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Engineering Global Preparedness: Parallel Pedagogies, Experientially Focused Instructional Practices*

GISELE RAGUSA
University of Southern California, Viterbi School of Engineering, Division of Engineering Education, University Park Campus, Denney Research Building 231-235, Los Angeles, CA 90089, USA. E-mail: ragusa@usc.edu

With advances in technology and blurring of national boundaries, colleges and universities worldwide are increasingly required to prepare their graduates for global workforces. Importantly, engineering industries are seeking graduates with globally focused communication and leadership skills. Additionally, graduates are sought after who have interdisciplinary research and professional abilities that enable them to work effectively in diverse engineering environments that cross national boundaries. The presented research responds to an emergent challenge of engineering global preparedness. Specifically, it represents a study that measures the impact of formal and informal experiences and socio-demographic factors that impact students' global preparedness in engineering. In this study, graduate and undergraduate engineering students were assessed using an engineering global preparedness index that measured the role that experiential and socio-demographic factors played in their global preparedness. The results indicated that students' internationally related pedagogical experiences and precursing life experiences positively impacted their preparedness for global workforces. Additionally, diversity in preparedness and socio-demographic factors among students was noted, revealing that students with diverse socio-demographic profiles had diverse preparedness indices. The study provides engineering educators with future directions as to the importance of providing globally focused experiences for their students in engineering education to assist them in becoming fully prepared for global engineering workforces.

Keywords: engineering education; global workforces; engineering preparedness; global experiential education

1. Introduction

We live in an era with unprecedented changes as a consequence of dramatic advances in technology on many fronts. Specifically, the explosive growth in computing and communication has revolutionized the way we work and live making our world virtually boundariless. This phenomenon has forced employers to "go global." The impacts of globalization, demographics, and technological advances are uniquely changing the role of engineering in society, [1–4] identifying a significant problem in the way universities address the engineering profession, engineering education, and associated engineering student assessment processes.

Several national reports identify critical issues that universities encounter in engineering education associated with globalization [2–4]. These reports challenge U.S. engineering schools to prepare their graduates to bring high level skills including team focused innovation, a comprehensive engineering problem-solving approach, cultural competence, internationally focused ethics, and leadership to their workplace. The necessity for engineering education reform requires radically new, innovative and closely aligned instructional and assessment practices and in particular approaches that tie globally focused student experiences to pedagogical and curricular elements. Such approaches must focus on preparing students to solve important engineering problems that stretch far beyond national boundaries geographically, culturally and socio-politically [6] and engineering schools must find effective and efficient ways to measure preparedness for global workforces of their engineering graduates.

Some engineering schools have initiated recent reforms in engineering education to meet the changing needs of engineers nationally and globally, however sparse research exists that comprehensively assesses these globally focused outcomes associated with such efforts. Accordingly, the presented research has as its primary purpose to measure diverse factors, both socio-demographic and experiential, that impact engineering students' preparedness for global workforces using a newly designed instrument, the Engineering Global Preparedness Index (EGPI). The EGPI builds on existing theoretically and practically significant structures, experiences, and globally relevant engineering practices.

1.1 World populations and global preparedness

International students dominate engineering graduate programs in the United States; foreign-born students make up 47% of all graduate enrollments in engineering in the United States. This socio-demographic change in U.S. engineering programs at the graduate level occurs while other countries are beginning to outpace the U.S. in producing scientists and engineers. Importantly, of all undergradu-

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ate degrees awarded worldwide in engineering in 2009, 72% were awarded outside the United States [7]. Similarly, of all doctoral degrees earned worldwide in engineering, 78% were earned outside the United States [8]. These contemporary statistics are not only alarming to U.S. industries and economists, they give rise to the critical importance of changing the structures and associated measurements of impact of engineering training programs to a global focus. As such, research by Blumenthal and Grothus [9] posits, "Engineers need global competencies and multicultural skills as much as any other professionals," regardless of where they reside. In the United States, the National Academy of Engineering [3] has challenged university engineering programs to prepare engineering students for global workforces. Similarly, numerous agencies worldwide challenge other nations with a similar preparatory charge. These implied directives have been very difficult for college and university engineering programs internationally to meet. This is particularly challenging at the undergraduate levels across nations, where students have comparably less interaction with students from diverse national backgrounds than at graduate levels per cross-nation enrollment statistics.

Not only do engineering programs have difficulty meeting society's global needs in their engineering education programs, engineering schools have even greater difficulty measuring their students' preparedness for global workforces even with attempts to change programs in place, pedagogically and curricularly. Global preparedness cannot be measured with a traditional examination as other content is measured in the engineering and other scientific fields because it involves difficult to measure or "latent constructs" that fit together as metrics of preparedness. Per measurement theory, a latent construct is an unobservable factor or characteristic that is recognized as an important aspect of learning but is difficult to directly measure [10]. These constructs are often crafted together via related sub-constructs often represented in subscales in instruments. Constructs are often attitudinal, learning, or ability focused. Global preparedness is a particularly important latent construct because the skills identified by industry and academies as indicators of global preparedness are considered engineering "soft" or "professional" skills, or those that cannot be easily measured through engineering traditions because they are difficult to universally determine [11].

1.2 Pedagogical practices in science and engineering and a global economy

The research on engineering global preparedness is quite sparse. Rather, it is loosely connected to science, technology, engineering, and mathematics (STEM) fields, is course or program specific, and is often small in scale research-wise. Few studies have focused on the role that pedagogical practices and associated experiences play in preparing college and university students for global careers in engineering. For example, Ahamed [12] conducted research on a university program designed to prepare students to work in a global environment. In this program, the students were supposed to develop skills in design, architecture and technological development, project management, compliance monitoring, and communication skills, loosely a STEM related skill set. Ahamed's research intended to identify which pre-industry instructed skills best prepared students for global workforces. Accordingly, Ahamed collected data via a survey from alumni of the referenced program to determine critical skills that assisted students for global workforces that may have been taught in program from which students had recently graduated. The alumni under study reported that the primary challenges identified included training with technology, enhancing students' team (or communication) skills, emphases on individual accountability, training in leadership and negotiation strategies (also communication related), in addition to training on risk management, and quality assurance skills (loosely related to ethical practices). The participant alumni in Ahamed's research recognized that while these skills were needed, they were not deliberately taught in the program from which they had graduated and in particular the program was not targeted toward global market places. As such, the former students in Ahamed's research who were now working in global settings reported having difficulty transferring these skills into their workforces. These identified skills align to those defined as critical latent constructs identified for global engineering in the literature in engineering education. Ahamed identified that a primary challenge to this research were twofold: (1) Finding opportunities to practice such skills in globally focused setting; (2) accurately measuring the skills learned. The EGPI (the primary metric for the present study) may provide answer to Ahamed's research challenges, in particular with regard to measurement of global skills and latent constructs.

In a related study, Mihelcic and colleagues [13] explored the role that a multidisciplinary approach to engineering education may play in engineering global preparedness. These authors combined a "sustainable futures model" with an approach catering to international development in their curricular study focused on global engineering. The researchers' curricular combination included environmental sustainability, economic sustainability, and societal sustainability, with a special emphasis on creating solutions for the developing world, as they posited that this particular content focus would be highly relevant for global workforces per existing "citizenry theory" and existing research. Mihelcic and colleagues' study [13] results indicated that to adequately address international engineering, a program must not only address issues of globalization, but must also include a focus on societal relevance. This study speaks to the importance of a including global relevance and other "professional" or "soft" skills in engineering curriculum and pedagogical practices to prepare future engineers for global workforces. Additionally, the content of this study is aligned with described subconstructs or "soft" or "professional" skills of global-centric behavior and engineering ethics, and community connectedness, three subconstructs measured by the referenced EGPI instrument for the presented study.

1.3 The role of communication in global preparedness

Engineering industries word-wide have recently pushed universities to train engineers to become better "communicators" because industries have come to recognize that communication is a key factor in succeeding in global engineering workforces especially when multiple cultural groups must work in concert with one another across national boundaries to solve world problems. To address this global industrial challenge, in an engineering curricular study, Ballentine [14] attempted to create an engineering course that would foster students' social and global awareness with an eye towards developing stronger communication skills via structured communication-centric course experiences. Ballentine embedded in-course employment discussions as a routine pedagogical practice in the course targeted for his research with a goal of increasing students' communicative competence as a means of fostering discussion about global engineering. Students in the course were asked to rate the course regarding communication training. They reported that the course allowed for ease of addressing communication problems a student may experience during his or her program. Additionally, participating students found that the in-class discussions concerning globalization were more pertinent to their future employment and helpful to improving their communication as future engineers. This course demonstrated promise for communication and global preparedness, however relying solely on students' evaluation of the course as a means of measuring preparedness limits direct measurement of the skills associated with engineering global preparedness. As such, a robust measure of this practice and its link to course experiences is of critical importance to determining the impact of such a pedagogical reform.

1.4 The effects of international schooling

One potential metric of engineering global preparedness is the role that international experiences play in global preparedness. Sparse research has explored the effects of international schooling on such preparedness and in particular for future engineers, however, in a recent study of engineering students conducted by Eckhardt Doerry [15], engineering alumni were surveyed to devise solutions to the obstacles preventing them from participating in "study abroad" programs. Surveyed graduates were asked why they did not make studying abroad a part of their engineering educational experience. Identified challenges from the survey results were: (a) engineering curriculum difficulty, (b) the need to learn a second language to fully participate abroad, (c) scheduling conflicts with diverse university systems, and (d) a perceived limited marketability of international study after graduation. To accommodate these identified challenges, as a potential solution, Eckhardt Doerry devised a "virtual student exchange," allowing students to participate in engineering design courses through distance learning, global internships, and specialized accelerated language acquisition courses. This "virtual" change represents a promising pedagogy in engineering education, however a measurement of its potential impact was missing from Eckhardt Doerry's research.

Grandin [16] added to the research on international experiences by exploring impacts of internships on engineering students' learning. Grandin's study attempted to uncover ways to develop engineering students capable of performing competently in global settings through an internship that provided "on the job training" coupled with extensive foreign language preparation. Grandin constructed the studied program in cooperation with industries adhering to the following structures: (a) the job should correspond to the skills learned by the intern; (b) the students were assigned to someone willing to train them as an apprentice; and (c) the student would live according to the language and customs of the host country. To measure progress in the described international engineering internship, each student sent journal entries every two weeks written in the language of the internship country to the researchers so that they could gauge the students' second language acquisition progress and the type and level of learning that the intern students were engaging with through the internship. The students' journals were qualitatively analyzed utilizing the themes of

(a) changes in global mindset, and (b) increased written language acquisition as indicators of the internship program's impact. Unfortunately, the qualitative analytical structures presented in Grandin's research were somewhat vague and limited empirically. Industry informal feedback served as a second metric of impact from the studied program. Grandin concluded that based on the data collected for the program, the experience was beneficial for the students professionally. Because of the limited sample size in this study (N = 6), the fact that the data self reported collected, and the method of collecting feedback from industry partners was unspecified, the study's conclusions are difficult to generalize to other such programs.

1.5 The importance of developing global competence or preparedness

Researchers have identified a need for a concise definition of a globally prepared or globally competent engineer. Accordingly, in a metaanalysis of literature compiled by Lohmann, Rollins, & Hoey [17], a definition of global competency in engineering was sought. The consensus definition that these researchers derived was "the ability to work knowledgeably and live comfortably in a transnational engineering environment and global society" [17]. These authors describe steps that universities are taking in preparing engineering students to enter the increasingly globalized workforce. They note that universities are developing international programs geared towards preparing students to live and work within a global context. In line with their definition of a globally competent engineer, Lohmann and colleagues stressed the importance of assessing global competence in engineering in their review of research on engineering global competence. Through this, they authors note that most reported evaluations present in the literature focus primarily on international experiences linked to study abroad programs; few evaluations have focused on student learning effects or career impact of the international programs. Still fewer focus on the effects of experiences and socio-demographic factors on engineering students.

Parkinson [18] reinforced the needs of assessing engineers for global preparedness posited by Lohmann and colleagues in his work on examining engineering study abroad programs. He noted the international nature of engineering and discussed a common practice of multi-national engineering teams that are typically responsible for designing products in one area of the world to be manufactured in another area of the world and distributed in yet another part of the world, thereby explaining the importance of understanding other cultures and countries in defining engineering global competence. Parkinson [19] also noted the importance of being able to work and globally coordinate within developing countries. Parkinson examined approximately twenty-five different schools and found various factors contributed to developing and maintaining, what he refers to as "exemplary programs" for preparing globally competent engineers. Factors contributing to "exemplary programs" are: providing rewards and support for participating faculty, alignment of programs with objectives, good student preparation, mentored travel experiences, strong support of the college leadership, excellent support from the university International programs office, and programs associated with increases in women participation. Parkinson reinforced the important of understanding the impacts of his described factors on the global preparedness of engineering students.

Downey and colleagues [20] examines field specific pedagogical practices that may further support development of a globally competent engineer. They stressed the importance of working effectively with others within an engineering context. Downey and colleagues noted the crucial nature of working effectively with individuals who may define problems differently (based on various cultures and global outlooks) in engineering programs as a characteristic of global competence. They examined learning criterion for engineers that can ultimately enhance global competency and identified three learning outcomes aimed at achieving the criterion. These outcomes include (a) demonstrating substantial knowledge of the similarities and differences among engineers and non-engineers from different countries, (b) an ability to analyze how people's lives and experiences in other countries may shape or affect what they consider to be at stake in engineering work, and (c) a predisposition to treat co-workers from other countries as people who have both knowledge and value, may be likely to hold different perspectives than they do, may be likely to bring these different perspectives to bear in processes of problem definition and problem solution. Downey and colleagues [20] emphasized that using such criterion and learning outcomes can assist in identifying a globally competent engineer. They further emphasized the importance of measuring engineering global competence against these criteria.

The described sampling of reviewed research on globally focused engineering education and its associated metrics of impact highlights the importance of engaging in additional research on global preparedness of engineering students. The current literature has limited empirical impact and generalizability. Accordingly, this difficulty provided the impetus for the research described herein. The present study adds to the field of engineering education internationally in terms of determining impact of diverse engineering education experiences, both formal and informal on students' global preparedness for engineering workforces and couples research on these experiential factors with students' socio-demographic characteristics in an attempt to determine the ideal experiential and student make-up for ample preparedness for global engineering workforces of the 21st Century.

1.6 The importance of measuring global preparedness

The engineering education literature emphasizes the increasing global nature of engineering. It presents a need for assessment of effectiveness and impact of global programs in preparing engineering students for the globalized environment that is often faced upon entering the workforce. During the past two decades, researchers have attempted to measure latent constructs similar to global preparedness across college/university majors utilizing constructs with relative generic foci including citizenry, cultural pluralism, global ethics, and internationally focused readiness in their university students. For example, Shealy [21], and Hammer and colleagues [22] have braved this measurement challenge through their instruments, the beliefs, events and values inventory (BEVI) and the intercultural development inventory (IDI) respectively. However useful and effective these two instruments have been in measuring the impact of international experiences for university students, they are not focused on engineering and therefore are unable to precisely align to career preparedness in engineering programs as identified in the described engineering education literature. Instead, the referenced constructs have indirectly and generically targeted career preparedness rather than being specific to engineering fields. Given the current state and demands of the engineering market, global preparedness in engineering involves several related subsconstructs within the general latent construct of engineering global preparedness. According to the current literature in global engineering education described above, these subconstructs involve engineering ethical practice, global engineering efficacy [23], community connectedness within and beyond engineering practice [13, 9], and globally-centric behavior that posits that engineers situate the world globally rather than within one own country [1]. Validated measures and instruments such as the Engineering Global Preparedness Index (EGPI) can help to address some of the questions and concerns presented in the literature.

2. Research design and instrument development

As described above, this study has as its primary purpose to measure the impact that particular experiences and socio-demographic factors have on engineering students' preparedness for global workforces. For this study, in terms of instrumentation, after exploring appropriate metrics in engineering education that measure students' preparedness for global workforces and recognizing that there were no such metrics with quantitative foci that could be administered with large sample size to conduct research robustly, the present research includes design, testing and full research implementation of an engineering student index that could measure this important preparatory construct: *engineering global preparedness.*

Precursing this research effort, the researcher was involved with an international research group that attempted to measure teachers' global citizenry at preservice levels. This teacher education research group developed an instrument to test the latent constructs associated with global citizenry for preservice teachers [24, 25]. The instrument was found to be a valid and reliable instrument, however it was generic in focus (not discipline specific) and did not specifically address engineering education or associated STEM contexts. Accordingly, for the present study, a similar construct associated with the global citizenry teacher instrument was utilized to design the engineering preparedness instrument, however the instrument was adapted to reflect engineering context and essentially engineering global preparedness identified in current engineering education research focused on global engineering.

In the present study, the newly designed instrument, referred to as the Engineering Global Preparedness Index (EGPI) was developed, tested and broadly administered to determine the impact that formal and informal pedagogical practices played on engineering students' global preparedness [23]. Importantly, in addition to being modeled after an existing instrument of global citizenry, The EGPI is aligned both to the recommendations put forth in the National Academy of Engineering 2005 publication, *Engineers for 2020* and to the Accreditation Board for Engineering and Technology (ABET) outcomes [11] in global preparedness, engineering ethics and communication. Subscales for the index were developed accordingly, while also aligning with sound theoretical and empirical research on global citizenry [24, 25, 12, 15] and the National Academy of Engineering's [3] expectations for engineering global preparedness. Four important subscales are utilized as subconstructs in the described EGPI. The subscales (or subconstructs) of the EPGI are described as follows:

- *Global Engineering Ethics:* Depth of concern for people in all parts of the world; sees moral responsibility to improve life conditions through engineering problem solving and to take such actions in diverse engineering settings.
- *Global Engineering Efficacy:* Belief that one can make a difference through engineering problem solving; support for one's perceived ability to engage in personal involvement in local, national, international engineering issues and activities towards achieving greater good using engineering problem solving and technologies.
- *Engineering Global-centrism:* Valuing what is good for the global community in engineering related efforts, not just one's own country or group; making judgements based on global needs for engineering and associated technologies, while not focusing on ethnocentric standards.
- *Engineering Community Connectedness:* Awareness of humanity and appreciation of interrelatedness of all peoples and nations and the role that engineering can play in improving humanity, solving human problems through engineering technologies, and meeting human needs across nations.

2.1 Instrument design and testing

In its present form, there are total of 30 items on the Engineering Global Preparedness Index (EGPI) with three to five response items per subscale. This item distribution and scale total is supported by item response theory (IRT) [10] for designing difficult to observe (soft skill) latent constructs, as is the case with the construct, global preparedness in engineering. The instrument was designed in accordance with best practices in instrument design established by both the Educational Testing Service [26] and the National Council of Measurement Education [27] and groundbreaking work on item response theory (IRT) by Mark Wilson [10]. Table 1 provides sample items for each of the four EGPI subscales.

Additionally, with regard to instrument design features, to avoid item response bias [10] the minimum of two items per subscale in the index are reverse scored items in the index in support of best practices in survey development, and true measurement of student knowledge (rather than student perception) beyond what is self-reported. A four-point Likert-type scale outcome space was employed for the EGPI in an effort to be certain that index respondents would not have the option to choose a "neutral" response to any EGPI item.

2.2 Item analysis: Development of the final scales in the EGPI

In the initial stages of development and testing of the EGPI, a set of 60 items were piloted tested with a group of undergraduate and graduate engineering students in 2007 (N = 148). These items were vetted and tested in various ways aligned with IRT building blocks [10] over a 16-month period. Various analyses were conducted on the initial set of items to identify whether similar subconstructs identified empirically in research on teachers' global citizenry and world mindedness [23] could be empirically identified in engineering students' global preparedness. To this end, the initial research task during instrument development was to examine how well the newly developed EGPI items were functioning across the hypothesized subscales. Therefore, a series of item analyses on the initial 60-item EGPI was conducted including an examination of subscale internal consistency (using coefficient alphas), inter-item and item-total correlations, and determining the relationships between the various EGPI subscales in the form of a statistical examination technique, exploratory factor analyses (EFA) [23, 28, 29].

2.3 Item internal consistency pilot testing

Coefficient alpha [29] was computed for each of the hypothesized subscales on the EGPI. The most reliable subscales included the Global Engineering Ethics, Global Engineering Efficacy, Engineering Global-centrism, and Global Engineering Community Connectedness subscales, all of which

Table 1. Sample EGPI Items by Construct

Subscale/Construct	Sample Index Item
Engineering Ethics	Engineers in my country have a moral obligation to share their engineering knowledge with less fortunate people of the world.
Engineering Efficacy	I believe that my personal decisions and the way that I implement them in my professional practice 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 in engineering practice, we need to ignore the color of people's skin in the workforce.

had coefficient alphas greater than 0.65. The internal consistency coefficients for the remaining subscales were not as statistically strong, indicating that there were some items that did not cohere with one another on each of the remaining subscales in the original form of the EGPI instrument. Item-total correlations were subsequently investigated to identify these potentially problematic items. Resulting from these pilot statistical analyses, fourteen problematic items were removed from the EGPI subscales to increase the coefficient alpha values of the individual subscales to an acceptable value [29].

2.4 Pilot testing: Item total correlations

Upon closer examination of the item-total correlations for items on each individual subscale, it was clear that a large number of the remaining items were moderately to highly correlated with their respective subscale's total score. It was, however common to find that one or two items on each subscale were the primary cause of the relatively low item that had an item-total correlation below the conventionally acceptable level ($r < 0.30$) and therefore additional items was considered for removal from the revised scales (EFA). This process resulted in the identification of sixteen items with low item-total correlations, and thus these items were removed. In addition, this analysis revealed that there were more significant problems with the two of the original subscales (the initial 60 item EGPI had 6 subscales), which were removed from the index.

The reliability of the remaining set of subscales of the 30-item instrument in the EGPI (after EFA) was again tested using Cronbach's correlational analysis procedures. This analysis provided important indicators of the reliability of the current version of the EPGI used for this present study. Internal consistency coefficients for the revised subscales ranged from 0.65 to 0.91 and the overall internal consistency of the EGPI increased from 0.63 to 0.77 after statistical testing and adjustment (described above) making the index satisfy the accepted alpha values per IRT [10, 29]. A listing of the internal consistency coefficients for the revised subscales is listed in Table 2.

Table 2. Reliability Coefficients on Final EGPI Subscales

EGPI Subscale	Cronbach's Alpha Value
Engineering Ethics	0.79
Engineering Efficacy	0.70
Engineering Global-centricism	0.68
Engineering Community Connectedness	0.69
Overall EGPI Reliability	0.77

2.5 Validity testing

To determine content and construct validity of the EGPI, five engineering Ph.D. students were chosen to engage in "cognitive interviews" to test the content and construct validity of each index item. Accordingly, the Ph.D. students completed the revised 30 item EGPI and then were interviewed to understand the rationale that they followed for making specific response choices on each EGPI item. Woolley, Bowen and Bowen [30] describe this cognitive interview process as having the individual discuss the message behind his or her responses. In particular, these scholars' measurement research has provided credibility for this instrument design technique as a powerful and viable means of developing content and constructs validity of survey-type self-report instruments for measuring beyond perceptual skills. All EGPI items in question from the cognitive interviews were revised with specificity according to the results of the cognitive interviews [23]. Post completion of the cognitive interview process and revision, the present study using the revised EGPI was conducted and is described as follows.

2.6 Study population

The present engineering global preparedness study was conducted with engineering students from eight diverse, research-focused undergraduate and graduate engineering programs in universities from across the United States. A total of 493 undergraduate and graduate engineering students participated in the study. Table 3 contains a description of all socio-demographic and experiential information for the study participants. In summary, relatively equal numbers of undergraduate and graduate engineering students were included in the sample with a 34–66 percentage split between female and male students respectively. This population diversity was deliberately achieved with the intention of testing using maximum variation techniques with diverse variables associated with global preparedness. Table 3 represents the study populations' full socio-demographic profile and international experience set.

It is important to note that this study is of US universities and colleges. As indicated in Table 3, approximately 14% of the entire sample size was comprised of international students. The majority of students were born in the United States, with at least one grandparent born in the U.S. (68%) indicating that they were not first generation U.S. students. Table 3 also describes the percentage of the sample that has resided within another country for an extended period of time. This is an important factor for consideration, particularly when studying

Table 3

Factors	Percentage
Gender	66% Male 34% Female
Age	31.3% Under 20 45.6% 20–24 14.3% 25–29 8.9% 30+
Ethnicity	51.4% Caucasian 37.1% Asian 9.7% Hispanic 5.8% African American 2.7% Middle Eastern 2.3% Pacific Islander 0.4% Indigenous Person
Citizenship	68% At least one parent born in US 12% Born in the US-parents born elsewhere 7% Student Visa 6% At least one parent born in US 5% Foreign born, but US citizen 2% Foreign born, but not yet US citizen
Setting: Grew up	42% Small town 35.3% Suburban 16.8% Urban 5.7% Rural
Setting: Last 5 years	41% Suburban 29.4% Urban 24.7% Small town 4.1% Rural
Resided in another country	64.6% Did not reside in another country 15.8% Resided in another country 4+ years 15.4% Resided in another country <1 year 4.2% Resided in another country 1–3 years
Studied abroad	74.5% Did not study abroad 14.3% Studied in a culture different than home culture 11.2% Studied in a culture similar to home culture
International Community Service	81.9% Did not engage in community service 15.4% Community service <1year 1.5% Community service 3+ years 1.2% Community service 1–3 years

the impact that international experience could potentially have on students' overall global preparedness. As such, in the study sample, nearly 20% of the participants were involved in some form of international community service associated with university education for an extended period of time. As previously stated, international, community-focused experience theoretically impacts overall global preparedness due to the exposure that individuals encounter when time is spent residing in and participating in community focused within other countries. This premise is supported by the literature on international education. Approximately 25% of the participants in the study reported studying abroad, which is also indicative an international experience.

Several statistical analytical procedures were utilized in this study to determine its results. Initially, descriptive statistical analyses were performed on all socio-demographic variables (described in Table 3 and above) and the Engineering Global Preparedness Index (EGPI) subscale means. The subscale means are represented in Fig. 1.

3. Comparative results

Importantly, there was not great diversity in the subscale means across subscales, with the exception of the global centric subscale.

As such, to further parse out potential differences across participant groups, the undergraduate group was compared to the graduate students in the study sample. This comparison is illustrated in Fig. 2.

This figure illustrates differences across groups. In nearly every subscale, graduates performed better than undergraduates. However, these differences were statistically significant in half of the subscales, engineering ethics and engineering efficacy ($p < 0.05$). Importantly, the student differences in overall global preparedness were also statistically significant ($p < 0.05$).

In an effort to determine which factors predicted

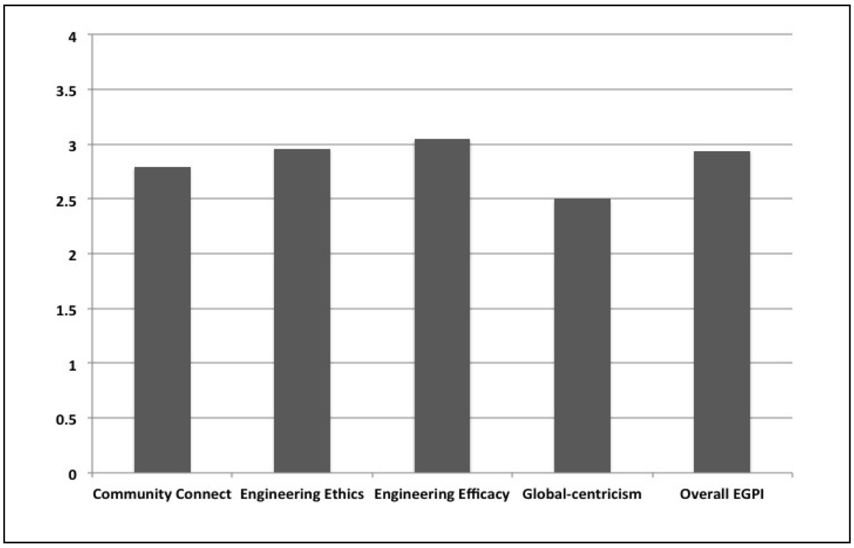

Fig. 1. Study Sample Engineering Global Preparedness by Subscale.

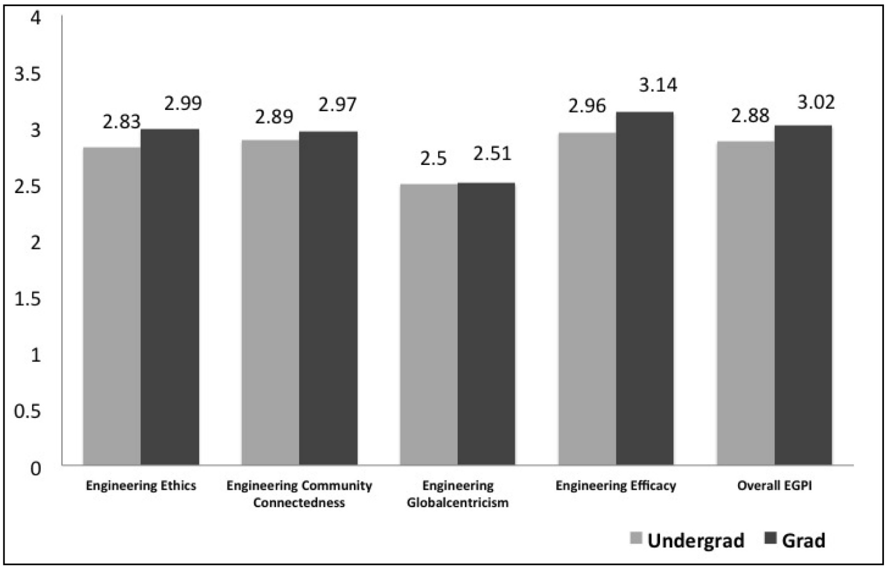

Fig. 2. Comparison of Undergraduate to Graduate Students' Engineering Global Preparedness.

engineering global preparedness, statistical correlational analyses and a two-step hierarchical multivariate regression analysis was conducted on the index data. Comparative and predictive results of these quantitative analyses are presented below. After computing descriptive statistics on the variables and socio-demographic factors present in this research, correlational analyses were conducted with particular variables to examine relationships between the study variables with a great degree of granularity. These comparative results indicate some interesting findings for both socio-demographic and formal and informal experiential factors. Results revealed that participants born abroad (students with VISAs) had higher levels of engineering ethics ($M = 2.97$, $SD = 0.56$, $r = 0.208$, $p < 0.01$) than their U.S. born student peers. Having a student VISA was also positively correlated to high levels of engineering community connectedness ($M = 2.67$, $SD = 0.64$, $r = 0.157$, $p < 0.01$) comparatively. Both of these correlations were statistically significant. This result indicates that global experiences that often occur with international students are indicative of stronger engineering community connectedness and global engineering ethics. In contrast to this, study participants who reported growing up in a small town had lower global engineering ethics and lower global engineering community connectedness ($M = 2.43$, $SD = 0.39$, $r = -0.359$, $p < 0.01$, $M = 2.77$, $SD = 0.66$, $r = -0.296$, $p < 0.01$, respectively) than their peers who grew up in large cities. This observed inverse relationship between rural residence and community connectedness may be attributed to the limited experience that participants may have with population diversity as a function of growing up in a small town where overall population is sparse, and ethnic homogeneity is typically common.

Additional correlational analyses indicate an inverse relationship between growing up in a rural area and global engineering ethics and global engineering community connectedness ($M = 2.14$, $SD = 0.43$, $r = -0.142$, $p < 0.01$, $M = 2.13$, $SD = 0.53$, $r = -0.112$, $p < 0.05$, respectively). Again, this may be indicative of potentially limited global experiences of students who grew up in small, rural communities with limited experiences with population diversity. Contrarily, growing up in a large, urban community was positively correlated with international community service ($M = 2.91$, $SD = 0.91$, $r = 0.173$, $p < 0.01$), indicating that urban learners were more likely to have engaged in international community services thus having a broader international experiential repertoire from which to draw beliefs and associated preparedness. These correlational analyses provide insights as to the experiences that align with representation of engineering global preparedness or competence as described by Parkinson [18] and Lohmann and colleagues [17].

As described above, in addition to correlational analyses, a two-step hierarchical multivariate regression analysis was conducted to further identify statistically significant predictors of engineering global preparedness for college and university students. A two-step procedure was applied for this regression analysis with socio-demographic variables loaded in to the regression first (including age, ethnicity, major, year in school etc.) as separate and then composite variables and experiential variables (including international experience, volunteer experiences, life experiences, and other experiential factors) were loaded in the second step individually. These multivariate analyses were conducted for the overall engineering global preparedness latent construct as well as individual subscales of the Engineering Global Preparedness Index (EGPI) [28].

Numerous significant findings were noted via the multivariate regression analyses. The results indicate that international experiences were highly predictive of engineering global preparedness in the study sample. In particular, both participants who reported that they were not yet U.S. citizens ($M = 3.26$, $SD = 0.47$, $\beta = 0.194$, $p < 0.01$) and having a student VISA ($M = 2.97$, $SD = 0.40$, $\beta = 0.256$, $p<0.01$) was highly predictive of high global engineering ethics. In addition, living in another country between one and three years was highly predictive of higher levels of global engineering ethics ($M = 3.00$, $SD = 0.42$, $\beta = 0.131$, $p < 0.05$). The results also revealed that being foreign born and not yet a U.S. citizen was a predictor of higher levels of engineering community connectedness ($M = 2.82$, $SD = 0.71$, $\beta = 0.146$, $p < 0.05$). These international experiential variables predicted particular aspects of engineering global preparedness in this study.

Interestingly, the regression results indicated that students representing "dominant" ethnic groups (European American in this study's case as it is a US university sample) held lower levels of engineering global-centrism ($M = 1.53$, $SD = 0.59$ $\beta = -0.203$, $p = 0.06$). Importantly, low levels of engineering global-centrism negatively predicted overall global preparedness in the study. This may be indicative of and supported by diversity related literature that dominant groups often are not "required" to engage in cultural altruistic behaviors routinely [31, 25] because they represent groups that dominate and are more often in power in higher education settings. While this phenomenon is often not overtly represented in diversity and cross-cultural studies, Banks [31] and colleagues have noted such population difference in occurrence.

In terms of global engineering efficacy, the regression results indicated an inverse relationship between engineering efficacy and being an international student ($M = 3.01$, $SD = 0.41$, $\beta = -0.215$, $p < 0.05$). This finding may be attributed to fundamental differences in educational systems, structures and pedagogical practices between some international students' home country and United States university systems, which may, in turn, contribute to lower global engineering efficacy.

Lastly, the regression analyses indicate that studying abroad in a culture different from the participant students' culture of origin was predictive of high levels of overall engineering global preparedness ($M = 3.30$, $SD = 0.22$, $\beta = 0.177$, $p < 0.05$). This indicates that exposure to different cultures and experiences positively impacts global preparedness. This finding is supported by literature on global citizenry [25, 28]. Importantly, these results suggest that engineering academic programs should develop engineering students capable of performing competently in engineering professions and those who can communicate effectively with other professionals in the globalized world through an experience that provides on-the-job training coupled with extensive cultural preparation [15]. It is also indicative that global community connectedness can be expanded by engaging students in longitudinal (beyond 3 weeks) international experiences, which may explain why studying abroad was found to be predictive of high levels of overall engineering global preparedness in this study.

4. Discussion, implications and future work

This multi-university engineering education study using a newly designed Engineering Global Preparedness Index provides engineering educators with insight as to the ''soft'' or ''profession'' skill areas [14, 17–19, 32] that must be provided in terms of training, education and experiences for engineering students if they are to be fully prepared to work in global workforces, the wave of future engineering employment. The described results, comparisons, and predictive factors succinctly inform engineering education pedagogical practices both within and beyond engineering schools' classroom walls. The EGPI is an important tool for measuring engineers' readiness for global workforces that can be applied across universities at large scale. While the results presented for this study do not claim ''causality'' in terms of links between programs and index results, given the robust sample in the study, the correlational and regression results presented indicate connections both between experiential and socio-demographic factors associated with engineering global preparedness and therefore the EGPI provides engineering educators with a promising measure for impact of program deliberately attempting to prepare future engineers for global workforces. This index can be used with diverse engineering students in their diverse majors within engineering as was indicated by this study's population. The study informs engineering education pedagogical practices both in formal (classrooms and programs) and informal settings and can also lead to engineering education interventions that will improve college and university students' preparedness for global engineering workforces.

This study is modestly limited both by its sample in terms of size and diversity, and by the level of granularity that was queried in the background section of the instrument used. In other words, future research should include greater specificity in questioning students about their experiences inside and outside of classrooms that may influence their preparedness for global engineering workforces.

5. Conclusions

This study represents one of the first of its kind that explores the relationships between engineering undergraduate and graduate students' experiences and socio-demographic factors and their preparedness for global workforces. The results indicate that as students become more advanced in their academic experiences, their engineering global preparedness improves. Providing students with international experiences was found to positively influence global preparedness as well. The study sets future direction as to the types of pedagogical and study abroad experiences that engineering faculty may provide for students to better prepare them for global engineering workforces.

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Gisele Ragusa, PhD is an associate professor at the University of Southern California (USC) in the Viterbi School of Engineering in the Division of Engineering Education. She co-directs USC's STEM Education and Research Consortium. Her research interests and areas of expertise include: engineering education, college access, STEM teacher education and retention, literacy education, content literacy, and special education as well as assessment and measurement in STEM education. She teaches courses in research design, measurement theory, critical pedagogy in STEM and courses in learning and instructional theory. She has extensive expertise in assessment, psychometrics, advanced quantitative analyses, and multimodal research design. Prior to joining USC, Dr. Ragusa held an appointment as an assistant professor in special education and bilingual education at California State University, Northridge in addition to a faculty position at Pacific Oaks College. She is active in many professional associations in the, engineering education, STEM education, program evaluation and special education fields. She has been the principal investigator on several federal grants through the US Department of Education, the National Institute of Health, and the National Science Foundation.