International Journal for Service Learning in Engineering,
Humanitarian Engineering and Social Entrepreneurship
Vol. 14, No. 2, pp. 1-15, Fall 2019
ISSN 1555-9033

Impact of International Service Learning on Macro-Ethics: A National Study of Senior Engineering Students

Brooke Baugher
Department of Civil and Environmental Engineering
Virginia Tech
Blacksburg, VA 24061
bbaugher@vt.edu

Josh Iorio
Myers Lawson School of Construction
Virginia Tech
Blacksburg, VA 24061
iorio@vt.edu

Tripp Shealy
Department of Civil and Environmental Engineering
Virginia Tech
Blacksburg, VA 24061
tshealy@vt.edu

David Knight
Department of Engineering Education
Virginia Tech
Blacksburg, VA 24061
dbknight@vt.edu

Abstract -- **To address complex problems in an increasingly globalized world, engineers must understand the ethical implications of their work on society. International service learning is one approach for engineers to gain this understanding. The purpose of this study is to investigate the benefits of international service learning on engineering ethics, more specifically macro-ethics, which is defined as an understanding of their impact on society through engineering. The quantitative study measured senior engineering students' macro-ethics understanding from a national sample of students enrolled in capstone design courses (n=2095). Students who participated in international service learning (ISL) through capstone and volunteer/work experience possess a greater understanding of macro-ethics compared to students without these types of experiences. Gender is also a contributing factor. Female engineering students possess an understanding of macro-ethics regardless of their ISL experience. Male engineering students with ISL experience have a greater understanding of macro-ethics compared to male engineering students without ISL experience. Male engineering students make up nearly 80% of engineering programs. The integration of ISL into engineering education can help these students develop an understanding of macro-ethics. Another approach is to recruit more women into engineering who seem to possess an understanding of macro-ethics without participating in ISL experiences.**

Index Terms -- International Service Learning, engineering ethics, capstone courses, co-curricular projects, international volunteer

Introduction and Background

Students graduating from engineering programs in the United States need skills and an ethical understanding to contribute to international projects that span countries and cultures.[1-3] Developing such globally-competent and ethically aware engineers is a defined outcome of ABET.[4,5] Prior to the 2000 ABET criteria update, engineering ethics was often overlooked in engineering education. This resulted in four out of every five engineers graduating without taking a course specifically emphasizing ethics as a topic.[6] Fortunately, this trend has shifted. Ethics are now integrated more formally in engineering courses because of ABET requirements.[7] While engineering education at accredited universities emphasizes the ABET requirements for ethical responsibility, many faculty responsible for meeting these requirements still find them to be unclear.[8]

One reason for the confusion is the multiple definitions and frameworks for ethics in engineering.[9,10] Herkert[11] defines ethics as having both a micro and macro component. Micro ethics views the topic from the lens of the individual and addresses ethical decisions that an engineer must make in his or her work. Macro-ethics views the topic from a systems perspective. The focus of macro-ethics is on an engineer's impact on society as a whole. These two views together create a more holistic perspective of ethics in engineering.

A majority of education about ethics in engineering focuses on micro-ethics, specifically the individual's responsibility to act ethical in their professional decisions.[11] There is much less emphasis in engineering education on macro-ethics.[10,12,13] Too frequently, engineering students do not consider the impact of their engineering decisions on society.[12] Engineers have a duty to uphold the welfare of the public.[14] Macro-ethics incorporates both welfare and equity.[12,15] Training future engineers to consider the societal impacts of their engineering decisions is critical for students to ethically meet grand challenges in engineering.[16]

One approach to teach macro-ethics is through service learning.[8,17,18] Service learning is a type of active learning where the goal is to build knowledge through the exploration of real-world challenges and problems. Students learn by tackling problems in a community setting and are often required to reflect on their interactions with their community-based clients. Inherently embedded in this type of learning are opportunities for students to consider how their engineering solutions impact the community, and society more broadly.

To gain an even more global perspective to solving community based problems is international service learning (ISL).[19,20] ISL is a subset of service learning, where there is an added emphasis on creating an awareness of cultural differences and enhancing sense of civic responsibility as a global citizen.[21] ISL combines organized service activities and international humanitarian engineering principles to meet community needs. ISL is generally situated within three main educational contexts: (1) formal courses, (2) independent volunteer and work experiences, and (3) co-curricular experiences. Each category of ISL differs in purpose and emphasis on student learning.

Integration of ISL into formal engineering courses typically results in a more structured framework, due to adherence to ABET criteria.[22] Within formal ISL courses, senior capstone courses are the most common.[23] ISL volunteer/work experiences are usually independently organized by the student and a host organization. Most of the areas of impact for ISL volunteer and work experiences are outside of the field of engineering[24], which may give engineering students different perspectives and values. ISL co-curricular programs vary in structure but these programs typically do not have a formal and direct focus on student learning. ISL co-curricular programs function to serve communities in need and rely on students having technical skills to contribute to real world projects.[25] Organizations like Engineers Without Borders and Bridges to Prosperity are examples of co-curricular programs.

Prior research about students learning ethics from ISL capstone courses offer a limited sample size of students predominately in civil and mechanical engineering[26,27], which may limit generalizability to other engineering disciplines. For example, Michigan Technological University's ISL senior civil engineering design course led to a positive increase in students' understanding about ethics, however the sample was limited to one class, and the results were discipline specific. Additionally, teaching and learning about ethics focuses predominately on micro-ethics. For example, Budny & Gradoville[26], posed an ethics question to students in an ISL capstone course, asking "how much has your senior design experience enhanced your understanding of professional and ethical responsibility?" This question addresses students' perception of their personal efficacy in ethics, but not the impact on the engineering field.

Prior research on ISL volunteer experiences predominantly focus on why volunteers participate or opt for work in an international service organization.[28-30] Host organizations involved with ISL volunteering are typically non-government organizations (NGOs) whose mission is community improvement not student learning.[31-33] This focus on efficacy of their program means that learning from volunteer or work experience is rarely documented or evaluated.

The effect of ISL co-curricular experiences, for example, through Engineers Without Borders (EWB), on engineering agency, identity, and engineering skills is well understood.[34-37] ISL co-curricular experiences appear to positively affect engineering identity, particularly among females.[34] However, a limitation of this prior research is the focus primarily on EWB, which makes the findings institution specific. Students who participate in regional and national EWB conferences presents some self-selection bias. Additionally, while engineering agency, identity, and skills have been studied within ISL co-curricular experiences, the influence of this type of experience on ethics is not well understood.[35-37]

ISL experiences may provide the missing macro-ethics component of ethics education for students due to the global nature of the experience. The different types of experiences through formal capstone courses, volunteer/work experience, and co-curricular activities present an opportunity to investigate how varying ISL experiences each shape student understanding of macro-ethics. The purpose of this study is to measure the effect of ISL experiences from capstone, volunteer/work, and co-curricular activities on macro-ethics understanding among engineering students in the United States. ISL in capstone, volunteer/work, and co-curricular activities each represent a uniquely structured approach to learning. The expectation is that students with ISL experiences possess a deeper understanding of macro-ethics than those without ISL experience. The expectation is also that understanding of macro-ethics will vary between types of ISL experience. Prior literature about ISL is often institution specific. So another expectation is to find differences among students with the same type of ISL experience but differ by institutional type. Gender is a contributing factor to observed differences in engineering identity among students who participate in co-curricular ISL like EWB. Female engineers who participate in EWB hold stronger engineering identities than female engineering students who do not participate.[34] The expectation is that gender is also a contributing variable to differences in understanding of ethics.

RESEARCH QUESTION

More specifically, the research questions are:

1) Do students with international service learning (ISL) through formal capstone courses, volunteer/work experience, or co-curricular projects possess a greater understanding of macro-ethics compared to students without these types of ISL experiences?
2) How do students with varying ISL experiences differ in their macro-ethics understanding?
3) What influence does institution and gender have on macro-ethics understanding among students with and without ISL experience?

International Journal for Service Learning in Engineering,
Humanitarian Engineering and Social Entrepreneurship
Vol. 14, No. 2, pp. 1-15, Fall 2019
ISSN 1555-9033

METHODOLOGY

The survey instrument used to measure macro-ethics was adapted from a previous survey called the Sustainability and Gender in Engineering (SaGE) survey.[38] The question from SaGE that was included to measure macro-ethics included items broadly about the environment, society, and the economy.[38] The survey question was edited to only include items about society to more closely align with Herkert's[17] macro-ethics framework. The specific survey item asked, "In your opinion, to what extent are the following associated with the field of engineering? ("not at all"=0, 1, 2, 3, "very much so"=4): improving quality of life, saving lives, caring for communities, addressing societal concerns, and feeling a moral obligation to help other people." To limit self-perception bias, the question intentionally asked students their perceptions of the field of engineering instead of asking for their opinion about acting ethically.[26] In addition, a five-point, instead of a four point, anchored Likert scale was used because prior literature shows that allowing respondents the ability to select a neutral position reduces discomfort for some participants, and grounding one side of the scale at an absolute value, such as not at all, provides an appropriate reference point.[39]

Due to the reduction in items being measured from SaGE and how the question is being asked about engineering broadly and not directly about ethics, the survey question was validated using both a focus group and a pilot survey. The focus group included twenty engineering students. It helped establish both face and content validity. The research team was able to hear how students were interpreting the question and probe them to understand their perceived association between the question and engineering ethics. The pilot survey was distributed to 220 upper level engineering students. An exploratory factor analysis (EFA) was performed with their responses[40] to predetermine factor groupings with the five question items.[41]

Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is a method used to validate the independent constructs that the survey instrument measures.[40] EFA does this through the mathematical analysis of the responses to determine the number of relevant factors in the question set. The goal of an EFA is to determine the minimum number of common factors to show correlation of variables.[42] As an exploratory study, the question items aimed to address social implications of macro-ethics from several viewpoints.

Generally, a factor cutoff value of 0.4 is used for unreliable measures in engineering education.[43] None of the factors had a loading below 0.4. So, all factors were included in the groupings. Two factor groupings emerged within the five question components. None of the factors were cross loaded between groups, meaning none of the factors resided in more than one factor group with a value higher than 0.4.[42] The factors in the first group, referred to as *equity*, describe an engineer's ethical duties to people on an individual and society scale. The question components that factored into the second group, called *welfare*, describe an engineer's duty to take care of communities and preserve life. The factor groups and correlating questions are shown in Table 1. While the number of variables in each factor are relatively small (two and three, respectively), the sample population receiving the instrument is large (i.e. greater than 200), which accounts for the low variable to factor ratio.[42] Each group had high loadings per factor, with the lowest loading being 0.459 (caring for communities), which indicates that these subsets are accurately describing the same construct. Finally, due to the small number of factors for each

International Journal for Service Learning in Engineering,
Humanitarian Engineering and Social Entrepreneurship
Vol. 14, No. 2, pp. 1-15, Fall 2019
ISSN 1555-9033

group, only complete student responses were used in the EFA and in the analysis of the results to maintain data integrity.

TABLE I
FACTOR GROUP LOADINGS BY QUESTION

Factor Group	In your opinion, to what extent are the following associated with the field of engineering? (“not at all”=0, “very much so”=4)	Loading	90% CI	Internal Reliability
Equity	Addressing societal concerns	0.770	0.011	0.7
	Feeling a moral obligation to other people	0.804		
Welfare	Improving quality of life	0.633	0.084	0.79
	Saving lives	0.851		
	Caring for communities	0.459		

A goodness of fit was then applied to these factor groups to ensure internal reliability. A 90% confidence interval was the benchmark. The Tucker Lewis Index of factor reliability was 0.99, which indicates a very good fit of the factors.[44] In addition, the factors show internal reliability with Cronbach’s alpha scores between 0.7 and 0.8. This indicates a reliable fit.[45,46] The 90% confidence intervals for the equity and welfare groups were 0.011 and 0.084, respectively. The confidence intervals indicate a high level of confidence consistent with prior engineering education research.[43] Each of the measurements used to validate the factor groups indicated that the groups were valid and reliable for the dataset.

Data Collection

The survey was distributed to accredited, four-year engineering institutions across the United States, both private and public institutions. Universities were chosen randomly from the National Center for Education Statistics. The schools were stratified based on size from small (<5,400), medium (5,400-14,800), and large (>14,800) institutions, and an equal number of universities were randomly selected from these bins for recruitment. Senior engineering students were the sample population targeted for recruitment because this group is the most likely to be enrolled in a senior design course where ISL may take place. This group of students have also had the most time and opportunities to participate in a co-curricular or volunteer ISL experience compared to juniors or sophomore engineering students.

Capstone instructors were mailed surveys and were provided with instructions to distribute the surveys in their senior engineering capstone course. Sixty-six instructors returned survey responses. The response rate was 53%. This is the number of surveys sent to participating instructors compared to the number returned. A national sample of n = 2,228 senior engineering students was collected. Of those who disclosed their gender in the survey, 77% were male and 23% were female, consistent with the national gender demographics of engineering students who graduate with bachelor’s degrees.[47] The representativeness of this sample across the United States is shown in Figure 1. Dots indicate home ZIP codes for at least one respondent (more than one respondent from a ZIP code appears as a single dot). Out of the 66 capstone instructors who returned completed surveys, 47 courses are represented in the results because of the response rate among students who completed all of the macro-ethics questions. The methods and instrument used in this study was approved by the Human Subjects Review Board at Virginia Tech.

International Journal for Service Learning in Engineering,
Humanitarian Engineering and Social Entrepreneurship
Vol. 14, No. 2, pp. 1-15, Fall 2019
ISSN 1555-9033

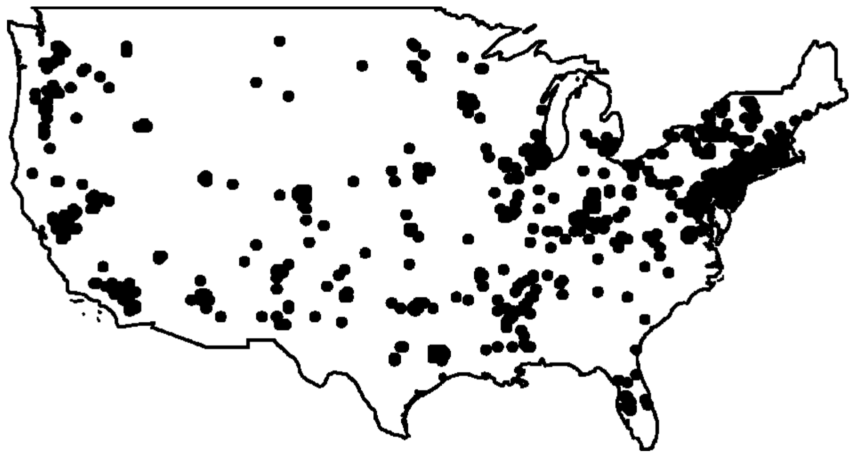

FIGURE I
SENIOR ENGINEERING STUDENT RESPONDENTS BY HOME ZIP CODE

Student responses to three survey questions were used to cluster students by capstone, volunteer/work, or co-curricular ISL experiences. Students with ISL capstone experience were defined as students who responded “yes” to the question: “did your most recent in-major engineering design course include an international service component?” Students with ISL volunteer/work experience were defined as students who responded with “limited”, “half a semester”, “one full semester”, or “more than one full semester” to the question, “while an undergraduate, have you done (or are you currently doing) any of the following?” with the item “worked or volunteered in a developing country”. Students that responded “never” were defined as students without ISL volunteer/work experience. The same question also included an item for ISL co-curricular experience. Students who responded “limited”, “half a semester”, “one full semester”, or “more than one full semester” to the item “traveled with an international service group (Engineers Without Borders, Students Helping Honduras, etc.)” were grouped together as students with ISL co-curricular experience. Students who responded with “never” were defined as students without ISL co-curricular experience. The sample size within the three types of ISL experiences were: 1703 for capstone, 1722 for volunteer/work, and 1762 for co-curricular experience. The sum of students between groups is greater than the number of students in the sample because students may have responded to more than one ISL experience. Table 2 distinguishes the responses by student groups with and without ISL experience for each of these three clusters.

TABLE II
SAMPLE BY ISL EXPERIENCE TYPE

International Service Learning Experience	Sample (n=)	ISL Experience	% Total	No ISL Experience	% Total
Capstone	1703	189	11.1%	1514	88.9%
Volunteer/Work	1722	245	14.2%	1477	85.8%
Co-Curricular	1762	108	6.1%	1654	93.9%

The largest percent participation in ISL experience is independent volunteer/work opportunities in developing countries, followed by capstone projects, and co-curricular experiences. While these groups are not mutually exclusive, the low percent of participation in these programs speaks to the limited integration and needed emphasis of ISL in engineering education.

The distribution of respondents is also provided by institution size (small, medium, and large) in Table 3. The sample includes more students with these experience from large (n=1008, 48%) institutions, then medium (n=830, 32%) and small (n=257, 12%). Within engineering disciplines, a majority of participants were studying mechanical/manufacturing (n=419), chemical (n=403), or civil engineering (n=245) with the remaining respondents split across 15 additional possible engineering disciplines. The sample size decreases from Table 2 to Table 3 because incomplete student responses from the macro-ethics question were removed. Incomplete responses were discarded to improve response validity. While the overall size decreased for each category from the initial sample to the sample who answered questions about macro-ethics in their entirety, the student data within the three types of ISL experiences showed normal distribution (absolute skewness less than 2 and kurtosis less than 7).

TABLE III

INSTITUTION SIZE RESPONSES

Institution Size		Sample		ISL Sample	
		n	%	n	%
Small	<5,400	257	12%	48	23%
Medium	5,400-14,800	830	40%	68	32%
Large	>14,800	1008	48%	94	45%

When comparing the number of students with ISL experience based on institution, the sample of students with ISL experience decreased slightly among students at large institutions (48% of the total sample but just 45% of those with ISL experience) and medium sized institutions (40% of the total sample but just 32% of those with ISL experience). There is an increase in students participating in ISL experience in small institutions (12% of the total sample but 23% of those with ISL experience).

In addition to comparing institution size, gender was also a variable checked for similar distributions between the type of ISL experience to avoid skewness.[48-50] Table 4 presents the composition of ISL experience by gender. Males compose the majority of the population in capstone, volunteer/work, and co-curricular experiences. Male students makeup the majority of the engineering population and the sample group. The difference in female student representation between the three types of ISL experience is not statistical different.

TABLE IV

ISL EXPERIENCE PARTICIPATION BY GENDER

International Service Learning Participation by Gender			
Gender	**Capstone (n=1703)**	**Volunteer (n=1722)**	**Co-Curricular (n=1762)**
Male	150 (80%)	177 (72%)	73 (68%)
Female	39 (20%)	68 (28%)	35 (32%)

Data Analysis

A score for each student was calculated by averaging the Likert scale score for each factor in the equity and welfare groups. Students that did not answer all of the questions for the factor groups

International Journal for Service Learning in Engineering,
Humanitarian Engineering and Social Entrepreneurship
Vol. 14, No. 2, pp. 1-15, Fall 2019
ISSN 1555-9033

were removed from the analysis. An independent t-test was used to compare students with ISL experience to students without ISL experience. A two-way ANOVA test was used to compare between students with and without specific types of ISL experiences.[51] Institution size and gender were control variables in this initial ANOVA test. Another ANOVA test was used to better understand the effects of institution and gender. The effect size between groups was calculated using Cohen's d. An effect size is the magnitude of the differences between two groups and it shows the importance of the means of the differences between groups.[52]

RESULTS

Students with ISL experiences possess a greater understanding of macro-ethics compared to students without ISL experiences in both equity and welfare factor groups. Students with ISL experiences score significantly higher (equity: M=3.34, welfare: M=2.90) compared to students without ISL experiences (equity: M=3.14, welfare: M=2.67) in both their understanding of equity ($p<0.001$) and welfare ($p<0.001$). The type of ISL experience is a contributing factor to these observed differences. Understanding of macro-ethics is significantly greater among students with ISL experience in capstone (equity: M=2.85, $p<0.001$; welfare M=3.33, $p<0.01$) and volunteer/work experience (equity: M= 2.98, $p<0.001$, welfare: M=3.36, $p<0.001$), but not co-curricular (equity: M=3.0, p=0.16, welfare M=3.38, p=0.066).

Macro-ethics understanding is not significantly different by institution size ($p>0.5$) but is significantly different by gender (equity: $p<0.01$; welfare: $p<0.05$). Males with ISL capstone experiences have a higher macro-ethics score for both equity (M=2.98) and welfare (M=3.6) than males without ISL capstone experiences (equity: M=2.16; welfare: M=3.0). The effect size is small to medium. Cohen's d for equity and welfare scores were 0.2 and 0.3, respectively. Male and female students with ISL capstone experience score similar in their understanding of equity (p=0.9) but male students with ISL capstone experience outperform female engineering students in understanding of welfare (p=0.03). Female students without ISL in their capstone course score significantly higher in their understanding of ethics (p=0.01) and welfare (p=0.018) compared to male students who do not participate in ISL in their capstone course. Figure 2 illustrates these results comparing ISL capstone experience and gender by equity and welfare factor groups.

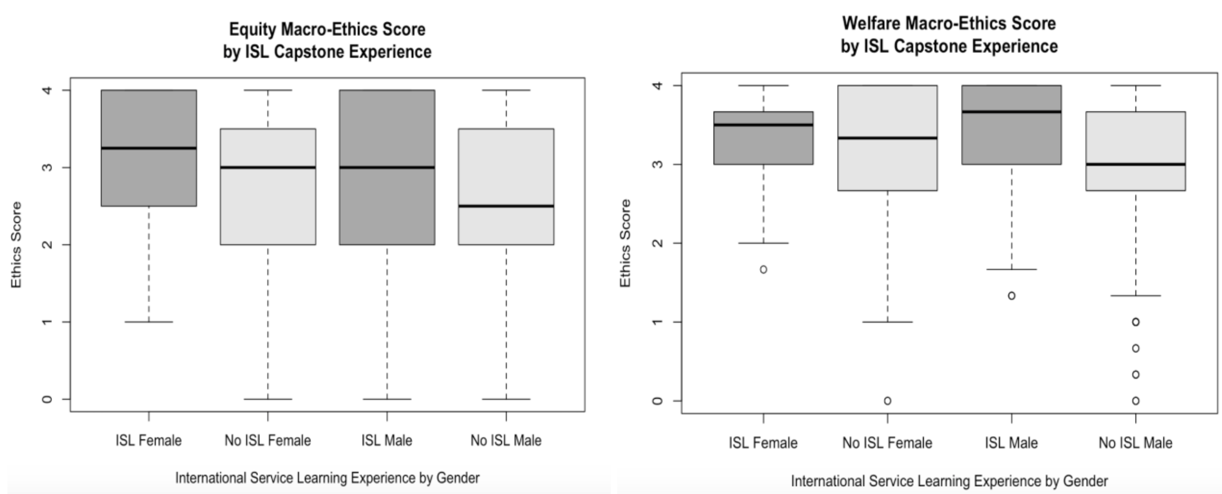

FIGURE II
EQUITY AND WELFARE MACRO-ETHICS FOR CAPSTONE EXPERIENCE SCORES

Male engineering students with ISL volunteer/work experience score significantly higher in both equity (p<0.0001) and welfare (p<0.0001) compared to male engineering students without ISL volunteer/work experience. The effect size is small to medium with a Cohen's d value of 0.35 for equity and 0.3 for welfare. Macro-ethic scores among female engineering students were not significantly different with or without ISL volunteer/work experience. In other words, understanding of macro-ethics among engineering students that are female does not change based on their ISL volunteer/work experience. With or without this type of experience, female engineering students possess an understanding for macro-ethics. Comparing male and female engineering students, female engineering students' score significantly higher in their understanding of both equity (p=0.036) and welfare (p<0.01) when both male and female engineering students do not have ISL volunteer/work experience. However, when comparing male and female engineering students who have ISL volunteer/work experience, both hold a similarly high level of understanding (equity: p=0.9; welfare: p=0.9). Figure 3 illustrates these differences in male and female engineering students' understanding of macro-ethics.

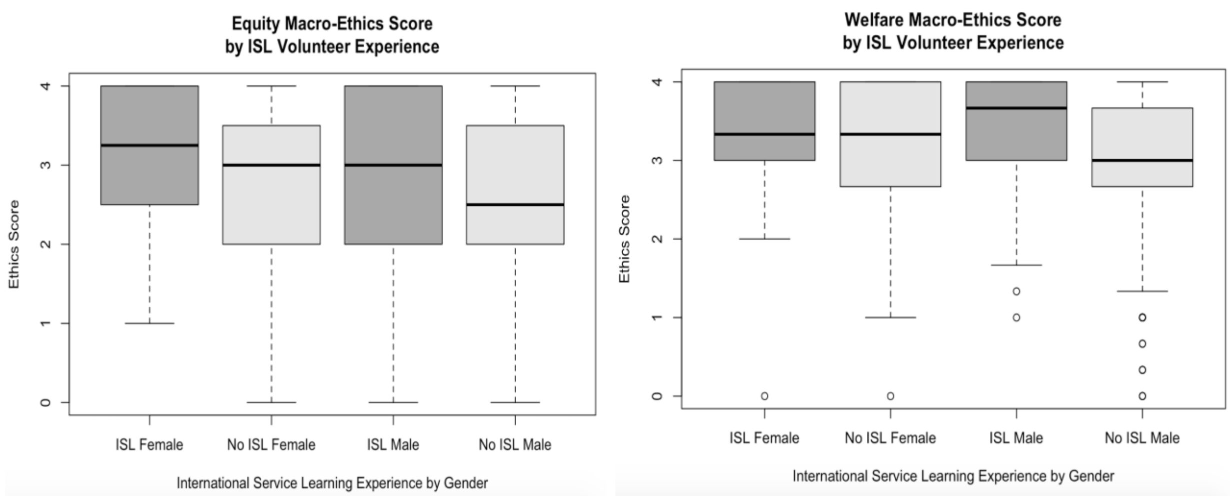

FIGURE III

EQUITY AND WELFARE MACRO-ETHICS FOR VOLUNTEER EXPERIENCE SCORES

Unlike ISL experiences in capstone courses and volunteer/work experiences, co-curricular experiences do not appear to influence students' macro-ethic scores regardless of gender. Figure 4 shows the distribution of ethics scores for students with co-curricular experiences. Male and female engineering students with ISL co-curricular experience possess a similar understanding of equity (p=0.67) and welfare (p=0.92). Female engineering students without ISL co-curricular experiences possess significantly different understanding of macro-ethics. Female engineering students compared to male engineering students score significantly higher in their understanding of welfare (p<0.001) but not equity (p=0.08).

Vol. 14, No. 2, pp. 1-15, Fall 2019
ISSN 1555-9033

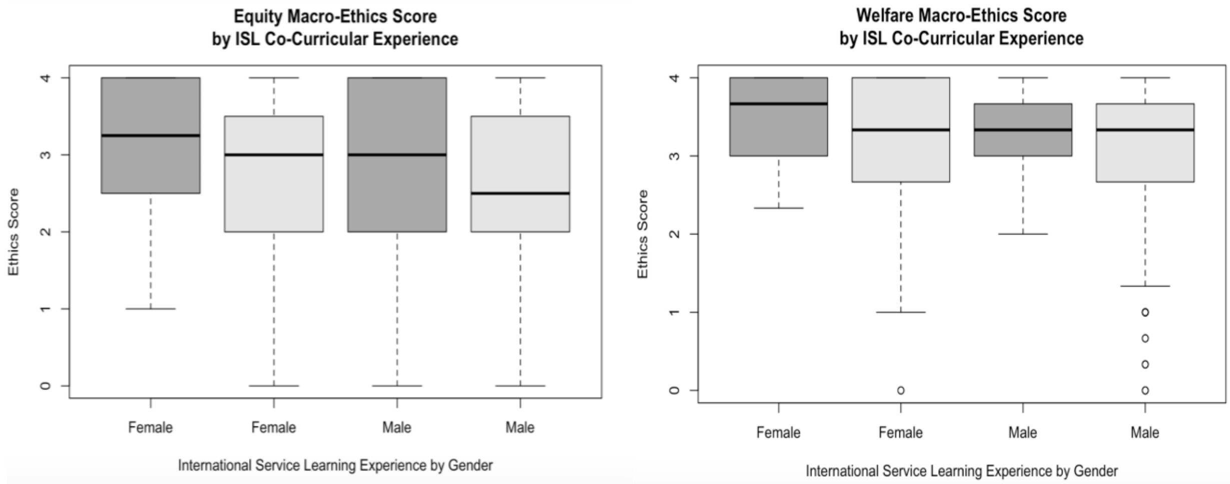

FIGURE IV

EQUITY AND WELFARE MACRO-ETHICS FOR CO-CURRICULAR EXPERIENCE SCORES

DISCUSSION

Three main findings emerged from the data: (1) male engineering students with ISL capstone experience possess a significantly higher understanding of macro-ethics compared to those without ISL capstone experience, (2) male engineering students with ISL volunteer/work experience possess a significantly higher understanding of macro-ethics than those without ISL volunteer/work experience, and (3) female engineering students generally possess significantly high macro ethic scores with or without ISL experiences compared to their male counterparts.

The combination of formal ethics training often in capstone courses[17] along with the hands-on experience with a global issue may allow male engineering students to more effectively apply their understanding of ethical responsible engineering.[4,18] Female engineering students seem to already possess this understanding. The reported small to medium effect (Cohen's D of 0.2 and 0.3, respectively) of ISL capstone experiences among male engineering students means that the average male engineering student who participated in an ISL capstone course would score higher than a male engineering student without ISL experience about 55% of the time in both equity and welfare macro-ethics. Taking into consideration the large percentage of the engineering population that is male, the increase in macro-ethics scores for nearly 1 out of every 2 male students who participate in ISL through capstone is a substantially large positive influence on the discipline.

Male engineering students with ISL volunteer experiences scored significantly higher in their perceived understanding of macro-ethics than those without. While ISL volunteer experiences likely do not contain formal engineering ethics training, they provide students with tangible experiences in the field. Prior research explains how this type of immersion in other cultures increases students' abilities to understand the global workforce.[53] As macro-ethics apply directly to the field of engineering and its respective impact on society, having a deeper understanding of the field could increase students' macro-ethics understanding. Similar to the effect size for ISL capstone experiences, the average male engineering student with ISL volunteer experience would outperform male engineering students without ISL volunteer/work experience in their understanding of macro-ethics about 55% of the time. Considering the increasing trend of students both in and out of engineering who want to volunteer in developing countries[54,55], the 55% increase

International Journal for Service Learning in Engineering,
Humanitarian Engineering and Social Entrepreneurship
Vol. 14, No. 2, pp. 1-15, Fall 2019
ISSN 1555-9033

in performance could translate into a large percentage of students nationally who possess critical macro-ethic understanding.

While differences were observed in macro-ethics understanding between students with and without ISL exposure through capstone and volunteer/work experience, there were no observed differences between students who participated and did not participate in co-curricular ISL experiences. This was surprising given that ISL co-curricular experiences positively influence engineering agency and identity, particularly among females.[34] One explanation is that the goals for a typical co-curricular program are related to project deliverables instead of student learning outcomes.[54] For example, Engineers Without Borders provides guidance and frameworks to evaluate design and implementation plans, however they do not provide student reflection templates to guide student learning.[53] The emphasis of design and implementation allows students to gain engineering skills and experience but ethics training may be overlooked.

Higher macro-ethics scores for females than males regardless of ISL experience

In both ISL capstone and volunteer experiences, female engineering students outscored male engineering students in their understanding of macro-ethics. Understanding of macro-ethics among female engineering students is not dependent on their ISL experience. Female engineering students possess an understanding of macro-ethics independent of their participation in ISL. They outperform their male counterparts who do not have ISL experience. But when male engineering students participate in ISL capstone or volunteer/work experiences they seem to obtain a similarly high level of macro-ethics as female engineering students.

Female students in engineering tend to care more about social impacts and people than their male counterparts in engineering.[57] This tendency to consider social impacts and responsibility may explain why females possess a higher macro-ethics score than male engineering students. Female engineering students appear to already understand macro-ethics in engineering, so recruitment of more women into engineering can increase understanding of macro-ethics in engineering as a whole. Participation of female engineering students in ISL experiences is slightly higher than their representation in the discipline. So, while ISL experiences does not increase their macro-ethics understanding it may be an approach for recruitment. Connecting engineering to macro-ethics in freshmen college programs may increase the number of women who recognize engineering as a profession focused on addressing these macro-ethical dilemmas.

STUDY LIMITATIONS & FUTURE WORK

Student perceptions were measured once in a single instance of time. While this provided comparative analysis between the groups, the results are not able to measure change in understanding over time. Future studies could consider using a pre- and post-experimental approach to capture shifts in understanding before and after these experiences. Another limitation of the results is students who self-select into international service-learning opportunities are not controlled for in the data analysis. Some university courses may allow for self-selection into design projects and others may require mandatory participation without the ability to self-select. The survey to students did not ask about self-selection. Including this question in future replications of this study would provide more insight. Also, the integration of a pre-and post-measure once self-selection is known would help measure the effect of self-selection bias.

Another consideration for future studies is the refinement of the macro-ethics instrument. High scores among females limited analysis because of a potential ceiling effect. Females with and without ISL experience scored toward the top of the scale. A revised scale with higher limits of macro-ethics or more detailed macro-ethic topics may help pinpoint differences among this group.

This study aimed to understand the differences between the three main ISL types. It was not, however, able to address significant differences among students who had multiple types of ISL experience due to sample size limitations. The added value of multiple types of ISL experiences for students should be investigated through more qualitative measures to understand the gains from each ISL experience or with a larger sample of students responding to the survey.

Investigation of ISL experiences by discipline may provide insight into which programs are best suited for ISL experiences. The number of students who participated in ISL was not a large enough sample to compare between disciplines. Future studies may want to target discipline-specific opportunities to ensure an adequate sample population for this analysis.

Another opportunity for future work is comparing these results to results among students in domestic service learning projects. Domestic service learning may provide different opportunities than international service learning. In addition to the distance between students and communities, one distinction between domestic and international service learning is the cultural similarities and differences between students and communities. Understanding how each service learning structure impacts students could be valuable in integrating the appropriate service learning opportunity to achieve the desired educational objectives.

Conclusion

Prior ISL research investigates ethics on a micro-level predominantly in small-scale case studies and shows improvements in student capabilities of using ethics in their engineering work.[26] The gap in understanding about ISL experiences and macro-ethics nationally motivated this study. The results suggest that integration of ISL experiences may be beneficial to learning macro-ethics. In particular, ISL capstone and volunteer/work experiences seem to increase understanding. However, the increase in macro-ethics appears gender specific. Male engineering students with ISL capstone and volunteer/work experience report significantly higher macro-ethic scores while females with or without these ISL experience score high on macro-ethics. Surprisingly ISL through co-curricular experiences had no effect on macro-ethics, regardless of gender. Integrating international service learning projects within capstone courses and encouraging volunteer opportunities in developing countries over co-curricular experience may significantly help improve macro-ethics understanding, predominately among male engineering students. The relationship between capstone and volunteer ISL experience needs further exploration in a more explanatory approach but the results suggests that these experiences are one method to better prepare engineering students to understand the macro-ethics of their work.

References

1 L. H. Lynn and H. Salzman, "Collaborative Advantage: Globalization of Innovation and Engineering," Social Science Research Network, Rochester, NY, SSRN Scholarly Paper ID 894348, Apr. 2006.

2 O. Alashiri, "Globalization and Engineering," in *School of Management and Business Studies: Lagos State Polytechnic, Ikorodu, Lagos, 2016 International Conference*, 2016, pp. 191–203.

3 L. H. Lynn and Hal Salzman, “The 'New" Globalization of Engineering: How the Offshoring of Advanced Engineering Affects Competitiveness and Development,” *Economics, Management, and Financial Markets*, vol. 4, no. 1, pp. 11–46, 2009.
4 G. L. Downey, J. C. Lucena, B. M. Moskal, R. Parkhurst, and et al, “The Globally Competent Engineer: Working Effectively with People Who Define Problems Differently,” *Journal of Engineering Education; Washington*, vol. 95, no. 2, pp. 107–122, Apr. 2006.
5 “Criteria for Accrediting Engineering Programs,” ABET, 2018 2017.
6 K. D. Stephan, “A Survey of Ethics-Related Instruction in U.S. Engineering Programs,” *Journal of Engineering Education*, vol. 88, no. 4, pp. 459–464, Oct. 1999.
7 B. Newberry, “The dilemma of ethics in engineering education,” *Science and Engineering Ethics*, vol. 10, no. 2, pp. 343–351, Jun. 2004.
8 B. Barry and M. Ohland, “ABET Criterion 3.f: how much curriculum content is enough?,” *Science & Engineering Ethics*, vol. 18, no. 2, pp. 369–392, Jun. 2012.
9 C. E. H. Jr, M. S. Pritchard, M. J. Rabins, R. James, and E. Englehardt, *Engineering Ethics: Concepts and Cases*. Cengage Learning, 2013.
10 B. Barry and J. Herkert, “Engineering ethics,” *Cambridge Handbook of Engineering Education Research*, pp. 673–692, Jan. 2015.
11 J. R. Herkert, “Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering,” *Science & Engineering Ethics*, vol. 11, no. 3, pp. 373–385, Sep. 2005.
12 E. Conlon and H. Zandvoort, “Broadening Ethics Teaching in Engineering: Beyond the Individualistic Approach,” *Science & Engineering Ethics*, vol. 17, no. 2, pp. 217–232, Jun. 2011.
13 Ayush Gupta, Andrew Elby, and Thomas M. Philip, “How Engineering Students Think About the Roles and Responsibilities of Engineers with Respect to Broader Social and Global Impact of Engineering and Technology,” in *American Society for Engineering Education*, 2015.
14 “Engineers’ Creed | National Society of Professional Engineers.” [Online]. Available: https://www.nspe.org/resources/ethics/code-ethics/engineers-creed. [Accessed: 05-Feb-2019].
15 J. R. Herkert, “Microethics, Macroethics, and Professional Engineering Societies,” in *Emerging Technologies and Ethical Issues in Engineering: Papers from a Workshop"*, 2004, pp. 107–114.
16 “Grand Challenges - Engineering for the Developing World,” *National Academy of Engineering Grand Challenges*, 05-Dec-2016. [Online]. Available: http://www.engineeringchallenges.org/cms/7126/7356.aspx. [Accessed: 20-Nov-2017].
17 J. R. Herkert, “Engineering ethics education in the USA: Content, pedagogy and curriculum,” *European Journal of Engineering Education*, vol. 25, no. 4, pp. 303–313, Dec. 2000.
18 M. J. Rabins, “Teaching engineering ethics to undergraduates: Why? What? How?,” *Science & Engineering Ethics*, vol. 4, no. 3, pp. 291–302, Sep. 1998.
19 A. Bielefeldt, K. Paterson, and C. Swan, “Measuring the Impacts of Project-Based Service Learning,” *American Society for Engineering Education Annual Conference*, 15 pp, 2009.
20 D. W. Dinehart and S. P. Gross, “A Service Learning Structural Engineering Capstone Course and the Assessment of Technical and Non-Technical Objectives,” *Advances in Engineering Education*, vol. 2, no. 1, 2010.
21 R. G. Bringle and J. A. Hatcher, “Implementing Service Learning in Higher Education,” *The Journal of Higher Education*, vol. 67, no. 2, pp. 221–239, Mar. 1996.
22 L. Phillips, A. Brady, and K. Jousma, “Interdisciplinary International Senior Design: How Service Learning Projects In Developing Countries Support Abet Accreditation,” presented at the 2007 Annual Conference & Exposition, 2007, pp. 12.944.1-12.944.35.
23 A. Bielefeldt, N. Canney, C. Swan, and D. Knight, “Contributions of Learning through Service to the Ethics Education of Engineering,” *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, vol. 11, no. 2, pp. 1–17, 2016.
24 Institute of International Education, “U.S. Study Abroad 2015/16-2016/17,” Institute of International Education, Open Doors Report on International Education Exhcange, 2018.
25 “Engineers Without Borders: Impact,” *Engineers Without Borders USA*. [Online]. Available: https://www.ewb-usa.org/our-work/impact/. [Accessed: 26-Oct-2018].

[26] D. Budny and R. T. Gradoville, "International Service Learning Design Projects: Educating Tomorrow's Engineers, Serving the Global Community, and Helping to Meet ABET Criterion," *IJSLE*, vol. 6, no. 2, pp. 98–117, Oct. 2011.

[27] L. E. Olson and J. R. Goldberg, "International service learning senior design projects: Human power and medical devices," in *2007 37th Annual Frontiers In Education Conference - Global Engineering: Knowledge Without Borders, Opportunities Without Passports*, 2007, pp. F4B-1-F4B-5.

[28] Z. Alexander, "International Volunteer Tourism Experience in South Africa: An Investigation Into the Impact on the Tourist," *Journal of Hospitality Marketing & Management*, vol. 21, no. 7, pp. 779–799, Oct. 2012.

[29] S. Brown, "Travelling with a Purpose: Understanding the Motives and Benefits of Volunteer Vacationers," *Current Issues in Tourism*, vol. 8, no. 6, pp. 479–496, Nov. 2005.

[30] N. G. McGehee and K. Andereck, "Volunteer tourism and the 'voluntoured': the case of Tijuana, Mexico," *Journal of Sustainable Tourism*, vol. 17, no. 1, pp. 39–51, Jan. 2009.

[31] A. Ebrahim, "Accountability In Practice: Mechanisms for NGOs," *World Development*, vol. 31, no. 5, pp. 813–829, May 2003.

[32] M. Edwards, "NGO Performance – What Breeds Success? New Evidence from South Asia," *World Development*, vol. 27, no. 2, pp. 361–374, Feb. 1999.

[33] R. Riddell, "Judging success. Evaluating NGO approaches to alleviating poverty in developing countries.," *Judging success. Evaluating NGO approaches to alleviating poverty in developing countries.*, no. No. 37, 1990.

[34] K. Litchfield and A. Javernick-Will, "Perceptions of engineering identity: Diversity and EWB-USA," in *2012 Frontiers in Education Conference Proceedings*, 2012, pp. 1–6.

[35] K. Litchfield and A. Javernick-Will, "'I Am an Engineer AND': A Mixed Methods Study of Socially Engaged Engineers," *J. Eng. Educ.*, vol. 104, no. 4, pp. 393–416, Oct. 2015.

[36] K. Litchfield, A. Javernick-Will, and A. Maul, "Technical and Professional Skills of Engineers Involved and Not Involved in Engineering Service," *J. Eng. Educ.*, vol. 105, no. 1, pp. 70–92, Jan. 2016.

[37] K. Litchfield and A. Javernick-Will, "Socially Engaged Engineers' Career Interests and Experiences: A Miner's Canary," *Journal of Professional Issues in Engineering Education and Practice*, vol. 143, no. 1, p. 04016018, Jan. 2017.

[38] L. Klotz, G. Potvin, A. Godwin, J. Cribbs, Z. Hazari, and N. Barclay, "Sustainability as a Route to Broadening Participation in Engineering," *Journal of Engineering Education*, vol. 103, no. 1, pp. 137–153, Jan. 2014.

[39] E. P. Cox, "The Optimal Number of Response Alternatives for a Scale: A Review," *Journal of Marketing Research*, vol. 17, no. 4, pp. 407–422, 1980.

[40] R. L. Gorsuch, "Exploratory Factor Analysis: Its Role in Item Analysis," *Journal of Personality Assessment*, vol. 68, no. 3, p. 532, Jun. 1997.

[41] T. Shealy and A. Godwin, "Survey Development to Measure the Gap Between Student Awareness, Literacy, and Action to Address Human-caused Climate Change: American Society for Engineering Education," *ASEE Annual Conference & Exposition*, 2017.

[42] E. Ferguson, "Exploratory Factor Analysis: A Users' Guide," *International Journal of Selection and Assessment*, 1993.

[43] A. F. Godwin, "Understanding Female Engineering Enrollment: Explaining Choice with Critical Engineering Agency," 2014.

[44] S. Cangur and I. Ercan, "Comparison of Model Fit Indices Used in Structural Equation Modeling Under Multivariate Normality," *Journal of Modern Applied Statistical Methods*, vol. 14, no. 1, pp. 152–167, May 2015.

[45] J. M. Cortina, "What Is Coefficient alpha? An Examination of Theory and Applications," *Journal of Applied Psychology*, pp. 98–104, 1993.

[46] H. A. DeVon *et al.*, "A psychometric toolbox for testing validity and reliability," *J Nurs Scholarsh*, vol. 39, no. 2, pp. 155–164, 2007.

[47] B. Yoder, "Engineering by the Numbers," ASEE.

[48] C. T. Amelink and E. G. Creamer, "Gender Differences in Elements of the Undergraduate Experience that Influence Satisfaction with the Engineering Major and the Intent to Pursue Engineering as a Career," *Journal of Engineering Education*, vol. 99, no. 1, pp. 81–92, Jan. 2010.

[49] R. M. Felder, G. N. Felder, M. Mauney, C. E. Hamrin, and E. J. Dietz, "A Longitudinal Study of Engineering Student Performance and Retention. III. Gender Differences in Student Performance and Attitudes," *Journal of Engineering Education*, vol. 84, no. 2, pp. 151–163, Apr. 1995.
[50] M. W. Ohland *et al.*, "Race, Gender, and Measures of Success in Engineering Education," *Journal of Engineering Education*, vol. 100, no. 2, pp. 225–252, Apr. 2011.
[51] S. G. West, J. F. Finch, and P. J. Curran, "Structural equation models with nonnormal variables: Problems and remedies," in *Structural equation modeling: Concepts, issues, and applications*, Thousand Oaks, CA, US: Sage Publications, Inc, 1995, pp. 56–75.
[52] G. M. Sullivan and R. Feinn, "Using Effect Size—or Why the P Value Is Not Enough," *Journal of Graduate Medical Education*, vol. 4, no. 3, pp. 279–282, Sep. 2012.
[53] G. L. Downey, "The Globally Competent Engineer," *Journal of Engineering Education*, 2006.
[54] N. M. Doerr and H. D. Taïeb, *The Romance of Crossing Borders: Studying and Volunteering Abroad*. Berghahn Books, 2017.
[55] D. McCall and A. S. Iltis, "Health Care Voluntourism: Addressing Ethical Concerns of Undergraduate Student Participation in Global Health Volunteer Work," *HEC Forum*, vol. 26, no. 4, pp. 285–297, Dec. 2014.
[56] "EWB UD – Process Details." https://www.ewb-ud.org/projects/process-overview/.
[57] C. Corbett, *Solving the equation: the variables for women's success in engineering and computing*. Washington, DC: AAUW, 2015.