicine and machinery for the benefit of the society has led me to opt for my current major of Mechanical Engineering"<br>-Female Graduate Mechanical Engineering Student at Engineering U<br><br>"Since a young age, I've been very interested in cars and engineering seems to be the major I'm most interested in."<br>-Male First-year Mechanical Engineering Student at Mid-Private U |