Identifying Factors That Enhance Undergraduate Engineering Students' Global Preparedness

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Abstract

The increasingly global scope of engineering requires both academic and industry stakeholders to seek engineering graduates who work effectively with peers from diverse national and cultural backgrounds. As a consequence, U.S. engineering programs are challenged to include international perspectives and experiences through a variety of approaches including curricular and co-curricular activities. Yet, research has not provided sufficient evidence about the types and programmatic components of such learning experiences that best promote the preparation of engineering students for the global workforce. This paper offers findings from the second phase of a multi-university research project, aimed at delineating how particular experiences and their components are associated with engineering students' global preparedness. Using two established assessment instruments, the Global Perspective Inventory (GPI) and the Engineering Global Preparedness Index (EGPI) for measuring outcomes related to global learning, the study investigated a sample of 185 undergraduate engineering students from three universities. Results from relational and predictive statistical analyses indicate that participation in such experiences as study abroad, engineering/non-engineering-focused service learning; engineering/non-engineering courses with a global focus, and personal tourism are associated with increased global preparedness. Further, students' performance on the instruments was found to be correlated with particular programmatic elements of the experiences such as duration of study abroad, the number of non-engineering courses students took with global foci, number of times traveled abroad, and the amount of student reflection that occurred during or after travelling abroad. The study broadens the knowledge base about contextual factors associated with engineering global preparedness.

Introduction

The engineering workplace is becoming increasingly multinational because of technological advances and global economic integration. Companies now seek graduates who are able to work in multinational teams that may cross temporal, geographical, and disciplinary boundaries.[1] To prepare engineering students to be effective in a multinational or global professional environment, engineering education needs to incorporate and develop global preparedness in future engineering workforces. In addition to teaching technical skills, engineering programs must prepare students for multinational and multicultural teamwork and communication, in addition to the ability to "understand economic, social, environmental, and international context of their professional activities."[2]

The necessity for engineering global preparedness has been recognized and spotlighted by both professional and educational engineering communities in conferences, national reports, and publications.[2] The National Academy of Engineering (NAE), the National Science Foundation (NSF), and the National Research Council (NRC) have charged engineering schools to prepare engineers for global workforces.[3-5] The American Society for Engineering Education's (ASEE) Green Report (2010) also calls for engineering colleges to adapt curricula and programs to incorporate "an appreciation of different cultures and business practices, and the understanding that the practice of engineering is now global."[6] Additionally, ABET requires engineering programs to demonstrate that their graduates have "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context."[7] Hence the accreditation requirement promotes engineering programs to provide avenues to meet this desired learning outcome.

General trends in engineering education reflect these changes. Engineering colleges recognize the need to equip graduates with the right skills to stay globally competitive, and many schools have begun making efforts to incorporate international learning experiences (both curricular and co-curricular) into their program structure. Research has indicated that international learning experiences are not necessarily predictive of students' engineering global preparedness[8]. Further, although curricular restrictions associated with majoring in engineering have been cited by students as a significant factor in deciding not to study abroad,[9-10] engineering student participation in study abroad programs has steadily increased in recent years, probably as a result of curricular changes and growth in the number of international programs specific for STEM students. In 2003-2004, for example, only 2.9 percent of all U.S. study abroad students majored in engineering.[11] In 2009-2010 that number raised to 3.9 percent.[12] In the 2012-2013 academic year, U.S. students majoring in the STEM (Science Technology Engineering and Math) fields for the first time outnumbered study abroad students in the Social Sciences, making up 22.5% of all U.S. study abroad students. Engineering students, specifically, increased their share to 4.1 percent of all US students studying abroad.[13]

Although there are trends that engineering education seeks to foster students' global preparedness through infusing international perspectives and experiences into curricula, research has not yet provided empirical evidence about specific types and programmatic components of learning experiences that best promote preparation of engineering students for the global workforce.

The present paper is part of a larger research effort to address these issues. It offers findings from a multi-university project funded by the National Science Foundation that inquires into how international and globally focused learning experiences (both curricular and co-curricular) contribute to engineering students' global preparedness. Specifically, this paper draws on a non-experimental exploratory study conducted among three collaborating schools in Spring 2014 and aimed at delineating particular types of learning experiences and their characteristics associated with engineering global preparedness. This research considers any travel abroad experience an international experience. Globally focused learning experiences may be in country or abroad, however they should consider culture, context and content as important global components.

For this research we draw upon a definition of engineering global preparedness that has emerged from our research in which students' engineering global preparedness requires them to become aware of, and able to contribute to a global engineering workforce and marketplace.[14-17.] We define global preparedness as the readiness to engage and effectively operate under uncertainty in different cultural contexts to address engineering problems, which are globally focused and require disciplinary skills and strategies. Engineering global preparedness brings together the set of congruent behaviors, attitudes, characteristics, skills and strategies and policies in a system, agency, or among professionals, enabling that system, agency, or those professionals to work effectively in cross-cultural situations in engineering contexts solving engineering problems across national, linguistic, and cultural boundaries.

The research presented in this paper is guided by two research questions:

1. What globally focused and international learning experiences are associated with engineering students' global preparedness?
2. What are specific programmatic components of learning experiences that are associated with engineering student global preparedness?

The study used two established assessment instruments used in contemporary international and engineering education research, the Global Perspective Inventory (GPI)[18] and the Engineering Global Preparedness Index (EGPI),[8] for measuring outcomes associated with global preparedness. We administered these instruments with freshmen and senior engineering students from three universities, who had previously engaged in an international school-based or non-school- based experience. In addition, each site recruited a comparison set of engineering students who had not had such experience as a comparison group.

Review of the literature

Engineering educators have acknowledged the vital role of global preparedness in training 21st century engineers, who are able to work and compete in a new global milieu.[8,19-21] Many contemporary discussions focus on engaging engineering students in various kinds of globally focused learning activities as a strategy to educate new generation of global engineers.[19] The literature review that follows provides a brief overview of pedagogical practices designed to foster global preparedness, their programmatic features, and impact on students.

Pedagogical and learning experiences that promote global preparedness: Universities use a variety of pedagogical approaches to incorporate global perspectives and international experiences into engineering curricula. Fundamental differences exist in the associated experiences accompanying these approaches and classifying these experiences assists in the assessment of learning outcomes associated with each. Although scholars agree that at least three components are essential to producing globally prepared engineers: coursework in international or global studies, second language proficiency, and international experience, [21-22] the literature is primarily concerned with international engineering programs. Multiple studies have proposed taxonomies of international engineering programs and their varying approaches to providing students with international or global experiences. Lohmann et al., for example, identified four categories of international programs designed to help engineering students take steps to achieve global preparedness: co-majors or dual majors, minors or certificates, international internships or projects, and study abroad.[20] Along similar lines, Grandin and Hirleman distinguished collaborative research projects and global teaming with partners abroad, service learning projects abroad, and graduate level international programs.[21]

Downey et al. are among few scholars who underscore the role of integrated class experiences as "an at-home effort to initiate students on the path to global competency in ways that fit their standard curricula."[23] According to the authors, integrated class experience often involves such activities as introductory education in the language, customs, history, and government in the country under study and sometimes provides a substitute for international travel through electronic interactions.

In addition to program types outlined above, scholars outline various program components. Grandin and Maher define seven parameters by which programmatic components may vary.[20] These parameters are as follows: Short-term vs. long-term; English-language vs. Non-English language; degree of cultural exposure/immersion; degree of curricular integration; degree of cultural/linguistic preparation for experiences abroad; degree of engineering-specificity; and degree of institutional/administrative commitment.

In the field of international education, Engle and Engle also proposed several defining components of international programs: Program length; entry target-language competence; language used in course work; context of academic work; types of student housing; provisions for guided/structured cultural interaction and experiential learning; and guided reflection on cultural experience.[24] Though these lists are quite similar, key differences exist. Unique to the list proposed by Engle and Engle is the role of guided reflection in international programs. Likewise, Grandin and Maher considered the degree, to which international experiences are integrated into curriculum, the degree of engineering-specificity of international programs, as well as commitment by the institution and/or administration to international experiences, none of which were included in Engle and Engle's defining program components. The program types and varying components outlined above were used to inform the development of the background instrument given to this study participants.

Assessment results from international experiences: In an effort to understand the impact of international experiences on students, several previous studies have attempted to examine learning outcomes involving cross-cultural competency, global-mindedness, and intercultural competency. In the field of study abroad and international education research, there have been several studies that have documented the significant relationship between programmatic features and learning outcomes. For instance, using a standardized assessment tool called Hammer's Intercultural Development Inventory (IDI), Medina-López-Portillo compared students who engaged in summer programs abroad.[25] It was found that students in the 16-week program were more likely to progress to the next intercultural development stage than students in the 7-week program. Similarly, Kehl and Morris revealed the impact of study abroad duration on student learning outcomes related to global-mindedness.[26] The authors observed statistically significant differences in global-mindedness of students at selected private universities who studied abroad for eight weeks and those who were enrolled in a semester-long program.

Although previous studies have attempted to examine the relationship between program features and learning outcomes, few of them have looked exclusively at engineering programs. Ragusa's work explored relationships between both background characteristics and types and lengths of programs and their relationship to global preparedness using the Engineering Global preparedness Index (EGPI). Her research indicates that international status and program length increase students' global preparedness. Additionally, her research suggests that students' global preparedness improves as students frame their engineering educational experiences after returning from experiences abroad. It indicates that perhaps, students' reflection post experience continues to be informed by their international experiences as they navigate engineering education and preparedness for engineering workforces. Accordingly, the current paper builds upon this work and utilizes the EGPI as a primary measure of engineering global preparedness.[8,14]

Vande Berg, Connor-Linton, and Paige conducted a study using Engle and Engle's model, and found several significant relationships between program components and student learning outcomes.[27] Greater intercultural competency gains were observed for students participating in longer programs, as well as enrolling in courses in the target language, completing courses with other U.S. students or a mix of U.S. and host students, and living with other students from the U.S. or host country students. Students who spent between one-fourth and one-half their time with host nationals made the most gains in intercultural competency.

Despite the diversity in pedagogical strategies across and within universities, limited research exists on the impact of these approaches on engineering students' global preparedness for multinational workforces.[15] This study aims to enhance research in this area with the purpose of informing a more comprehensive and integrated approach toward developing global preparedness in engineering students across engineering colleges to meet the changing needs of society worldwide.

Methodology

The study utilized a non-experimental, exploratory research design, which intends to examine trends in the sample of undergraduate engineering students regarding their participation in various global and international experiences both within and beyond of academic walls. The study also sought to investigate how student engagement in various learning experiences is associated with their learning outcomes related to global preparedness. This design is typically used when little is known about a topic of interest, as in the case with this study.

Study Participants: The study participants consisted of undergraduate students enrolled in diverse engineering majors at three universities, which span the nation (geographically). For the purpose of this pilot study, we assumed that the differences across the three institutions were negligible. Overall, 185 undergraduate engineering students participated in this study. Twenty six percent of the respondents identified themselves as freshmen and 74% identified themselves as seniors. Males constituted 57% of the sample and females made up 43%, respectively. The racial-ethnic distribution of the sample included: 67% Caucasian students, 18% Asian, 6% Hispanic, 4% African American, and 3.5% Indigenous or Pacific Islander. Ninety-three percent of the participating students were born and raised in the U.S.

Data collection and procedures: Data were collected using a multidimensional, multi-scale questionnaire including two established instruments, the GPI[19] and the EGPI,[8] and comprehensive background and experiential items. Participating students were recruited and surveyed in Spring 2014 through various freshmen and senior seminars, senior capstone courses, and other engineering courses common to most engineering undergraduate programs. An electronic questionnaire was administered using a publicly available survey platform, *Qualtrics®*.

Outcomes Measurement and Associated Instrumentation: The outcome measure (engineering global preparedness) was obtained via use of two instruments, the Engineering Global Preparedness Index[8] and the Global Perspectives Inventory[19]. The dependent variables were measured in two ways: (a) the students' subscale and overall scale scores on the GPI, and (b) the students' subscale and overall scale scores on the EGPI. Brief descriptions of the instruments are presented below.

The Engineering Global Preparedness Index. Designed and extensively tested by one of the study's Investigators, the EGPI instrument is aligned to both ABET's outcomes (Criterion 3) and the NAE's *Engineer of 2020*.[8] The EGPI directly measures how prepared students are to enter globally focused engineering workforces. The EGPI uses a 6-point Likert-type scale and has four subscales, each of which have been extensively validated and tested for reliability using item response theory. The four subscales for the EGPI are described below.

<u>Global Engineering Ethics and Humanitarian Values</u> refers to the depth of concern for people in all parts of the world, with a view of moral responsibility to improve life conditions through engineering problem solving and to take such actions in diverse engineering settings ($\alpha = .90$).
<u>Global Engineering Efficacy</u> refers to the belief that one can make a difference through engineering problem solving and is in support of one's perceived ability to engage in personal involvement in local, national, international engineering issues and activities towards achieving greater global good using engineering problem solving and technologies ($\alpha = .85$).
<u>Engineering Globalcentrism</u> refers to a person's value of what is good for the global community in engineering-related efforts, compared to what benefits just one's own country or group. It is associated with an individual's ability to make sound judgments based on global needs in which engineering and associated technologies can have impact on global improvement ($\alpha = .79$).
<u>Global Engineering Community Connectedness</u> refers to one's awareness of humanity and appreciation for the interrelatedness of all people and nations and the role that engineering can play in improving humanity, solving human problems via engineering technologies, and meeting human needs across national boundaries ($\alpha = .72$).

Table 1 presents sample items for each EGPI subscale.

Table 1: EGPI Sample Items by Selected Subscales/Constructs

Subcale/Construct	Sample Index Item
Engineering Ethics & Humanitarian Values	Engineers in my country have a moral obligation to share their engineering knowledge with the less fortunate people of the world.
Global Engineering Efficacy	I believe that my personal decisions and the way that I implement them in my work activities can affect the welfare of others and what happens on a global level.
Engineering Global-centricism	I think my country needs to do more to promote the welfare of different racial and ethnic groups in engineering industries.
Engineering Community Connectedness	To treat everyone fairly, we need to ignore the color of people's skin in our workplaces.

The Global Perspective Inventory. The GPI, developed by Braskamp, Braskamp, and Merril,[18] measures how students think, how they view themselves as people with a cultural heritage, and how they relate to others from other cultures, backgrounds, and values. This instrument uses a 5-point Likert-type scale. In constructing the GPI, the authors have conducted a number of studies to address three major issues in survey measurement: trustworthiness of self-reports, reliability, and validity including face validity, concurrent validity, and construct validity. They conclude that a set of analyses provides "a strong statistical rationale for the current scales used in the GPI."[18] The instrument identifies three major domains of human development (cognitive, intrapersonal, and interpersonal) and associated questions: "How do I know?" "Who am I?" and "How do I relate to others?" Description of the three GPI domains follows.

Cognitive domain centers on one's knowledge and understanding of what is true, what is important to know, and how one determines each of these things. It includes the subscales of *Knowing* (α = .66) and *Knowledge* (α = .77). *Knowing* is the degree of complexity of one's view of the importance of cultural context in judging what to know and value. *Knowledge* is the degree of understanding and awareness of various cultures and their impact on our global society; it is also the level of proficiency in more than one language.
Intrapersonal domain seeks to understand how one integrates one's personal values and self-identity into one's personhood and how one becomes more aware of this process. It is measured by the *Identity* (α = .74) and *Affect* (α = .73) subscales. Identity is a combination of the level of awareness of one's unique identity and degree of acceptance of one's ethnic, racial, and gender dimensions of that identity. Affect is the level of respect for and acceptance of cultural perspectives different from one's own and degree of emotional confidence when living in complex situations.
Interpersonal domain considers one's willingness to interact with persons with different social norms and cultural backgrounds, acceptance of others, and comfort with relating to others. The Interpersonal domain is measured by the *Social Responsibility* (α = .73) and *Social Interactions* (α = .70) *subscales*. Social Responsibility measures the level of interdependence and social concern for others. Social Interactions subscale measures the degree of engagement with others who are different from oneself and degree of cultural sensitivity when living in pluralistic setting.

Table 2 below illustrates the GPI sample items by selected subscales/constructs.

Table 2: GPI Sample Items by Selected Subscales/Constructs

Subcale/Construct	Sample Index Item
Cognitive Knowing	I take into account different perspectives before drawing conclusions about the world around me.
Intrapersonal Identity	I put my beliefs into action by standing up for my principles.
Intrapersonal Affect	I am sensitive to those who are discriminated against.
Interpersonal Social Interaction	I frequently interact with people from a race/ethnic group different from my own.

Experiential (independent) variables: Two categories of experiential variables, which are considered independent variables in this studies analyses were utilized to respond to the study's research questions. One category included various international, coursework and service learning related experiences, in which the participating undergraduate engineering students had been involved. They included the following dichotomous variables: (a) Study abroad, (b) intership abroad, (c) a project abroad, (d) personal tourism abroad, (e) a second-language course, (f), an engineering course with a global focus (g), a non-engineering course with a global focus (h) engineering-focused service learning (i) non-engineering-focued service learning, and (j) an international roommate(s). The other category of independent variables included specific components of students' experiences such as (a) duration of the experience, (b) the number of times a student had participated in the experience, (c) comfort zone while in the experience, and (d) the amount of reflection occurred during/after the experience. We also collected data related to students' demographic and backround characteristics such as gender, race-ethnicity, academic status, level of interest in global issues and others.

Analytical Approaches: Descriptive analyses (means, standard deviations) were computed followed by outcome focused comparative approaches, (*t*-tests with effect size computations via Cohen's *d,* and correlations). In an effort to determine which types of experiences and their programmatic elements predicted learning outcomes related to global preparedness (GPI/EGPI scores), stepwise regression techniques were executed using SPSS, Version 22. Importantly, stepwise regression is useful approach for exploratory analyses when large numbers of independent variables are hypothesized to be related to a particular dependent variable.[28] In this study, stepwise regression was used to determine the best fit of combination of learning experiences and their constituents (independent variables) to predict the participating students' GPI and EGPI scores (dependent variable). Regressions using the EGPI and GPI scores as the dependent variable were run separately from one another.

Results

Results of the two outcome instruments are interesting and diverse. The results are summarized as Figures 1 and 2 below.

Figure 1. Engineering Global Preparedness Index: Distribution of Subscales & Overall Mean by Academic Status (*N* = 185)

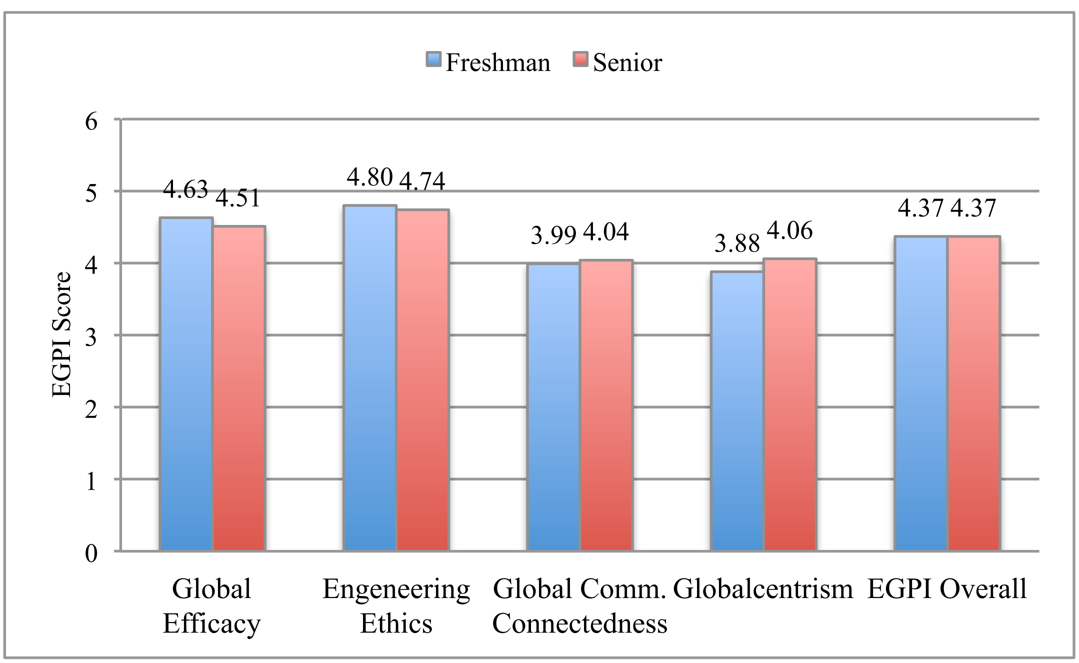
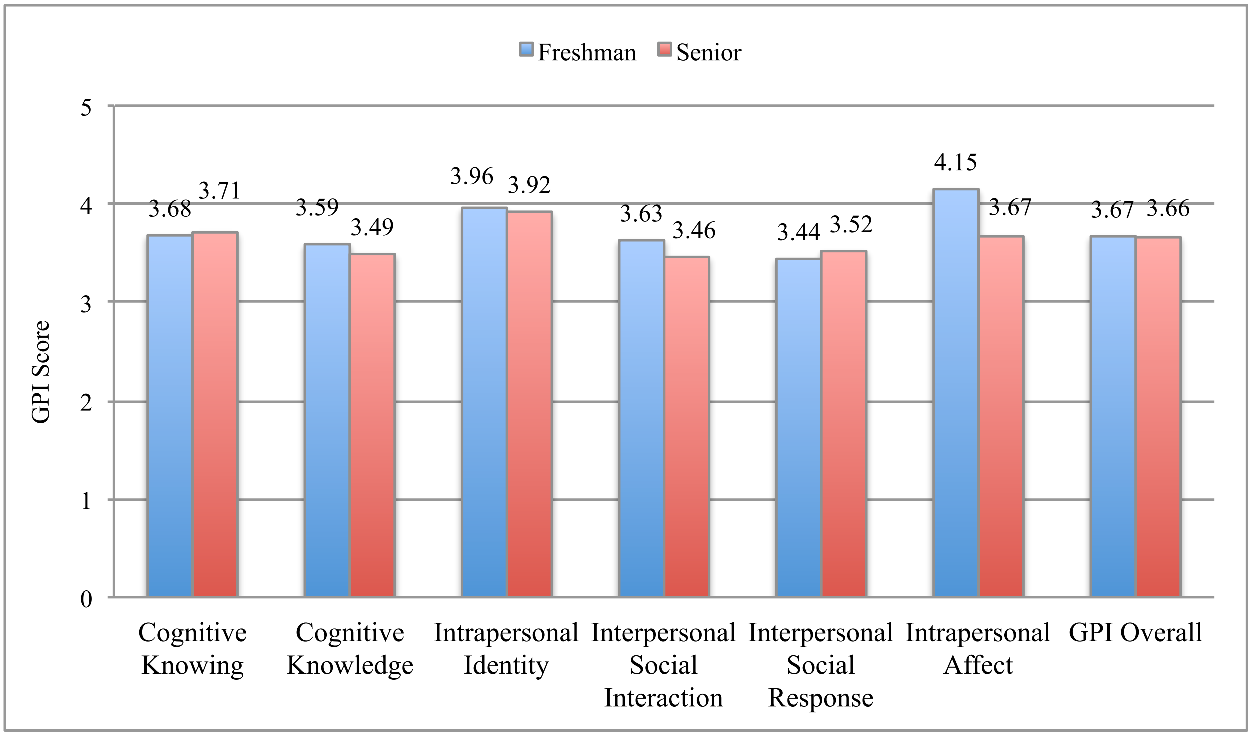


Figure 1 illustrates results using the EGPI and reveals an identical mean EGPI score for freshmen and seniors of 4.37 on a six-point Likert-type scale. Additionally, both freshmen and seniors scored highest on the Engineering Ethics and Humanitarian Values subscale ($M = 4.80$, $M = 4.74$, respectively) of the EGPI. Freshmen scored lowest on the Globalcentrism subscale ($M = 3.88$) and seniors scored lowest on the Global Community Connectedness subscale ($M = 4.04$)

Results on the GPI shared some commonality with the EGPI. Figure 2 summarizes these results descriptively.

Figure 2. Global Perspective Inventory: Distribution of Subscales & Overall Mean by Academic Status (*N* = 185)



As it is evident from the figure, results from descriptive analyses using the GPI revealed an almost identical mean GPI score for freshmen and seniors ($M = 3.67$ and $M = 3.66$, respectively) on a five-point Likert-type scale, with the highest mean score for freshmen on the Intrapersonal Affect subscale ($M = 4.15$) and for seniors on the Intrapersonal Identity scale ($M = 3.92$). Freshmen scored the lowest on the Interpersonal Social Responsibility subscale ($M = 3.50$) and seniors received lowest score on the Interpersonal Social Response subscale of the GPI ($M = 3.44$).

The students' experiences varied greatly. Experientially, more than 70% of the respondents disclosed somewhat high to extremely high personal interest in international issues and other cultures (51% and 22%, respectively). More than half of the participants indicated that they had resided in or visited three or more countries in their lifetimes and approximately one-third of the participants had lived in or traveled to one or two countries. Only 14% of the respondents reported that they had never been abroad.

With regard to globally or internationally focused coursework, on average, participating students completed approximately three college-level courses that focused on global, cross-cultural, intercultural or international content; and spent, on average, 33% of their time working with non-US students in their classes. Seventy four percent of the respondents said they did not speak any foreign language fluently. The actual distribution of experiences by student academic status is illustrated in Figure 3

Figure 3. Distribution of Student Involvement in Particular Experiences by Academic Status (*N* = 185)

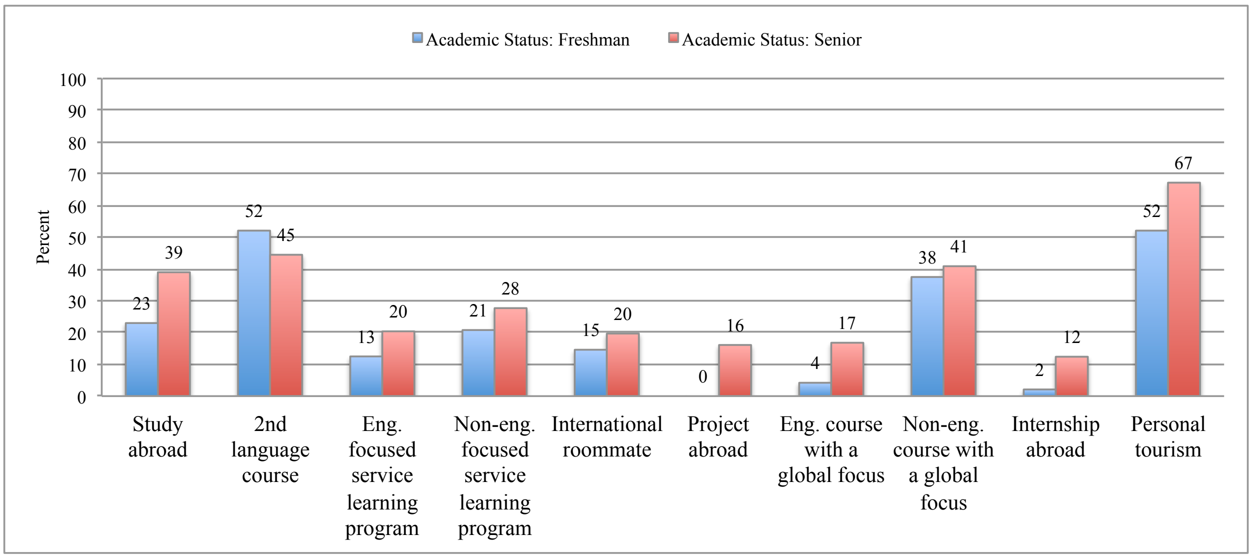


Figure 3 indicates that both the freshmen and senior students across institutions have been involved in diverse experiences ranging from a second-language course to study and internship abroad programs. Personal tourism, however, was the most common abroad activity experienced by the sample (i.e., 52% freshmen and 67% of seniors indicated that they had traveled abroad for personal tourism purposes). The second highest type of experience that students had been involved was taking a second-language course (52% and 45%, respectively). Enrollment in a non-engineering course with a global focus was rated the third: 38% of freshmen and 41% of seniors indicated that they had taken at least one of such class. Although 23% of freshmen indicated that they had studied abroad, fewer respondents indicated that they had an international roommate(s) (15%), participated in engineering-focused service learning programs (13%), or had enrolled an engineering course with a global focus (4%). Not surprisingly, the senior participants had much higher participation in study abroad, engineering focused service learning programs, and in projects and internships abroad.

To determine relative differences and similarities in student scores across the two outcome measures (the EGPI and GPI), independent sample *t*-tests and Cohen's *d* effect were calculated for the study sample. Table 3 below presents statistically significant *t*-test results by type of experience for the study's population.

Table 3. Two-Sample *t*-Test Results by Various Types of Experiences ($N = 185$)

Outcome	Group						95% CI for Mean Difference				
	Studied abroad			**Did not study abroad**							
	M	**SD**	**N**	**M**	**SD**	**N**			**t**	**Df**	**C's d**
GPI	3.77	0.300	65	3.60	0.349	120	0.075	0.278	3.45**	183	0.52
EGPI	4.52	0.568	65	4.29	0.589	120	0.050	0.404	2.54***	183	0.40
	Participated in Eng. focused SL			**Did not participate in Eng. focused SL**							
	M	**SD**	**N**	**M**	**SD**	**N**			**t**	**Df**	**C's d**
GPI	3.83	0.363	34	3.63	0.328	151	0.08	.33	3.23**	183	0.58
EGPI	4.67	0.677	34	4.30	0.550	151	0.15	.58	3.344*	183	0.60
	Participated in non-Eng. SL			**Did not participate in non-Eng. SL**							
	M	**SD**	**N**	**M**	**SD**	**N**			**t**	**Df**	**C's d**
GPI	—	—	—	—	—	—	—	—	—	—	—
EGPI	4.61	0.578	48	4.28	0.572	137	0.145	0.524	3.48**	183	0.57
	Took Eng. course with global focus			**Did not take Eng. course with global focus**							
	M	**SD**	**N**	**M**	**SD**	**N**			**t**	**Df**	**C's d**
GPI	3.80	0.330	25	3.64	0.341	160	0.007	0.296	2.07**	183	0.48
EGPI	4.62	0.641	25	4.33	0.575	160	0.040	0.536	2.29*	183	0.48
	Took non-Eng. course with global focus			**Did not take non-Eng. course with global focus**							
	M	**SD**	**N**	**M**	**SD**	**N**			**t**	**Df**	**C's d**
GPI	3.75	0.320	74	3.61	0.347	111	0.041	0.241	2.79*	183	0.42
EGPI	4.47	0.585	74	4.30	0.587	111	0.001	0.348	1.99*	183	0.29
	Participated in personal tourism			**Did not participate in personal tourism**							
	M	**SD**	**N**	**M**	**SD**	**N**			**t**	**Df**	**C's d**
GPI	3.71	0.335	117	3.58	0.342	68	0.032	0.234	2.59*	183	0.38
EGPI	4.48	0.589	117	4.18	0.545	68	0.133	0.478	3.49**	183	0.33

$^*p < .05$ $^{**}p < .01$ $^{***}p < .001$
Eng. focused SL – Engineering-focused service learning
Non-Eng. SL – non-Engineering-focused service learning
Eng. Course with global focus – Engineering course with global focus
Non-Eng. Course with global focus – non-Engineering course with global focus

As it is evident from the table, participation in experiences such as study abroad, engineering/non-engineering focused service learning, engineering/non-engineering courses with global focus, and personal tourism abroad are statistically relevant to students' scores on both the GPI and EGPI. Importantly, those who participated in international or globally focused experiences outscored those who did not. Notably, the mean EGPI score of students who reported study abroad ($M = 4.52$, $SD = 0.568$, $N = 65$) was significantly higher than that of those who did not study abroad ($M = 4.29$, $SD = 0.589$, $N = 120$), $t\ (183) = 2.536$, $p < 0.001$. Cohen's d value of 0.40 indicates moderate practical significance of the result.

In contrast, participation in second-language course, projects or internships abroad, or having an international roommate did not reveal a statistically significant difference in students' EGPI or GPI scores.

To specifically understand the relationships between outcome scores and various types and characteristics of learning experiences, Pearson bivariate correlation analysis was computed. Notable relationships among these variables include the following: EGPI overall mean score was significantly related to various types of learning experiences. It was positively correlated with student participation in study abroad programs ($r = 0.184$, $p < 0.05$), engineering-focused service learning ($r = 0.240$, $p < 0.01$), non-engineering-focused service learning ($r = 0.249$, $p < 0.01$), an engineering course with a global focus ($r = .167$, $p < .05$), a non-engineering course with a global focus ($r = 0.145$, $p < 0.05$), and personal tourism ($r = 0.250$, $p < 0.01$). There was also a significant (but relatively weak) positive correlation between the overall GPI score and study abroad ($r = 0.247$, $p < 0.01$), engineering-focused service learning ($r = 0.232$, $p < 0.01$), an engineering course with a global focus ($r = 0.151$, $p < 0.05$), a non-engineering course with a global focus ($r = 0.202$, $p < 0.01$), and personal tourism, ($r = 0.223$, $p < 0.01$).

To determine the relationships between student performance on the two instruments and particular programmatic components of the learning experiences, correlational analyses indicate that in relation to students' scores on the EGPI, duration of study abroad was significantly correlated with the overall EGPI mean score ($r = 0.306$, $p < 0.05$) as well as with the EGPI subscales Engineering Global Community Connectedness ($r = 0.270$, $p < 0.05$) and Engineering Globalcentrism ($r = 0.347$, $p < 0.01$).

For the GPI, Cognitive Knowing subscale scores were significantly correlated with duration of a student's study abroad program ($r = 0.269$, $p < 0.05$). Cognitive Knowledge subscale scores were correlated with the number of non-engineering courses with a global focus students took, ($r = 0.291$, $p < 0.05$) and number of times traveled abroad ($r = 0.327$, $p < 0.051$), which was also positively correlated with the overall GPI score ($r = 0.201$, $p < 0.05$). The amount of reflection that occurred during or after personal tourism experience was correlated with the overall GPI ($r = 0.201$, $p < 0.05$) and overall EGPI scores ($r = 0.254$, $p < 0.01$).

Regression statistical techniques were used to explore potential relationships between student experiences and their global preparedness. Stepwise regression was conducted to evaluate which types of learning experiences and their characteristics were most effective in explaining variance in students' performance on both outcome instruments. Independent variable loading order was both theoretically motivated and aligned with the results of a priori correlational analyses. The regression results indicate that the combination of such experiences including engineering focused service learning, study abroad, and non-engineering course with a global focus accounted for approximately 12% of the variance in the GPI performance. These three types of experiences contributed to model fit (0.05 significance), with study abroad being the major contributor, followed by engineering focused service learning program, and non-engineering course with a global focus (see Table 4 for specifics).

Using the EGPI as outcome measure in regression, a combination of engineering focused service learning program, non-engineering focused service learning, engineering course with a global focus, and personal tourism accounted for 17.5% of the variance in the overall score. These experiences contributed to model (0.05 significance) with personal tourism being the strongest contributor, followed by non-engineering focused service learning, engineering course with a global focus, and engineering focused service learning.

Table 4. Stepwise Regression Results: Summary of the Contribution to and Effects of Particular Types of Experiences on the GPI and EGPI (*N* = 185)

Variable	GPI Score		EGPI Score	
	Contribute at .05 level (+ or -)	Contribution to R^2	Contribute at .05 level (+ or -)	Contribution to R^2
Engineering focused service learning program	yes (+)	0.037	yes (+)	0.023
Non-engineering focused service learning program	no	N/A	yes (+)	0.055
Engineering course with a global focus	no	N/A	yes (+)	0.035
Personal tourism	no	N/A	yes (+)	0.062
Study abroad	yes (+)	0.061	no	N/A
Project abroad	no	N/A	no	N/A
Internship abroad	no	N/A	no	N/A
Second language course	no	N/A	no	N/A
Non-engineering course with a global focus	yes (+)	0.022	no	N/A
International roommate	no	N/A	no	N/A
Total R^2		0.120		0.175

Key findings and implications

The goal of this research has been to determine the particular types of learning experiences that were positively associated with learning outcomes related to undergraduate engineering students' global preparedness. The results indicate that participation in study abroad, engineering/non-engineering-focused service learning, engineering/non-engineering courses with a global focus, and personal tourism abroad are positively associated with students' engineering global preparedness. Further, student performance on the two global preparedness measures was found to be significantly but relatively weakly correlated with particular programmatic components of the experiences such as the duration of study abroad, the number of non-engineering courses with a global focus in which students had enrolled, the number of times students traveled abroad, and the amount of reflection that the students engaged in during or after traveling abroad. This finding is consistent with the previous research that documented significant relationships between program features and student learning outcomes.[25-27]

Importantly, the combination of study abroad, engineering-focused service learning, personal tourism, and both engineering and non-engineering courses with global foci were found to be significantly related to students' global preparedness scores.

These study findings inform engineering education pedagogical practices both inside and beyond classroom walls. Specifically, the results of this study imply that integrating global perspectives and international experiences into undergraduate engineering programs should be considered critical to students' global learning and essential elements of obtaining engineering degrees. Certainly, such experiences must be designed with clear goals and objectives, particular components for optimal impact, appropriate timelines, and adequate resources.

Limitations of the study

Several limitations of the current study exist. First, this work is exploratory and as such results in a non-experimental design, which, in turn, did not allow observing causal relationships between the outcome and experiential variables. Additionally, because the study utilized cross sectional data across three institutions collected at one time point and the exposure to experience and outcome were simultaneously assessed, there is limited evidence of a temporal relationship between the exposure to globally focused experiences and the outcomes. That is, although the study determined that there was a positive association between particular types of learning experiences and students' global preparedness, there was no evidence that the exposure to various experiences caused the outcome as measured by student scores on the GPI and EGPI. A final study limitation was the relatively small sample size, which limited the generalizability of findings. These limitations will be addressed by this research team's future research.

Conclusions and Future Work

Global perspectives and international experiences are increasingly becoming important components of the 21st century engineering academic programs because learning how to study and work with people from other nations and cultures "can help solve global challenges together and also prepares future leaders to contribute to making the world a less dangerous place."[13] The present study results provide valuable information that informs the engineering education research community about the importance of employing various international and global experiences on and off campuses to enhance engineering global preparedness in future engineers. Results from this study broaden the knowledge base about contextual factors related to engineering global preparedness. In particular, the results offer the engineering education community insight into the types of pedagogical approaches and their defining parameters, and how these potentially relate to students' learning outcomes. Engineering educators can utilize findings as references for designing pedagogical practices and engineering curriculum.

In future work, the research team will collect data on larger groups of undergraduate students and engage in quasi-experimental research design to examine the extent to which specific learning outcomes have resulted from student prior experiences, curriculum models, and pedagogy. It will also explore the effect of student demographic and background factors and how various international educational activities are associated with the global preparedness of different engineering student groups (e.g., minorities, women, foreign nationals).

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