Investigation of International Service Learning in Engineering Education

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ABSTRACT

International service learning (ISL) has been integrated into engineering education and has become increasingly more popular in co-curricular experiences. While prior research investigates each of these avenues of ISL, we have not investigated how these experiences compare to one another in terms of student learning outcomes or understood these experiences from a national perspective. The purpose of this thesis is to address these gaps in existing literature and to provide a comprehensive, holistic perspective of ISL experiences ability to impact student learning on a national scale. To better understand student learning outcomes in engineering ethics, agency and identity and draw comparisons in student career choices, several survey instruments were used within a nationally-representative survey distributed to engineering seniors (n=1911) at four-year universities within the United States. Descriptive statistics were used to categorize he responses by type of ISL experience: capstone, work, or co-curricular. The survey instruments were used to measure the individual learning outcomes: engineering ethics contained 5 items, engineering identity contained 14 items, and engineering agency contained 12 original items. Each survey instrument was validated using an exploratory factor analysis (EFA) to determine the relevant factor groups for each construct. An ANOVA test or Kruskal Wallis, the non-parametric equivalent test, was used for each dataset depending on normal distribution of the data. Responses in engineering ethics showed a significantly higher score in students' ethics understanding with ISL capstone ($p < 0.001$) and work experience ($p<0.0001$) and a medium effect size for both (Cohen's d=0.3). Responses in engineering agency scores showed a significant difference with ISL capstone ($p<0.05$) and co-curricular experience ($p<0.05$) with a medium effect size (Cohen's d=0.3). Additionally, responses to predicted career choice post-graduation showed a lower percentage of students anticipating leaving engineering from the 9% population rate to 6% for those with ISL capstone experience and 5% for those with ISL co-curricular experience. These results give reason to consider more frequent incorporation of ISL projects into engineering courses such as senior capstone design.

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GENERAL ABSTRACT

International service learning (ISL) is a way of learning that allows students to use their engineering skills to help others, while gaining experience in a global context. ISL projects allow students to interact with people around the world, gaining experience with cultural and social diversity while using and developing their engineering skills. ISL projects take many forms and have been used within engineering education in many ways. The three most common ISL experiences are integration into capstone courses, independent ISL work experience, and co-curricular programs such as Engineers Without Borders. Prior research has focused mainly on capstone and co-curricular ISL experiences. Research found ISL experiences beneficial for student learning, however prior research has not investigated how these experiences compare. Additionally, many studies are conducted within courses or programs which provides a limited general understanding. This study aims to provide more clarity between student learning by ISL experiences and provide a national perspective on the impacts of ISL experiences. The purpose of this study was to determine how effective ISL experiences are in improving student learning in engineering ethics, agency, identity, and retaining engineering students in the field after graduation. A survey with a total of 31 questions related to these topics (5 for engineering ethics, 12 for engineering agency and 14 for engineering identity) was nationally distributed to senior engineering students enrolled at four-year universities in the United States. The responses were categorized by student's ISL experience (capstone, work, and co-curricular) and compared for each engineering topic. The data was analyzed statistically, and the survey questions were analyzed to ensure that they were measuring student learning as expected. The results showed that ISL capstone projects improved students' understanding of engineering ethics, increased their sense of engineering agency, and led to a lower percentage of students who planned to leave the field of engineering after graduation. ISL work experiences improved ethics understanding for students but had little to no impact on engineering agency. Finally, ISL co-curricular experiences had little impact on engineering ethics understanding, but improved student's engineering agency beliefs and led to a less students leaving the field. These results give reasons to consider integrating ISL experiences into engineering education more frequently to provide benefits to students.

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ATTRIBUTION

This foreword describes the contribution from each author for the two chapters within this thesis manuscript.

Chapter 1:

Brooke Baugher- Brooke performed the literature review, developed the research questions, determined the methods, performed the data analysis and wrote the chapter which includes comments from the other authors.

Tripp Shealy- Tripp helped to develop the questions and methods for this chapter. He also provided feedback on the document through multiple rounds of revision.

Josh Iorio- Josh provided assistance early on with feedback for the methods and data analysis for this chapter. He also provided feedback on the document.

David Knight- David helped provide feedback for the data analysis methods used in this chapter. He additionally provided feedback on the chapter.

Manuscript 2:

Brooke Baugher- Brooke performed the literature review, developed the research questions, determined the methods, performed the data analysis and wrote the chapter which includes comments from the other authors.

Tripp Shealy- Tripp helped to develop the questions and methods for this chapter. He also provided feedback on the document through multiple rounds of revision.

Allison Godwin- Allison provided the needed technology to convert the data to a digital form. She assisted with the implementation of the EFA statistical analyses and provided the background framework for the identity and agency measurements used in this chapter.

David Knight- David helped provide feedback for the data analysis methods used in this chapter. He additionally provided feedback on the chapter.

INTRODUCTION

International service learning (ISL) has been studies in many ways, in many contexts within education (Bielefeldt, Canney, Swan, & Knight, 2016; Bringle, Hatcher, & Jones, 2012; Budny & Gradoville, 2011; Green, 2009; Hayward, Li, Venere, & Pallais, 2015; Kaitlin Litchfield, Javernick-Will, & Maul, 2016; Litchfield Kaitlin & Javernick-Will Amy, 2017; Olson & Goldberg, 2007; Phillips, Brady, & Jousma, 2007). Existing literature investigates one of two types of ISL experience: capstone projects or co-curricular opportunities such as Engineers Without Borders. Research in ISL capstone courses is typically bounded by the specific class or classes and has little generalizability due to the case study nature. ISL co-curricular projects have bene investigated more extensively, particularly EWB, however the sample populations for many of the studies is drawn from students who participate formal EWB events. This sample population has limited generalizability due to the risk of self-selection bias in the sample population. While many studies exist, very little is understood about the differences between types of ISL experiences. This manuscript aims to answer questions such as how do students with different types of ISL experience differ in learning outcomes such as engineering ethics? How do ISL experiences impacts student's sense of agency and identity? Does ISL experience help to retain students in the field of engineering after graduation?

This manuscript is comprised of two chapter that aim to answer these questions. The first chapter investigates the impacts of ISL experiences (capstone, work, and co-curricular) on student understanding of macro-ethics through a quantitative study. We utilize a nationally-representative survey to create generalizability. We aim to answer questions about how students perceive engineering's effect on the world and society as a whole. The second chapter also utilizes national survey data to answer our research questions. This chapter focuses on engineering students engineering agency and their propensity to remain in engineering after graduation. Both chapters aim to gain a more holistic perspective on the role of ISL in engineering education and universities.

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IMPACT OF INTERNATIONAL SERVICE LEARNING ON ETHICS: A NATIONAL STUDY OF SENIOR ENGINEERING STUDENTS

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Abstract

To address complex problems in a globalized workplace, future engineers must understand the ethical implications of their work in the global context. International service learning (ISL) is a possible approach for engineers to gain an understanding of ethical implications in a global context. The purpose of this study is to investigate the potential benefits that ISL may add to engineering ethics education. The quantitative study measured senior engineering students' understanding of ethics from a national sample of students enrolled in capstone design courses (n=1700) in three types of international service learning experiences: capstone, volunteer/work, or co-curricular. Students who participated in international service learning through capstone and volunteer/work experience scored significantly (p<0.01, 0.001) higher to questions that measured their understanding of ethics. Males compared to female engineering students showed the largest difference in their understanding of ethics. The integration of international service learning into engineering education should be more seriously considered to aid in more effectively teaching ethics. Male engineering students, in particular, can benefit in their ethics education from experience with international service learning.

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

Introduction and Background

As technology improves, engineering as a profession is becoming increasingly globalized [1]–[3]. Engineers are expected to have the appropriate skills and ethical understanding to work in these global environments. Developing globally-competent, ethical engineers is a defined outcome of ABET's engineering education [4], [5].

Prior to the 2000 ABET criteria update, engineering ethics was often overlooked in engineering education, resulting in one in five graduating engineers taking a course specifically emphasizing ethics as a topic [6]. This trend has shifted with the updating of the ABET criteria, and ethics are now integrated more formally in engineering courses [7]. While engineering education at accredited universities emphasizes the ABET requirements for professional and ethical responsibility, many faculty responsible for fulfilling these requirements find them to be unclear [8].

While many frameworks exist [9], [10], the ethics framework in this study is modeled on Herkert (2015), where ethics are defined as having both a macro and micro component [11]. Micro ethics views the topic from the lens of the individual and addresses ethical decisions that the engineer may make in their work. Macro ethics view the topic from a systems perspective, focusing on engineering's impact on society as a whole. These two views together create a holistic understanding of ethics in engineering.

A majority of engineering ethics education focuses on micro-ethics with little emphasis on macro-ethics [12], [13]. Too frequently, engineering students do not consider their impact on society as a whole [12]. This is critical in order to develop a macro-ethics point of view and must be addressed in order to prepare students to ethically meet grand challenges in engineering [14].

Prior scholars who suggest methods for teaching ethics often group pedagogy by traditional lecture and active learning. The traditional lecture pedagogy focuses more explicitly on the theoretical implications of ethics, while the active learning model focuses more on team-based problem

solving. Both pedagogies seem necessary [8], [15], [16]. There is no conventional naming scheme, so we use *theoretical* and *application* to describe methods for teaching ethics. Both theoretical and application approaches offer complimentary outcomes necessary for students to fully understand ethics.

While both theoretical and application-based teaching of ethics seems necessary, faculty members who are required to teach ethics in their courses often find that the integration of engineering ethics material removes the space available for technical material [17]. Potential solutions to this issue include mini-insertions [17] and utilizing ethical dilemma problems to supplement activities [18]. Prior literature shows that simply increasing the time that education focuses on ethics does not guarantee a positive learning outcome for students [8], so options to more effectively integrate ethics training must be considered.

One approach to teaching macro-ethics is through International Service Learning (ISL) [19], [20]. ISL is a subset of service learning, as defined by Bringle and Hatcher (1996) where there is an added emphasis on global skills. ISL is defined as a credit-bearing educational experience that combines organized service activities and international humanitarian engineering principles to meet community needs and reflect on the experience in order to further understanding of course content, a broader appreciation of engineering, and enhance student's sense of civic responsibility.

ISL falls within three main categories within education: formal courses, independent volunteer and work experiences, and co-curricular experiences. Each category of ISL offers different frameworks and emphasis on student learning outcomes. The differences between the programs present an opportunity to investigate many different types of ISL experiences to explore how they differ.

Integration of ISL into engineering courses typically results in a more structured framework, due to adherence to ABET criteria [22]. Within service learning courses, senior capstone design courses are the most common to imbed ISL within required courses. Design-focused courses in students' sophomore or junior years were most common in the elective course group [23]. ISL engineering courses have the strongest focus on student learning outcomes and offer the most structured learning of the three categories.

ISL volunteer/work experiences are usually independently organized by the student and the 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. Research conducted on ISL volunteer experiences predominantly focuses on why volunteers participate or opt for work in an international service organization, and focus more explicitly on social impacts [25]–[27]. The host organizations involved with ISL volunteering, typically non-government organizations (NGOs), focus on community improvement, and their success is evaluated on the efficacy of their program implementation [28]–[30]. This focus for evaluation means that learning from volunteer or student work experience is rarely structured or evaluated.

ISL co-curricular program structures vary by organization. These programs typically do not have formal structures with focus on student learning, rather they function to serve communities in need and rely on students having technical skills from their education [31]. This focus allows students to apply their engineering skills to ISL projects. Organizations like Engineers Without Borders and Bridges to Prosperity are examples of co-curricular programs.

ISL experiences may provide the missing macro-ethics component of ethics education for students due to the global nature of the experience. The purpose of this quantitative study is to investigate the effect of ISL through capstone, volunteer, and co-curricular experience on senior engineering students' perception of engineering macro-ethics from a national perspective. We investigate ISL in capstone, volunteer and co-curricular activities as each represents a uniquely structured approach to learning. This research offers a national perspective of the impacts of ISL on engineering ethics training from students in their senior year of engineering. We propose that students with ISL experiences will score higher in macro-ethics than those without ISL experience and scores will vary between the ISL categories. The findings from this study will inform how engineering education teaches engineering ethics.

Motivation and Research Question

Emphasizing holistic understanding of engineering ethics in undergraduate curriculum will help universities produce engineers who can better operate in global environments. Investigation of ISL projects as a mechanism to improve macro-ethics learning is necessary since emphasis of macro-ethics has historically lacked behind micro-ethics [10]. Using a national sample, students were surveyed about their experience with ISL in capstone courses, independent volunteer and work experiences, and co-curricular projects.

Prior research about ethics from ISL capstone courses offers a limited sample sizes of students and lacks generalizability. For example, Michigan Technological University's ISL senior design course led to positive increase of understanding about ethics, however the sample was limited, and the program was very specific. It does not represent programs nationally [22]. Additionally, the focus on teaching and learning ethics has focused predominately on micro-ethics. Budny & Gradoville (2011), posed an ethics question to students in an ISL capstone course, "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, not the impact of the engineering field.

ISL volunteer experiences are most commonly considered as volunteering efforts associated with co-curricular programs [33]. Nearly 55% of all participants in international volunteer efforts are students [34]. This equates to between 40-50 thousand students per year traveling outside of the United States to perform some type of service activity. While these experiences may not be exclusively based in engineering, the impact of international volunteer experiences on engineering students should be considered as a method of increasing macro-ethic understanding. Consideration of ISL volunteer experiences led us to include this group in our comparison across experiences between students.

ISL co-curricular experiences through Engineers Without Borders (EWB) have been studied to understand the impact on engineering agency [35], identity [36], and engineering skills [37], [38], however, the studies have been derived from a very specific population of engineering students.

The students who participated in ISL co-curricular studies were sourced from regional and national EWB conferences, which presents some self-selection bias within the sample population. While engineering agency, identity and skills have been studied within ISL co-curricular experiences, the impact on ethics is not well understood. Our research question is meant to explore the relationships that exist between ISL experiences and student understanding about ethics.

Specifically, we ask the following research question: *do students with international service learning through formal capstone projects, volunteer experience, or co-curricular projects show a difference in macro-ethics score from those who do not participate in ISL experiences?*

Methodology

The instrument used to measure ethics aimed was focused on macro-ethics traits among senior engineering students. Students were compared based on three categories of ISL experience. The scale was developed using the macro-ethics framework developed by Herkert (2000). This framework explains that micro and macro are the two components to ethics in engineering. Macro ethics addresses engineering as a field's impact on society [15]. Explanation of the development and validation of the scale is described in the following sub-sections.

Survey Instrument

Elements in the instrument focused on student perceptions of ethics as they apply to the overall social impact of engineering. Evaluating student perceptions of the field of engineering additionally allowed us to limit the self-perception bias seen in previous studies [32] by asking for the student's view of engineering instead of asking their ability to act ethically. A five-point anchored Likert scale was used to measure students' macro-ethics score with scores ranging from 0, "strongly disagree" to 4, "strongly agree". 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 end, such as not at all, provides an adequate reference point [39].

Our survey instrument was adapted from the Sustainability and Gender in Engineering (SaGE) survey [40]. The original question scope included issues related to the field of engineering in three broad areas about the environmental, society, and economy [40]. We adapted the original questions from SaGE by reducing 10 components to 5 and focusing specifically on the socially-driven impact of engineering because this aligns with the overarching concept of macro-ethics for the field of engineering. The survey included the following items:

In your opinion, to what extent are the following associated with the field of engineering?
("not at all"=0, "very much so"=4)
>> *Improving quality of life*
>> *Saving lives*
>> *Caring for communities*
>> *Addressing societal concerns*
>> *Feeling a moral obligation to other people*

Since we adapted our instrument from SaGE, the instrument requires validation for the final question components. We performed an exploratory factor analysis (EFA) to validate the survey instrument [41]. EFA was used to determine the factor groupings for our survey instrument.

Validation of Survey Instrument: Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is a method used to validate the independent constructs that the survey instrument measures [41]. 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 questions aimed to address social implications of macro-ethics from several viewpoints and were hypothesized to load into two factor groupings which address the two main teaching methods used in engineering ethics education. Consideration for the feasibility of the factor analysis was made based on the predicted factor groupings. While the number of variables are small (five potential), the population is exceedingly greater than 300, which accounts for the low variable to factor ratio as explained by Ferguson & Cox (1993).

For the EFA, a factor cutoff value of 0.4 was used, which is consistent with comparable research in the engineering education field [43]. Any factor that had a loading below 0.4 was considered an unreliable measurement and was therefore excluded from the factor groups. Cross loaded values residing in more than one factor group with a value higher than 0.4 were removed from the factor groups because the cross loading does not allow accurate measurement of the variable [42].

Through the EFA, the theoretical and application factor groups emerged with the five question components. The question components that factored into the theoretical grouping *describe* engineer's ability to impact society at large and the feeling of moral obligation to people. The question components that factored into the application group more directly emphasize actions that engineers *do* to impact society at large (e.g. improving, saving, caring). The factor groups and correlating questions are shown in Table 1.

Table 1: 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
Theoretical	Addressing societal concerns	0.770	0.011	0.7
	Feeling a moral obligation to other people	0.804		
Application	Improving quality of life	0.633	0.084	0.79
	Saving lives	0.851		
	Caring for communities	0.459		

The small number of questions for each factor group requires complete responses from the data analysis in order to maintain the integrity of the dataset. Each group had high loading per question, with the lowest loading being 0.459 (caring for communities), which indicates that these subsets are accurately addressing the same construct.

We validated the factor groups through goodness of fit, internal reliability and the 90% confidence interval. We determined 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, which indicate a reliable fit [45], [46]. The 90% confidence intervals for the theoretical and application groups were 0.011 and 0.084, respectively. The

confidence intervals indicate a high level of confidence [43] consistent with confidence intervals in engineering education research. Each of the measurements used to validate our factor groups indicated that the groups were valid and reliable for the dataset.

Data Collection

Quantitative methods were used on a national data sample comprised of senior engineering students. Responses were broken down into three categories of international service learning experience: capstone, volunteer, and co-curricular using descriptive statistics. The questions from this study are a subset of questions from a larger national survey. The survey was distributed to accredited, four-year engineering institutions across the United States. Universities were chosen randomly from the National Center for Education Statistics. The schools were stratified based on size to try to achieve equal representation from small, medium, and large institutions, and an equal number of universities were randomly selected from these bins to recruit for the study. Participating capstone instructors were sent paper copies of the survey and they distributed the surveys to their students, who responded by scantron.

The sample population (n=2095) was comprised of 20% female and 66% male responses, with the remaining percentages either reported as other or NA. This study investigates only the male and female groups due to the small sample size of the "other" group (n=36) and the high number of different identifications within the group. The female to male distribution was consistent within the engineering major demographic [47].

Descriptive statistics were used to identify each of the international service learning (ISL) categories: capstone experience, volunteer/work experience, and co-curricular experience based on survey questions. Three survey questions asked about the student's specific ISL experience in order to categorize their responses. ISL capstone experience was identified from the question: "Did your most recent in-major engineering design course include an international service component?", which had a yes or no response option. ISL volunteer/work experience used the question "Worked or volunteered in a developing country". ISL co-curricular experience was identified based on the questions "Traveled with an international service group (Engineers Without Borders, Students Helping Honduras, Bridges to Prosperity, etc.)". Both the volunteer and co-

curricular questions allowed answer selections of "never", "limited", "half a semester", "one full semester", and "more than one full semester". Selection of "limited" or higher was kept for each category to consider spring and winter break trips which may be shorter in length than half a semester. The sample size for each of these categories were n=1703, n=1722, and n=1762, respectively. Table 2 below shows the responses by ISL experience.

Table 2: Sample by ISL 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%

Overall, the highest percent of participation in international service learning experiences was through independent volunteer/work opportunities in developing countries, followed by capstone projects, and finally co-curricular experiences. While these groups are not mutually exclusive, the percent of participation in these programs speaks to the limited integration and needed emphasis of international service in engineering education.

In addition to using descriptive statistics to categorize ISL experience, we investigated the distribution of respondents from institution size (small, medium, and large) and engineering major. Table 3 shows the distribution of institution size within the sample. Overall, the distribution of responses between institution size was large (n=1008, 48%), medium (n=830, 32%) and small (n=257, 12%). Within engineering disciplines, a majority of participants responded that they were studying one of three main engineering disciplines: mechanical/manufacturing (n=419), chemical (n=403), or civil engineering (n=245) with the remaining respondents split between the remaining 15 engineering discipline options.

Table 3: Institution Size Responses

Institution Size	Sample		ISL Sample	
	n	%	n	%
Small	257	12%	48	23%
Medium	830	32%	68	32%
Large	1008	48%	94	45%

By combining descriptive statics for ISL experiences, institution size, and major, we investigated the distribution of students between the ISL groups. Overall, participation in ISL experiences showed a shifted distribution in student's home institution size. Students with ISL experience showed slight decreases in large (n=94, 45%) and medium (n=68, 32%) sized institutions but showed a large increase for the small (n=48, 23%) institutions. The distribution of student engineering discipline was consistent within the ISL groups as it was in the overall population.

The sample size decreased from the data collection to the analysis process due to incomplete student responses for each of the categories. The data analysis for this study requires students to completely answer all macro-ethics questions to account for the small factor groupings. Incomplete responses were discarded to improve validity of the response. While the overall size decreased for each category from the initial population, they are still representative of the national population. Additionally, all of the categories showed normal distribution (an absolute skewness less than 2 and a kurtosis less than 7), allowing for use of Analysis of Variance tests for the data analysis [48].

Data Analysis

Macro-ethics responses were calculated by averaging the respondent's score for each factor grouping, under the condition that the respondent answered all questions within the factor group. Students that did not answer all of the questions for the factor groupings were removed from the analysis.

A two-way ANOVA test was used to analyze each group of data. Previous literature shows that gender influences student learning outcomes and experiences [49]–[51], therefore we controlled for this in our ANOVA. Additionally, we investigated the impact that institution size and

engineering discipline had on the responses. After analyzing the data, we determined the effect size of the results using Cohen's d. An effect size is the magnitude of the differences between two groups [52] and it shows the importance of the means of the differences between groups. this study, effect size was calculated to determine the impact of male's macro-ethics scores based on ISL experience for the overall sample.

Results

To answer our research question (*do students with international service learning through formal capstone projects, volunteer experience, or co-curricular projects show a difference in macro-ethics score from those who do not participate in ISL experiences?)*, we compared the individual ISL category respondents to respondents without ISL experience. In addition to this comparison, we provide an explanation for the impact that additional influencing factors such as gender or engineering discipline have within these categories.

The dataset shows that both males and females pursue ISL experiences through volunteer experience more than capstone or co-curricular experiences. Table 4 shows the breakdown of ISL experience and gender.

Table 4: ISL Experience Participation by Gender

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

We separated the data by gender to provide more clarity in ethics scores by each group when compared by ISL experience, as males had a much larger population in each of the ISL categories. The responses based on gender showed significant differences and were analyzed independently to investigate the differences.

We additionally investigated any potential differences that arise between responses based on institution size or engineering discipline. Neither proved to have a significant effect on macro-ethics scores by ISL group or independently.

Males with ISL Capstone Experiences Had Higher Macro-Ethics Scores than Males with Non-ISL Capstone Experiences

The two-way ANOVA showed significant differences between students' macro-ethics score and experience in capstone ISL projects for both factor groups, theoretical ($p<0.01$) and application ($p<0.001$). Figure 1 shows student scores by theoretical and application groupings and gender.

	Addressing societal concerns
Theoretical	
	Feeling a moral obligation to other people

	Improving quality of life
Application	Saving lives
	Caring for communities
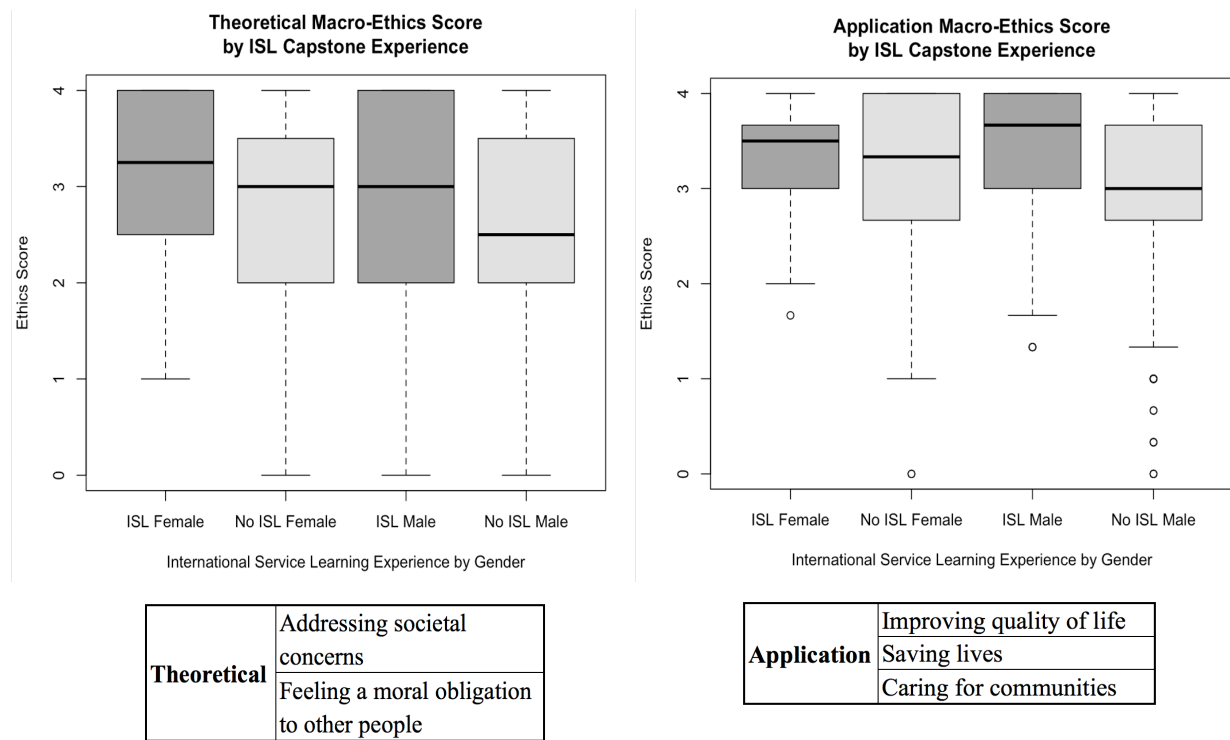
Figure 1: Theoretical and Application Macro-Ethics for Capstone Experience Score

Within gender, males showed a greater difference in ethics score between those who had and who did not have ISL experience through their capstone course. Female engineering students showed little change. The Cohen's d value for theoretical and application scores were 0.2 and 0.3, respectively, which shows each to have a small effect size on the population.

Males with ISL Volunteer Experiences Had Higher Macro-Ethics Scores than those without ISL Volunteer Experiences

Male students with ISL volunteer experiences scored significantly higher on both factors, theoretical ($p<0.0001$) and application ($p<0.0001$). Females showed no significant difference between those with and without ISL experience.

	Addressing societal concerns
Theoretical	
	Feeling a moral obligation to other people

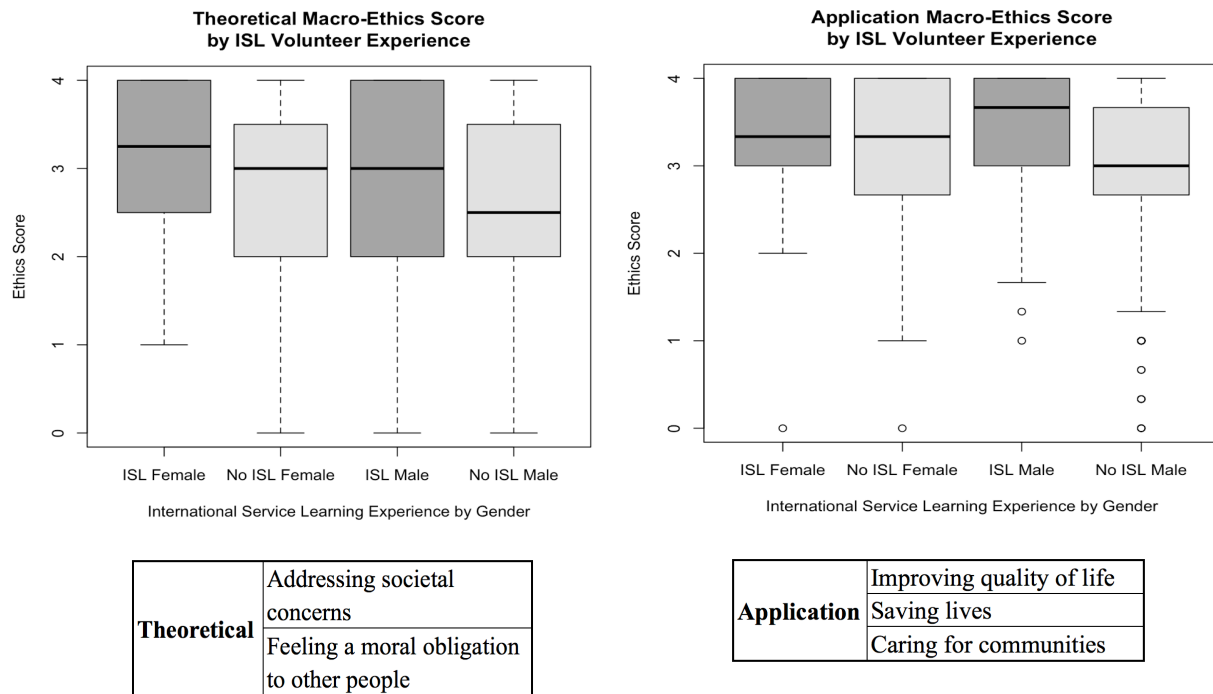|	Improving quality of life
Application	Saving lives
	Caring for communities

Figure 2: Theoretical and Application Macro-Ethics Score for Volunteer Experience

As with students with international experience through capstone courses, males who have ISL experience through volunteering reported higher scores in macro-ethics scores for both factor groupings. Female engineering student's macro-ethic scores were not influenced by ISL volunteer experiences. A Cohen's d value of 0.35 and 0.3 was calculated for theoretical and application ethics scores for males, respectively.

ISL Co-Curricular Experiences Lack Significant Differences in Students Macro-Ethics Scores

Unlike ISL experiences in capstone courses or in volunteer opportunities, co-curricular experiences did not show any differences in students' macro-ethics scores regardless of gender. This result aligns with the framework and goals for typical co-curricular programs, emphasizing the project deliverables instead of student learning outcomes. Co-curricular programs emphasize design and implementation skills, which is demonstrated through the framework of the programs. For example, EWB provides guidance and frameworks to evaluate design and implementation plans, however they do not provide student reflection templates to guide student learning ("EWB UD – Process Details"). The emphasis of design and implementation allows students to gain engineering skills and experience however ethics training often requires formality, which is not integral to co-curricular projects.

Discussion

How do students with ISL experiences differ in macro-ethics scores from students without ISL experiences?

Three main differences that emerged from the results are (1) males with ISL capstone experience showed significantly higher macro-ethics scores than those without, (2) males with ISL volunteer experience showed significantly higher macro-ethics scores than those without, and (3) females had no significant difference in macro-ethics scores by ISL experience, yet they consistently outscored males across all groups. Each of these differences are discussed in the following sections.

Male students with ISL capstone experience had significantly higher macro-ethics scores than male students without ISL experience

While traditional capstone courses sometimes integrate formal ethics training modules into the curriculum [54], the focus of a majority of ethics training is on micro-ethics [15]. ISL experiences provide students with opportunities to engage in global challenges and work with people from culturally and socially different backgrounds [4] in order to help teach macro-ethics. The combination of formal ethics training along with the hands-on experience with a global issue may

allow male students to more effectively apply their understanding of the individual's ethical responsibility to the field of engineering.

The results from our study show an effect size of 0.2 and 0.3 for the respective factor groups in macro-ethics. This effect size quantifies the impact that the results can have on the overall population. The effect of the ISL capstone male macro-ethics scores means that the average male engineering student who participated in an ISL capstone course would score higher than a male without ISL experience 55% of the time in both theoretical and application macro-ethics. Taking into consideration the propensity for male students to prefer international service learning experiences in capstone courses and the percentage of the engineering population that is male, the difference of ethics scores between the groups appears to offer potential impact on male student's understanding of macro-ethics.

Male students with ISL volunteer experience had significantly higher macro-ethics scores than male students without ISL experience

Additionally, males with ISL volunteer experiences scored significantly higher macro-ethics scores than those without. While ISL volunteer experiences likely do not contain a formal engineering ethics training, they provide students with tangible experiences in the field. Prior research has shown that immersion in other cultures increases students' abilities to understand the global workforce [55]. As macro-ethics apply directly to the field of engineering and its respective impact on society, having a stronger understanding of the field could increase student understanding of macro-ethics.

Similar to the effect size for ISL capstone experiences, the average male engineering student with ISL volunteer experience would score higher in macro-ethics 55% of the time over those who do not. Considering the increasing trends of students both in and out of engineering who want to volunteer in developing countries [56], [57], the effect of our results could impact an increasingly large percentage of students.

Female's macro-ethics scores were higher than male's and did not differ by ISL experience

In both ISL capstone and volunteer experiences, females tended to outscore males in their macro-ethics scores with an average score of 3.67/4. Additionally, female macro-ethics scores were consistent with or without ISL experience. This suggests that females have a stronger understanding of macro-ethics than males independent of their participation in ISL experiences.

Prior literature shows that females in engineering tend to care more about social impacts and people than males [58]. This tendency to consider social responsibility and the impact that designs have on people may explain why females show a higher macro-ethics score than males. Although there was no difference in macro-ethics scores between those with and without ISL experience, a higher ratio of females participated in ISL from the overall sample population, which shows that females find value in ISL experiences.

Knowing that women in engineering hold views about the role engineering for social implications, ISL may be an approach to recruit more women to engineering. Connecting engineering to macro-ethics in high school and freshmen college programs may increase the number of women who recognize engineering as a profession focused on addressing many of these macro-ethical dilemmas. As they already seem to understand macro-ethics in engineering, recruitment of more women may aid the engineering field as a whole to consider macro-ethical implications in design and workplace decisions.

There is potential for ISL in formal engineering education to improve ethics training, particularly for males

While this study is descriptive in nature, the results suggest that integration of ISL experiences may be beneficial to teaching macro-ethics to engineering students. With a majority of the engineering population being male, integrating ISL experiences into engineering education could help with engineering ethics education, particularly for males. In addition to integration of ISL into engineering education, encouraging students to pursue ISL volunteer opportunities may aid in engineering ethics education. By pursuing ISL experiences, engineering education is presenting a new lens from which to view engineering, which may help males improve their macro-ethical understanding or may help females align their values with the possibilities of social impact through engineering.

Conclusion

Prior ISL research investigates ethics on a micro-level predominantly in small-scale case studies and shows improvements in student's own capabilities of using ethics in their engineering work [32]. The gap in understanding about the relationships between ISL experiences and macro-ethics led to this study. Our findings suggest capstone and volunteer ISL experiences positively relate to student's macro-ethics understandings. Capstone projects are often not optional so are less likely to be affected by self-selection bias. Students' with ISL volunteer experience may have held these beliefs prior to the volunteer experience. The relationship between capstone and volunteer ISL experience needs further exploration in a more explanatory approach but suggests one approach to better prepare engineering students to understand the macro-ethics of their work is through these types of experiences.

Males with ISL experience reported significantly higher macro-ethics scores while females did not show a difference between scores of those with and without ISL experience. Specifically, males that participated in ISL projects through capstone or volunteer experience reported significantly higher scores in macro-ethics from male students without ISL experience. Integrating international service learning projects within capstone courses and encouraging volunteer opportunities in developing countries appears to positively relate to, and may help significantly improve macro-ethics understanding, specifically among male engineering students.

Future Work

While prior literature shows that service learning courses often integrate an average of eight ethical topics into the curriculum [23], variation between these programs may result in different learning outcomes for students. Future research should investigate how programs within ISL experiences effect engineering student's perception of engineering macro-ethics. This data would allow engineering education to make more well-informed decisions of how to integrate ISL projects into courses to achieve the maximum learning for students.

Additionally, further investigation is needed to understand the learning differences between male and female students related to macro-ethics. While males showed a significant increase of macro-

ethics scores when participating in ISL experiences, female engineering students appear to be unaffected by ISL. This could be due to female engineering students already having an understanding of macro-ethics. Understanding the difference between where males and females gain and understanding of engineering macro-ethics could further aid engineering education in giving students the skills to succeed in the global workplace.

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Journal Paper:

International Service Learning Projects Impact on Engineering Student Confidence and Career Choice: A National Study

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Student Engineering Confidence and Career Choice Based on their International Service Learning Experience: A National Study

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Abstract

Historically, engineering students tend to leave engineering after graduation if they do not feel they can change or impact the field through their work. Strengthening students' sense of engineering agency and identity during their undergraduate education is one method to increase retention of students' pursuing careers in engineering. Prior literature shows that students engineering agency and identity strengthens through co-curricular international service learning (e.g. Engineers Without Borders). Yet, the influence of international service learning (ISL) through other experiences like formal education (e.g. capstone) or work experience is not well understood. This quantitative study measured students' engineering agency and identity based on their ISL experience. Validated survey questions measuring engineering agency and identity were distributed to a national sample of engineering seniors (n=1911). Students were clustered by type of international service learning experience: formal coursework through capstone (210), work experience (n=287), or co-curricular (n=128). The integration of ISL into capstone and ISL through co-curricular experiences were highly correlated with higher engineering agency beliefs (p<0.01). The scores were consistent across genders. Additionally, students with ISL capstone or co-curricular experience showed a reduced likelihood of pursuing a career outside of engineering than those without ISL experience.

Introduction & Background

International service learning (ISL) projects have become increasingly popular in engineering education and co-curricular activities (Bringle et al. 2012; Duffy 2008). ISL projects offer students the opportunity to develop global skills (Downey et al. 2006) alongside engineering skills (Budny and Gradoville 2011). ISL projects can be grouped in three main categories: formal engineering

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courses, independent volunteer experiences, or co-curricular opportunities like Engineers Without Borders (EWB). Each category provides a different level of structure for student learning.

The levels of structure in ISL experiences result in different learning opportunities for participating students (Baugher et al. 2018). ISL courses in engineering education are the most framed around student learning and are therefore the most structured (Phillips et al. 2007). ISL volunteer opportunities are typically self-pursued, and host organizations usually use social impact and the long-term sustainability of programs to measure effectiveness (Ebrahim 2003; Edwards 1999). Research in ISL volunteer experiences focuses mostly on why participants choose to participate (Alexander 2012; Brown 2005; McGehee and Andereck 2009), instead of the learning gained. ISL co-curricular opportunities leverage student's engineering skills that they learn through education to pursue engineering projects ("Engineers Without Borders: Impact" n.d.).

Prior research describing ISL experiences indicates that improvements in student learning vary by type of experience. ISL course experiences, particularly those in capstone design courses, tend to increase engineering skills set by the Accreditation Board of Engineering and Technology (ABET) (Amelink and Creamer 2010; Budny and Gradoville 2011; Dinehart and Gross 2010; Green 2009; Onal et al. 2017; Ravel et al. 2015), which are often the guidelines for building engineering courses. ISL co-curricular experiences do improve technical and professional skills (Litchfield et al. 2016) and explain career choices (Litchfield and Javernick-Will, 2017). Additionally, ISL co-curricular experiences have been shown to increase some student's sense of engineering agency and identity (Litchfield 2014; Litchfield and Javernick-Will 2012, 2015) and typically attracts a higher percentage of female participation (Litchfield and Javernick-Will 2012). Prior research about ISL volunteer offers insight into why individuals participate in these experiences (Brown 2005), but there is little focus on learning outcomes.

In addition to student learning outcomes, ISL experiences emphasize global skills, cultural experiences, and service to others. At the national level, participation in study and volunteer abroad opportunities continues to increase, adding over 100,000 participants over ten years (Institute of International Education 2018). Of these participants, approximately 45-55% of them are college students (Institute of International Education 2018). As the importance of service and global

experiences increases for college age students, ISL experiences seem like an appropriate method to use to improve recruitment and retention of diverse students.

Both engineering education and practice acknowledge the value that diversity brings to engineering (Arastoopour et al. 2014; Du and Kolmos 2009). However, not only recruiting equal females to males but retaining both males and females engineering students within the field after graduation remains a challenge (Godwin et al. 2016; Litchfield and Javernick-Will, 2017). In fact, prior literature shows that males and females consistently leave engineering careers after graduation, and after 10-14 years post-graduation, males and females with engineering degrees remaining in engineering roles are 40% and 35% respectively (Corbett 2015). With fewer females entering engineering this means fewer are represented in the field post-graduation.

Students' propensity to leave the engineering field can stem from barriers in succeeding in the workplace (Ayre et al. 2013) or misalignment of values between the individual and the field (Eccles 2007; Faulkner 2009; Rulifson and Bielefeldt 2017). Females in particular are deterred from engineering due to the identity associated with the field of engineering (Cech et al. 2011) and the misalignment of their personal values and perceived work values (Faulkner 2007). For example, females tend to value creativity and social impacts over objects and things (McIlwee and Robinson 1992), which is not commonly aligned with the perception of engineering. This resonates with bachelor degree statistics, which show that only 20% of females achieve bachelor degrees in STEM per year since 2000 (Science and Engineering Indicators 2018).

Retention in engineering improves with increased engineering agency and identity beliefs (Amelink and Creamer 2010; Godwin et al. 2016; Zeldin et al. 2008). For example, Pierrakos et al. (2009) found that a reoccurring reason freshman engineering students changed majors was that engineering did not align with their expectations. In other words, students felt that they did not identify with the engineering discipline. One major takeaway from their work is that engineers must be exposed to the breadth of what the engineering field can offer or can be as early as possible in effort to retain them in engineering.

Many methods are used to increase recruitment and retention in engineering by exposing students to "real world problems", such as problem based learning (PBL), active learning (AL), and experiential learning (EL) (Arastoopour et al. 2014; Du 2006; Freeman et al. 2014). PBL is a model which places the student at the center of the process and allows them to constructively solve problems utilizing self-directed learning (Walker et al. 2015). On the other hand, AL and EL focuses on connections between personal development, work, and education as a means to improve learning for students (Kolb 2014). All three models allow students to gain confidence in their engineering skills and understand the wider context of engineering (Taborda et al. 2017), however none of these methods specifically integrate values or create alignment for students with the field of engineering.

A different way of exposing students to the diverse applications of engineering is through framing. Klotz et al (2014) describe the concept of "reframing" engineering to appeal to diverse groups. In their study, they reframe engineering through the lense of sustainability in order to show students a different perspective of engineering. They found that by expanding student's views of what an engineer could be, they could attract a wider range of students to engineering. While they had success in their study, they acknowledge that sustainability is not the only lense from which engineering can and should be framed. ISL may provide another lense from which to view engineering for students who may not align with the traditional view of engineering.

This study investigates the effects of ISL experiences on student's engineering agency and identity beliefs and tests whether ISL offers an approach for improvement in recruiting and retaining students in engineering. Engineering agency is defined as a deep understanding of engineering, confidence in engineering abilities, and the ability to use engineering for change (Basu et al. 2009). Engineering identity is defined through students perception of themselves as effective members of their field (Basu 2008; Godwin et al. 2016). Engineering agency and identity are measured separately, but are both are relevant when evaluating a student's likelihood to persist in engineering after graduation (Godwin et al. 2016). Students with a strong sense of engineering agency and identity are much more likely to persist in engineering careers (Ayre et al. 2013) especially among women in engineering (Ayre et al. 2013; Gill et al. 2008).

Two indicators of engineering agency are students' confidence in their engineering skills (Hutchison et al. 2006; Litzler et al. 2014) and self-assessed propensity to choose a career in engineering (Godwin et al. 2016). Increasing student confidence in engineering through their perceived skills allows them to feel that they can make an impact on the field (Bandura 1982, 1993, 1994; Besterfield-Sacre et al. 1997). Additionally, student intentions to pursue engineering as a career prior to entering the field shows student's perceived capabilities as an engineer (Lent et al. 2008; Mamaril et al. 2016; Zeldin et al. 2008). The most highly reported "important" engineering skill from engineers just entering the field is the ability to think creatively and problem solve (Martin et al. 2005; Passow 2012). Therefore, engineering skills in this study address creativity and problem solving.

Engineering identity is comprised of three main components: recognition, interest, and performance (Godwin et al. 2016). Recognition measures student's perceptions of how other view them in their field. Interest addresses student's excitement towards engineering. Finally, performance addresses how students perceive their own ability to succeed in engineering. These three constructs collectively make up engineering identity.

Through improving engineering agency and identity in students, ISL experiences may help to attract and retain a more gender diverse population in the field of engineering. ISL experiences provides social (Amerson 2010), global (Budny and Gradoville 2011), and service components while encouraging diversity (Litchfield and Javernick-Will 2012) in engineering. ISL is effective in teaching technical and professional skills (Litchfield et al. 2016) and strengthening students' perceptions of themselves as engineers in co-curricular experiences (Litchfield 2014; Litchfield and Javernick-Will 2012). While a few studies exist addressing the impact of ISL experiences on career goals, they are not comprehensive of the multiple types of ISL experiences (Litchfield Kaitlin and Javernick-Will Amy 2017) and the possible variability in influence of each.

We propose that different types of ISL experiences will impact students' engineering agency and identity. Those with more structured ISL experiences through course-work are more likely to intend to pursue careers in engineering after graduation through enhanced alignment of personal values and expectations of the engineering field.

Motivation and Research Questions

Recruitment and retention of diverse individuals in the engineering field is critical to integrating multiple perspectives into the design process and ultimately leading to more sustainable solutions (Amadei et al. 2009; Ayre et al. 2013). Strengthening engineering agency and identity, particularly in less represented groups in engineering such as women, will help universities develop confident, diverse engineers for the field. Investigation of ISL experiences as a mechanism to improve engineering agency and identity is important, as these projects emphasize a global focus with a social impact and allow students to see themselves in real world scenarios that they would experience as working engineers. To evaluate ISL experiences, we used a national sample of senior engineering students with capstone, volunteer/work, and co-curricular ISL experiences.

While prior literature shows that co-curricular ISL experiences positively impact engineering agency and identity in participating students (Litchfield 2014; Litchfield and Javernick-Will 2012, 2015), the sample populations consist of active members of EWB (those that attend regional and national conferences), and therefore may present a biased view of the impact of the ISL experience over the total population.

We aim to investigate how students with ISL experiences differ in engineering agency and identity beliefs from those without ISL experience in a more representative population of engineering students which includes all three categories of ISL experience. While we cannot eliminate the self-selection bias due to the nature of the projects, we aim to reduce it through a national, less specific population.

This study aims to investigate the differences in engineering student's engineering agency and identity beliefs through a national perspective. Determining if students with ISL experiences have higher engineering agency and identity beliefs in students will help inform engineering education of methods to recruit students to engineering as well as methods to retain students in the field of engineering. The national perspective provided through this study ensures that the findings are

applicable across institutions and are not program or institution-specific. We plan to investigate the differences engineering students through the following research questions:

RQ1. How do students with international service learning experiences through capstone projects, volunteer experience, or co-curricular projects differ from those without in engineering agency and identity beliefs?

RQ2. How do students' predicted career paths vary between those with international service learning experience and those without international service learning experience?

Where career paths in engineering are categorized by the specific characteristics of the job. For instance, if a student were to be pursuing sales of medical technology as a career, they would select "other" instead of "biomedical", as it is not an engineering role.

Methodology

Quantitative methods were used to measure senior engineering students' responses to engineering agency and identity beliefs. A validated survey instrument was distributed to the sample population, and responses were divided into three ISL experiences: capstone, co-curricular, and volunteer/work using descriptive statistics for analysis.

Survey Instrument Development and Validation

The instrument was intended to measure student's self-reported agency beliefs and identity scores. We used questions from the Sustainability and Gender in Engineering (SaGE) survey (Klotz et al. 2014) and the Creativity Agency and Confidence questionnaire (Royalty et al. 2014). 14 items from SaGE were used to measure engineering identity scores, and 12 items from the Creativity Agency and Confidence questionnaire were used to measure engineering agency beliefs.

All of the measurement items used to score student responses used a five-point anchored Likert scale with response options ranging from "strongly disagree" (0) to "strongly agree" (4). This scale aimed to limit respondent discomfort by offering a middle position and providing clear anchors to the upper and lower answer choices (Baugher et al. 2018).

Engineering Agency Scale

The questions used for engineering agency intended to measure student perceptions of their own technical skills through their ability to manage risk and ambiguity in design as well as their ability to think creatively to develop innovative solutions. The instrument was developed by Royale et. al to measure creative agency in students to apply the measure to design thinking (Royalty et al. 2014). The questions and motivations from the original instrument's study aligned with the aim of this study to measure engineering students' agency beliefs in their technical skills, which inherently requires creative thinking, persistence, and problem solving (Woods et al. 1997). In addition to research showing the importance of these skills, problem solving is perceived as one of the most necessary skills that engineers entering the workforce believe they should have to succeed in engineering (Martin et al. 2005; Passow 2012).

The scale used in this study is a measure of student's confidence in their engineering proficiency skills consisting of 12 items based on the five-point anchored Likert scale. The instrument asks respondents "How confident are you in your ability to do the following: ("not confident at all" =0, "very confident" =4) followed by the 11 items used to measure agency. The question includes items such as "effectively work on a problem that does not have an obvious solution", "Share your work with others before it is finished" and "Solve problems in ways that others would consider creative".

We conducted an exploratory factor analysis (EFA) to validate the 12-item engineering skills proficiency instrument. An EFA is used to determine if items in an instrument are measuring the same question (Gorsuch 1988). The EFA showed three factor groupings associated with the instrument and included 11 of the original 12 items. These three factor groups addressed aspects of problem solving and failure associated with design. We defined these groups as creativity, failure, and ambiguity in problem solving. The Tucker Lewis Index of factoring reliability was 0.967, indicating a high factor correlation. The questions that factored into creativity addressed the student's confidence in their ability to think creatively and design unique solutions. Questions that factored into the failure to problem solve address student's confidence in experiencing and persisting through failure. Questions that factored into the ambiguity in problem solving group

address student's confidence in shaping problem definitions and working on problems that are unclear. Table 5 shows the factor groupings and the associated survey items for each group.

Table 5: Engineering Agency Factor Groups

Factor Group	To what extent do you agree or disagree with the following? ("not at all"=0, "very much so"=4)	Loading	90% CI	Internal Reliability
Creativity	Shape or change your external environment to help you be more creative	0.436	0.04	0.72
	Help others be more creative	0.708		
	Identify and implement ways to enhance your own creativity	0.879		
	Explicitly define or describe your creative process	0.766		
	Solve problems in ways that others would consider creative	0.571		
Failure	Share your work with others before it is finished	0.618	0.0513	0.7
	Try an approach to a problem that may not be the final or best solution	0.729		
	Continue work on a problem after experiencing a significant failure	0.492		
Ambiguity	Find sources of creative inspiration not obviously related to a given problem	0.401	0.04	0.85
	Effectively work on a problem that does not have an obvious solution	0.759		
	Change the definition of a problem you are working on	0.526		

The factor groups were validated using goodness of fit (Tucker Lewis Index), internal reliability (Cronbach's alpha) and the 90% confidence interval. The TLI was 0.965 which indicates a very good fit (Cangur and Ercan 2015; Tucker and Lewis 1973). Cronbach's alpha was acceptable for creativity (0.72), failure (0.7), and ambiguity (0.85) which all indicate a reliable fit (Cortina 1993; DeVon et al. 2007). The 90% confidence intervals were all acceptable values with the highest being 0.0513 (failure). Each of these measurements shows that the factor groups were valid and reliable given our dataset.

In addition to measurement validation, these factors relate to previous literature. For instance, problem solving is described by young engineers as a key skill that they need to succeed in engineering (Martin et al. 2005; Passow 2012). Creativity is studied extensively in design, and is

necessary to create unique and sustainable solutions to difficult problems (Kaufman et al. 2008; Toh 2014). Ambiguity is an inherent component of problem solving with real-world application (Woods et al. 1997). Finally, failure has been discussed in engineering education as a necessary experience to prepare students to create sustainable and successful final designs (Petroski 2018). Creativity, ambiguity and failure were all constructs referenced in the development of this instrument and are therefore aligned with theory as well as measurements.

Engineering Identity Scale

The questions intended to measure engineering identity were adapted from a validated survey question used in Godwin's identity framework (Godwin et al. 2016). Godwin's instrument consisted of 11 measures for recognition (3), interest (3), and performance (5). The instrument used in this survey expands the original 11 survey items to 14. Table 5 shows the survey items. The items added from the original instrument are italicized. Two items were added to address recognition of self, including "I see myself as an engineer" and "I have had experiences in which I was recognized as an engineer". These items were intended to address student's self-efficacy, which is important to student's perception of themselves as engineers (Lent et al. 2008) and interest in engineering (Mamaril et al. 2016). The third item added was "I can overcome setbacks in my engineering courses", which was intended to address student perceptions of their performance through adversity, which is critical in the engineering field (Petroski 2018).

We conducted an exploratory factor analysis to validate the 14-item instrument. The instrument was originally developed to measure freshmen students (engineering and non-engineering). However, we used the instrument to measure senior engineering students. The EFA helped validate the independent constructs within the new sample population (Gorsuch 1988). Additionally, the increase from 11 to 14 items created the need for an EFA opposed to a confirmatory factor analysis (CFA) (Ferguson 1993). As in comparable research studies, (Godwin 2014), we used a cutoff value of 0.4. Factors that cross-loaded into more than one factor group were removed for accurate measurement of the variables (Ferguson 1993).

No cross loadings were present in the EFA, and thus all 14 items were kept for data analysis. The resulting factor groups were similar to Godwin's factors for recognition, interest, and performance.

Recognition addresses students' perceptions of how others view them as engineering and how they view themselves as an engineer, interest addresses students' personal interest in engineering, and performance addresses students' beliefs in their capabilities as an engineer. Table 6 shows the factor groups, correlated questions, and their associated confidence intervals.

Table 6: Engineering Identity Factor Loadings

Factor Group	To what extent do you agree or disagree with the following? ("strongly disagree"=0, "strongly agree"=4)	Loading	90 % CI
Recognition	*I see myself as an engineer*	0.547	0.049
	My professors see me as an engineer	0.728	
	My peers see me as an engineer	0.880	
	My parents see me as an engineer	0.589	
	I have had experiences in which I was recognized as an engineer	0.451	
Interest	I am interested in learning more about engineering	0.794	0.059
	I find fulfillment in doing engineering	0.891	
	I enjoy learning engineering	0.759	
Performance	I understand concepts I have studied in engineering	0.631	0.04
	I can do well on engineering exams	0.832	
	I am confident that I can understand engineering in class	0.837	
	I am confident that I can understand engineering outside of class	0.606	
	Others ask me for help in this subject	0.592	
	I can overcome setbacks in my engineering courses	0.470	

Career Choice Measurement

The career choice question asks students what they believe their career path to be after graduation. This question interprets answers as either an "engineering" choice from selections such as mechanical engineering and civil engineering or "non-engineering" career choice from selections such as business, medical or other.

Data Collection

Data was collected through a national survey. Surveys were randomly distributed to 4-year institutions across the United States, listed in the National Center for Education Statistics. The schools were stratified to obtain similar responses from small, medium, and large universities.

Responses (n=2095) were gathered via scantron and were subsequently processed in the R coding language (Godwin 2014). Zip code data from survey responses allowed us to show the distribution of responses across the United States, depicted in Figure 3. The dots in the figure represent a response from at least one student with this home zip code.
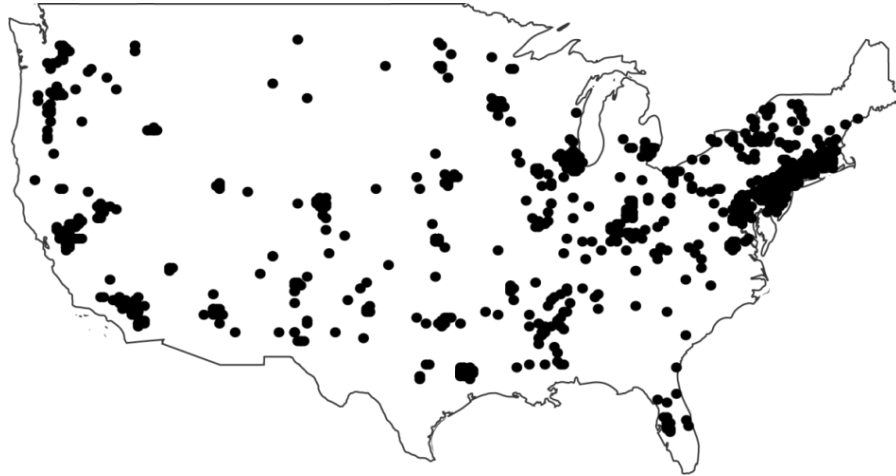

Figure 3: Student respondents by home zip code

Responses consisted of 20% female and 66% male responses. The remaining responses included either "other" or "NA", and these were removed from the dataset due to the small populations and high number of different identifications within the "other" group. This yielded approximately 25% of responses being from females and the remaining 75% from males. Complete responses were grouped by ISL experience questions, meaning that the sample populations were reduced to only include responses that fully answered the questions that were needed to categorize them into: capstone (n=1700), work (n=1722), and co-curricular (n=1762).

Three survey questions asked about the student's specific ISL experience in order to categorize their responses. ISL capstone experience was identified from the question: "Did your most recent in-major engineering design course include an international service component?", which had a yes or no response option. ISL volunteer experience used the question "Worked or volunteered in a developing country". ISL co-curricular experience was identified based on the questions "Traveled with an international service group (Engineers Without Borders, Students Helping Honduras, Bridges to Prosperity, etc.)". Both the volunteer and co-curricular questions allowed answer

selections of "never", "limited", "half a semester", "one full semester", and "more than one full semester". The distribution of male and females in this sample population is representative of national trends in gender distributions within engineering (Corbett 2015).

In addition to using descriptive statistics to categorize ISL experience, we also investigated the size of institutions (small, medium, large) and engineering discipline of respondents. The distribution of responses between institution size was small (n=257, 12%), medium (n=830, 32%) and large (n=1008, 48%). Within engineering disciplines, a majority of participants responded that they were studying mechanical/manufacturing (n=419), chemical (n=403), or civil engineering (n=245) with the remaining respondents split between the remaining 15 engineering discipline options.

We then compared the institution size and engineering discipline within the ISL experience categories. The engineering disciplines reported in each of the ISL experience categories showed a majority participation in the same three majors as the overall majority of majors: mechanical/manufacturing, chemical, and civil engineering. While the institution size distribution of the response groups was consistent for the majority of ISL categories, the ISL capstone responses had a higher percentage of participation from small schools (22%).

Data Analysis

Engineering agency (11-item instrument) and identity scores (14 item instrument) were calculated by averaging the responses from in each associated factor group. The scores for the creativity agency instrument and the engineering identity instrument ranged from 0-4. Incomplete responses for both the agency and identity questions were removed to ensure validity as the majority of the factor groups were small. Additionally, students who did not answer the career choice question were discarded because career choice is necessary for answering our research questions.

The response data for the engineering agency instrument showed a normal distribution (absolute skewness less than 2 and kurtosis less than 7), and since the same population was large (n=1700), a two way ANOVA was used to characterize differences between groups (West et al. 1995). An

ANOVA is used when the data assumes a normal distribution and a two-way ANOVA is used when two factors are assumed to influence the data responses.

We included gender as a factor that influences engineering agency in addition to ISL experiences because prior literature outlines this relationship (Amelink and Creamer 2010; Felder et al. 1995; Ohland et al. 2011). After the two-way ANOVA was run, effect size was calculated. An effect size is the magnitude of the differences between two groups, and shows the importance of the mean differences in the groups (Sullivan and Feinn 2012). The effect size was used to determine if engineering agency score differences were meaningful.
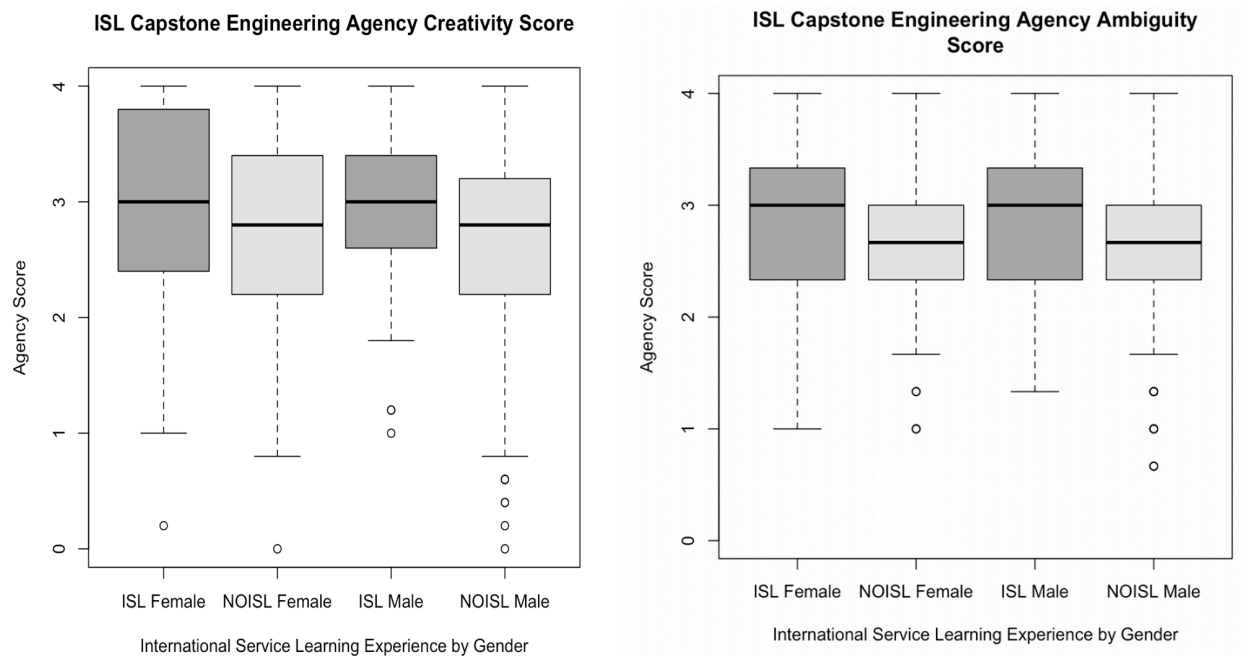
The data from the engineering identity survey instrument showed right skewed distribution. This skewness made the use of ANOVA inappropriate. Instead, the Kruskal-Wallis test was used to analyze the response data. Kruskal-Wallis is a non-parametric test similar to an ANOVA and is used when data does not adhere to normality, or when using data types besides continuous data (Kitchen 2009). As with identity, we included gender as a factor for engineering identity.

Results

Related to engineering agency, the results demonstrate that ISL capstone and co-curricular experiences score significantly higher for creativity and ambiguity. Students perceived engineering identity was high with or without ISL experiences. Finally, students with ISL capstone and co-curricular experiences were less likely to anticipate leaving engineering, while students with ISL work or volunteer experience were more likely to indicate leaving engineering. These results are further discussed in the subsections about agency, identity, and career choice.

Engineering Agency Scores

The relationship between ISL capstone and student scores for creativity ($p<0.001$) and ambiguity in problem solving ($p<0.05$) were significant. While slight variations exist between male and female scores, there was no statistical significance between gender. The effect size was medium for creativity ($d=0.3$) and small for ambiguity in problem solving ($d=0.15$). Figure 4 shows student scores for creativity and ambiguity.
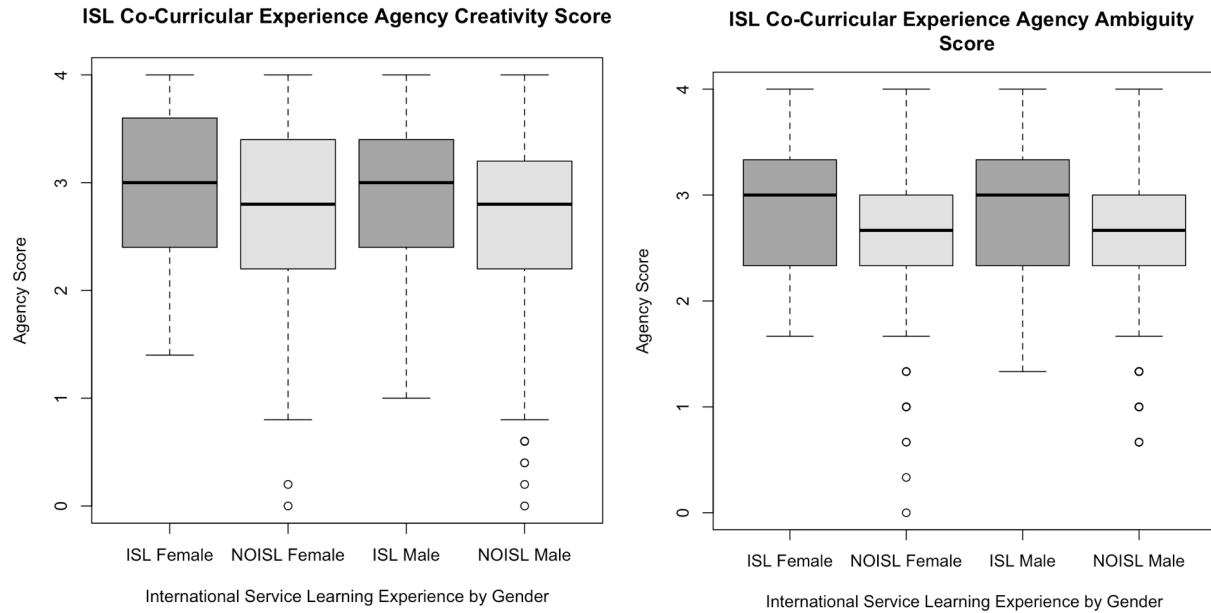
ISL Capstone Engineering Agency Creativity Score

Creativity	Shape or change your external environment to help you be more creative
	Help others be more creative
	Identify and implement ways to enhance your own creativity
	Explicitly define or describe your creative process
	Solve problems in ways that others would consider creative

Ambiguity in Problem Solving	Find sources of creative inspiration not obviously related to a given problem
	Effectively work on a problem that does not have an obvious solution
	Change the definition of a problem you are working on

Figure 4: Creativity and Ambiguity Scores for ISL Capstone Experience Boxplot Results

Relationships between ISL co-curricular experience and student scores for creativity ($p<0.01$) and ambiguity in problem solving ($p< 0.05$) were also significant. The influence of gender was negligible. The effect size was small for creativity ($d=0.2$) and ambiguity in problem solving ($d=0.14$). Figure 5 illustrates student scores for creativity and ambiguity.

ISL Co-Curricular Experience Agency Creativity Score

ISL Co-Curricular Experience Agency Ambiguity Score

Creativity	Shape or change your external environment to help you be more creative
	Help others be more creative
	Identify and implement ways to enhance your own creativity
	Explicitly define or describe your creative process
	Solve problems in ways that others would consider creative

Ambiguity in Problem Solving	Find sources of creative inspiration not obviously related to a given problem
	Effectively work on a problem that does not have an obvious solution
	Change the definition of a problem you are working on

Figure 5: Creativity and Problem-Solving Agency Scores for ISL Co-Curricular Experience Boxplot Results

Engineering Identity Scores

Students' with and without ISL experiences did not show a significant difference in engineering identity. The mean engineering identity scores were high (3.67/4). Gender was also not a factor. Males and female students scored equally high. This is in contrast to prior studies with freshmen. Prior work investigates engineering student's perception of their engineering identity during their freshman year (Godwin et al. 2016) and shows that engineering identity increases over student's engineering studies (Godwin and Lee 2017). The high engineering identity scores is consistent in this study. While prior work has shown a disparity in engineering identity by gender (Du 2006; Godwin 2014; Pierrakos et al. 2009), the responses in this dataset show that these disparities are not relevant by student's final year in engineering.

Engineering Career Choice

The percent of students who said they would not choose a career in engineering was 9% of the total sample population (n= 1784, x = 152). Table 6 shows the percent of engineering students who plan to leave engineering by ISL experiences and those with no ISL experience. Those with ISL capstone or co-curricular experiences tended to anticipate remaining in engineering at a higher percentage than those without. However, students with work or volunteer experience intended to leave engineering at a higher percentage than those without.

Table 6: Students Who Plan to Leave Engineering by ISL Type

Sample	Persist			Switch			Percentage
	1632			152			9%
ISL Type	ISL Experience			NO ISL Experience			
	Persist	Switch	%	Persist	Switch	%	
Capstone	177	12	6%	1383	131	9%	
Work	214	31	13%	1361	116	8%	
Co-curricular	103	5	5%	1509	145	9%	

Of those switching out of engineering (n=152), 17% selected a business career (n=26), 15% selected a medical career (n=23), and 68% reported neither business or medical (n=103). Experience in both ISL capstone and ISL co-curricular experiences showed a decrease in propensity for students to select a career trajectory outside of engineering (6% and 5%, respectively).

Discussion

The results of this study yield two major takeaways. First, addressing RQ1 (*How does international service learning experiences through capstone projects, volunteer experience, or co-curricular projects affect students' engineering agency and identity?*), the results of this nationally representative study show that students with ISL capstone and co-curricular experiences report higher engineering agency scores than students without these experiences. Addressing RQ2 (*How do students' predicted career paths vary between those with international service learning*

experience those without international service learning experience?), the results show that students with ISL capstone and co-curricular experience are less likely to switch out of engineering than those without. Additionally, students with ISL volunteer experiences have a higher likelihood of switching out of engineering than those without.

Capstone and Co-Curricular scores for creativity and ambiguity

Student with ISL capstone and co-curricular scores were on average higher by 0.33 points for both attributes of creativity and ambiguity in problem-solving related to agency compared to those without ISL experience. This difference is statistically significant and medium in effect size. Students' higher personal perception of their creative abilities attests to their confidence in creating unique design solutions. Creativity is imperative to developing new solutions (Hsiao and Chou 2004; Toh 2014; Toh et al. 2014) and directly ties into technical skills. Ability to analyze and solve problems is a fundamental concept in ABET requirement of undergraduate engineering (*Criteria for Accrediting Engineering Programs* 2017). The integration of ISL projects is of medium effect, which means that approximately 5% of students who participate in ISL capstone projects will outscore those without ISL capstone experiences. The higher scores for students within ISL capstone projects show that students feel more confident in their creative and problem-solving abilities even with a small overall score value difference.

Both ISL capstone and co-curricular experiences seem to positively relate to student perceived creativity and problem-solving ability. These two factor groupings of engineering agency give students the confidence to apply their engineering skills to difficult problems. The field of engineering is increasingly globalized (Alashiri 2016), and engineering students who are able to find creative solutions to ambiguous problems and redefine problems effectively will be better suited to excel in complex and ever globalizing working environments (Downey et al. 2006). While creativity and problem-solving skills allow students to better address these issues, student's perception alone of their ability to creatively solve ambiguous problems contributes to their sense of engineering agency and allow them to be confident in their own role as an engineer.

Additionally, considering the effect size of the results for ISL capstone and co-curricular experiences gives insight into the broader impacts of the study. ISL capstone experience scores

had a medium effect size of 0.3 for the creativity attribute of agency and a small effect size for the ambiguous problem-solving attribute of agency. Translating these values to a percentage of the population affected by this result, effect size for the creativity attribute of agency for ISL capstone experiences (0.3) has a 58% probability of superiority (Fritz et al. 20110808), which means that the likelihood of a respondent from the ISL capstone category to outscore a respondent from the non-ISL capstone category is likely to occur 58% of the time. Similarly, 56% of students would outscore those without ISL capstone experience in the ambiguous problem-solving attribute of agency. ISL co-curricular experiences had an effect size of 0.2 and 0.14 for creativity attribute of agency and the ambiguous problem-solving attribute of agency, respectively. This translates to a 56% and 53% probability of superiority for each factor.

For both ISL capstone and co-curricular, students reported low confidence in failure scores. The scores were consistent across ISL experience. This is indicative of a larger trend in engineering education that emphasizes on success over failure both through the use of grades and through the steps taught in the design process (Pahl and Beitz 2013). Within engineering education, success is often viewed as the norm or goal while failure is not addressed, often due to the already dense technical course load (Rendon-Herrero 1993; Rendon-Herrero Oswald 1993; Sasley 2010). This aspect of engineering agency should be explored further to understand students' experience with failure in ISL experiences.

Additionally, ISL work or volunteer experiences showed no difference on student's agency scores. This could be attributed to the variation in the type of work performed. For instance, if the work or volunteer experience was not within the engineering field, it may not impact students' engineering agency. Additional research is needed to better understand ISL work experiences for engineering students.

Engineering Career Choice Between ISL Types
While students without ISL experience maintain a 9% rate for students leaving engineering post-graduation, those with ISL experience show a lower rate of leaving for those with capstone and co-curricular experiences. The ambiguity in the type of ISL work experience students are reporting likely contributes to the increased departure (13%) from the field of engineering compared to the

rate of departure for capstone and co-curricular ISL experiences. Opportunities for work and volunteer experiences are extensive in fields outside of engineering, with the most frequent service types being tutoring, mentoring, engaging in general labor, and providing counseling, medical care or protective services (Lough 2015). From 2004 to 2014, participation in these opportunities is approximately 55% by students, which totals to between 40-50 thousand participants on average per year (Lough 2015). With these trends in student work and volunteer experiences, it is highly likely that engineering students are participating in ISL work and volunteer experiences outside of engineering.

The high likelihood of students to be participating in work or volunteer experiences outside of engineering aligns with the increased likelihood to leave the field of engineering. For instance, if students are not working in engineering roles during their ISL work experience, they may identify with a different professional role outside of the engineering field. Students that reported intentions to switch out of engineering within the ISL work experience group most frequently reported "other" as their intended career path (55%), with equal distribution of the remaining responses in business and medical, which gives little insight into where students plan to work after graduation. Additional questions in the survey show that there is no concentration of students leaving engineering from any specific discipline.

Conclusion

ISL experiences give students opportunities to explore real-world experiences to develop engineering skills. Prior literature in ISL capstone experiences present benefits for student's engineering agency and identity predominantly through case studies. Similarly, literature in ISL co-curricular experiences describe benefits to student's engineering agency and identity yet the sample of students is often skewed to those represented at conferences. The results of this study present a national perspective about differences between students engineering agency and identity with and without ISL experiences.

ISL experiences in capstone and co-curricular may provide more opportunities for students to strengthen their engineering agency and help to retain more engineering students in the workforce post-graduation. Students with either ISL capstone and co-curricular experiences reported higher

confidence in their engineering skills including creativity in design and ability to manage ambiguity in problem solving. With a small to medium effect size, which means approximately 53-58% of students with ISL capstone or co-curricular experiences will outscore students without these ISL experiences. The increased perception of student's engineering skills will positively contribute to their likelihood to remain in engineering.

Students with ISL capstone or co-curricular experiences also tend to have a lower propensity to leave engineering. While ISL experiences are not the sole way to increase retention in engineering, the integration of ISL experiences in formal engineering may be an effective method to aid other strategies in retention efforts. The increased sense of engineering agency among students with ISL experience may contribute to this retention rate and will help create a more prepared engineering workforce.

Future Work

ISL capstone and co-curricular experiences have inherent differences that should be further explored to understand their impact on student agency and identity. While both showed higher engineering agency scores, little can be said about how the frameworks of each ISL experience helped or hindered this improvement. In other words, ISL programs vary drastically by university and department, and this national survey does not capture these programmatic differences. By comparing ISL capstone and co-curricular experiences impact on engineering agency and identity more formally, the differences between the frameworks can be better understood and used to make changed in engineering education Additionally, future research should investigate student's agency beliefs and identity scores prior to and after ISL experiences in order to determine the impact of the experience itself. In this study, students were only surveyed at the end of their college careers and therefore failed to capture any perspectives before ISL experiences during college.

The national sample and results presented in this paper only allows us to draw conclusions on whether or not engineering students are intending to remain in engineering post-graduation. However, work and volunteer experiences should be more descriptively measured to explain student experiences in an attempt to understand why a higher percentage of students who have ISL work experience intend to leave engineering. This data would allow us to draw clearer conclusions

about the effect of engineering work in a culturally diverse context and better address student concerns who are leaving engineering.

Each of these components will lead to a better understanding of how ISL projects impact student engineering agency and identity along with their intent to pursue engineering careers. Understanding how these projects impact students is a foundation for further research into how to better design ISL projects and programs to enhance these benefits. In order to retain diverse engineers in engineering careers, engineering education must continue to investigate methods such as ISL to create an engineering curriculum which diverse students feel a part of.

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CONCLUSION

ISL provides students with unique engineering experiences during their undergraduate education. The work in this manuscript suggests that ISL projects create benefit for engineering student learning outcomes. These findings lead us to further investigation of ISL projects. Chapter 1 shows that both ISL capstone and work experiences yield higher scores for male student's understanding of engineering ethics, and both of these experiences provide tangible experiences for students to gain this understanding of engineering ethics. This chapter suggests that using ISL projects within engineering education can help overcome some of the barriers that exist to teaching ethics, in particular overcoming the technically dense course load to provide space for ethics. Chapter 1 gives recommendations for further investigation of ISL experiences including gaining a better understanding of gender differences in engineering ethics education. Additionally, the main recommendation for this chapter is to encourage integration of ISL projects within formal engineering education as a method to better teach engineering ethics.

Chapter 2 shows that ISL experiences, specifically capstone and co-curricular, have higher scores for student's engineering agency and show lower anticipation for engineering students to leave engineering post-graduation. ISL work experiences, however, showed no difference in engineering agency and students tend to predict to switch out of engineering at a higher percentage. The integration of ISL experiences in capstone courses is suggested to improve student's engineering agency and retain more engineers within the field.

The opportunities for future research in ISL are expansive. First, future research should aim to improve the depth of understanding generated in this manuscript. Future research could focus on ISL work experience to better understand the characteristics of the work students are involved in. By better understanding the field of work that students participate in, we could better understand why they tend to leave the field of engineering at a higher than average rate. ISL capstone experiences showed consistent improvements to student learning outcomes across both studies, however variation in the implementation of the projects could be better understood to provide more insights on how to better use ISL experiences in engineering education. To do this, a deeper understanding of the programs and courses containing ISL experiences must be understood.