

Cross-Cultural Competence: A Comparative Assessment of Engineering Students*

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As many recent reports and accreditation guidelines acknowledge, engineers are increasingly expected to work effectively across countries and cultures. This trend has helped establish and legitimate a mandate for providing more engineering students with educational experiences that enhance their global competency. However, there remain questions about what global competency means, and how it might develop and be assessed. This study addresses these themes by first arguing that cross-cultural competence is a key facet of global competency for engineers. It then presents an empirical study of US engineering students (n=147), using the Miville-Guzman Universality-Diversity Scale—Short form (MGUDS-S) to determine their openness to and appreciation of cultural diversity. An analysis of the dataset reveals significantly higher levels of cross-cultural competence among three groups of students opting into global engineering programs as compared to a baseline group of first-year students. Additionally, a pre/post-experience study focused on one of the global groups (n=55) indicates that an immersive research experience abroad significantly enhanced the cross-cultural competence of participating students. Also reported are variations in results based on factors such as gender and prior experience living abroad. The paper concludes by discussing some practical implications of our findings and opportunities for further research.

Keywords: assessment; cross-cultural competence; global competency; global engineering education; IREE; MGUDS-S; UDO; Universal-Diverse Orientation

1. Introduction

Efforts to internationalize engineering education can be traced back to at least the 1950s [1]. Yet this movement has intensified since the mid-1990s, especially amidst workforce diversification trends, the increasingly global character of corporate enterprises and educational institutions, and growing awareness for the social and cultural aspects of engineering practice. As evidenced by numerous reports from both industry and academic stakeholders, engineers and other technical professionals are increasingly expected to work effectively across countries and cultures [e.g. 2–7]. In response, leading professional bodies around the world have acknowledged the importance of various aspects of global competency in accreditation guidelines and curricular recommendations for engineering degree programs.

While such developments have helped establish and legitimize a contemporary mandate for global engineering education, important questions remain unanswered. For example, what kinds of educational experiences best prepare future engineers for global practice, from on-campus activities and short international field trips to immersive, long-term programs involving research or study abroad

[8, 9]? How can higher education institutions expand quality global programs when also faced with strained institutional budgets, significant travel expenses, and a long history of low participation by engineering students [1, 6]? And what does global competency mean for engineering students and professionals, and how might it be systematically assessed [8, 10, 11]?

This paper is part of a growing body of scholarly literature addressing such questions. It begins by engaging definitional themes, such as arguing that cross-cultural competence is a key facet of global competency for engineers. An empirical study of cross-cultural competence is then presented to characterize the extent to which select groups of engineering students are aware of and appreciate cultural similarities and differences. The primary instrument used for this research was the Miville-Guzman Universality-Diversity Scale—Short form (MGUDS-S), which measures a construct called Universal-Diverse Orientation (UDO). Our study addresses two main research questions:

1. Are there significant differences in openness to and appreciation of cultural diversity between baseline groups of engineering students and those who opt into global engineering programs?

2. Does an immersive global educational experience affect openness to and appreciation of cultural diversity for participating engineering students?

To address these questions, we begin by reviewing various definitions of global competency, as well as relevant prior research on cross-cultural competence and related topics in engineering education. We then present our study methods and findings, including research hypotheses proposed and tested using multiple statistical techniques for data analysis. The final sections of the paper discuss our results, including some practical implications and directions for future research. We intend that this study will improve our understanding of levels of cross-cultural competence among engineering students, support development of more effective global programs and experiences, and stimulate further research.

2. Literature review

2.1 *Global engineering and cross-cultural competence*

Accreditation guidelines serve as one important source of evidence regarding the perceived importance of cross-cultural competence and related attributes for engineering graduates. In some cases, these abilities can only be inferred from general statements related to the global dimensions of professional practice. The EU-based EUR-ACE framework, for example, simply indicates that second cycle (or Masters degree level) graduates should have the ability to “work and communicate effectively in national and international contexts” [12, p. 17]. The US-based ABET EC2000 framework is even less specific, stating only that graduates of engineering programs should “understand the impact of engineering solutions in a global, economic, environmental, and societal context” [13, p. 3]. While these recommendations are suggestive, their ambiguity makes it difficult to define, develop, and assess such outcomes in the context of engineering courses and programs.

Other guidelines and reports are more explicit about desirable attributes for global engineers, including as related to teamwork and cross-cultural skills. Engineers Australia (EA), for example, mandates that licensed professional engineers should: have “[u]nderstanding of social, cultural, global, and environmental responsibilities”; “function effectively as an individual and in multidisciplinary and multicultural teams”; “[r]ecognise the value of diversity”; and “develop effective interpersonal and intercultural skills” [14, pp. 23, 27]. Along similar

lines, the American Society of Civil Engineer’s *Civil Engineering Body of Knowledge for the 21st Century* recommends “Globalization” as one of many professional outcomes for U.S. civil engineering graduates [15, p. 144]. This same report adds that civil engineers should have the ability to “[o]rganize, formulate, and solve engineering problems within a global context” and “[a]nalyze engineering works and services in order to function at a basic level in a global context” [15, p. 144]. In addition, it echoes some of the themes evident in the EA guidelines, such as being able to “work alongside and report to people from other cultures” and “meet challenges that cross cultural, language, legal, and political boundaries while respecting critical cultural constraints and differences” [15, pp. 134, 163].

Cultural adaptability is also frequently mentioned in discussions about “global competency,” an umbrella term often used to cover the full array of attributes required for effective global practice. In his review of previous studies and reports, for example, Rollins notes that most definitions of global competency recognize the importance of having *global knowledge* (i.e. an understanding of globalization trends and relevant historical details), *global skills* like cultural awareness and adaptability, and *global attitudes* such as openness and appreciation toward other cultures and belief systems [16]. Parkinson, on the other hand, reviews the literature to identify thirteen desirable attributes for globally competent engineering graduates, including “appreciate other cultures,” “communicate across cultures,” “work in diverse teams, and understand cultural differences in engineering practice” [11]. Even more broadly, Downey *et al.* propose that globally competent engineering students should have the “knowledge, ability, and predisposition to work effectively with people who define problems differently than they do” [8, p. 110].

As this overview indicates, cross-cultural competence is often viewed as an important attribute for global engineers. While definitions and terminology vary, this literature highlights a range of characteristics that can be located along a psychological spectrum with attitudinal (which includes affective or emotional components), behavioral, and cognitive dimensions. More specifically, we find an emphasis on *attitudes* like openness and respect toward other cultures, *behavioral* flexibility and adaptability in diverse cultural settings, and *knowledge* of cultural differences. As we discuss below, the MGUDS-S instrument is well aligned to measure such outcomes since its subscales probe these same three dimensions. First, however, it is important to review other empirical studies of cross-cultural competence in engineering education.

2.2 Assessing the cross-cultural competence of engineering students

In ongoing efforts to investigate the cross-cultural competence of university students in engineering and beyond, the Intercultural Development Inventory (IDI) has emerged as a prominent assessment tool. Based on a developmental model pioneered by Bennett, the IDI is a valid and reliable instrument designed to measure perceived and actual levels of intercultural sensitivity on a scale ranging from denial of cultural difference to defense/reversal, minimization, and finally acceptance and adaptation [17]. While many studies have reported IDI data, here we point to a few especially relevant examples. Georgia Tech, for instance, has published IDI results for incoming undergraduate students ($n=3,781$) to the school's College of Engineering [18]. IDI data have also been reported for 500 sophomore-level mechanical engineering students at Purdue University [19]. Both of these studies show higher levels of sensitivity for women compared to men, and tentatively indicate that students opting into long-term global programs tend to have higher IDI scores.

IDI has also been used to study changes in intercultural development resulting from global educational experiences. The Georgetown Consortium study, for example, used data from students in 61 different programs ($n=1,297$) to detect significant increases in IDI scores among students participating in a variety of study abroad programs [20]. However, attempts to study changes in IDI scores specifically among engineering students have been less successful. Research conducted at Worcester Polytechnic Institute (WPI), John Brown University, Michigan Technological University, and University of Michigan failed to identify significant gains for students in a variety of global educational programs [21–25]. Many of these studies suffered from small subject groups, significant variations in methods, and a failure to control for factors like gender, age, ethnicity, and prior international experience. These studies have also failed to account for non-linear developmental trajectories, i.e. when intercultural sensitivity regresses and rebounds over time [26]. Nonetheless, Georgia Tech's efforts to systematically collect and analyze IDI data is starting to generate more favorable results, with early reports indicating significant gains in scores for students completing various international programs [27].

Many other strategies have also been proposed for examining the cross-cultural competence of engineering students. Del Vitto, for example, has proposed investigating the "cultural intelligence" of students in global engineering programs by using instruments like the Cross-Cultural Adaptability

Inventory (CCAI) and Global Awareness Profile (GAP) test [28]. Researchers at the University of Michigan have explored use of both the Revised Ethnocentrism Scale and Personal Report of Intercultural Communication Apprehension (PRICA) [25]. However, no data have yet been reported from use of such instruments in engineering education.

Some researchers are creating new instruments for studying various aspects of global competency in engineering education and practice. Most notably, Ragusa's Engineering Global Preparedness Index (EGPI) is a 30-question survey with four subscales:

1. engineering ethics,
2. engineering efficacy,
3. engineering global-centrism,
4. engineering community connectedness [29].

Preliminary results have been reported for a multi-institutional pilot of EGPI with students ($n=493$) from six research universities, with the data showing that EGPI scores are in part predicted by socio-demographic characteristics and prior international experiences in work and life. However, no studies have yet reported changes in EGPI scores over time, or before and after certain kinds of learning experiences.

In engineering education, Bielefeldt and High pioneered use of MGUDS-S to study the cultural orientation of various groups of engineering students, with particular emphasis on civil and environmental engineering majors, and those participating in Project-Based Service Learning (PBSL) experiences [30, 31, 32]. Researchers outside engineering education have also used MGUDS-S to measure changes in cultural orientation resulting from specific learning experiences, albeit with mixed results. Longerbeam and Sedlacek, for instance, used this instrument to examine the impacts of service-learning programs on participating students, but found no significant changes in their cultural outlook [33]. On the other hand, Seaman *et al.* found small but significant changes in MGUDS-S scores among youth aged 13–19 ($n = 74$) who participated in an informal diversity education program [34]. It is also worth noting that most research involving MGUDS-S has focused on subjects in the US, with the exception of a handful of studies in Australia and the UK [e.g. 35, 36].

3. Methods

3.1 Subject groups and research contexts

The subject groups for this study included students recruited from the following courses and programs:

1. ENGR195H, Creativity and Innovation in Engineering Design I, a first-year honors engineering course (n = 50),
2. Maymester China, a one-month study abroad program (n = 24),
3. Global Engineering Alliance for Research and Education (GEARE), a comprehensive study and internship abroad program (n = 16),
4. International Research and Education in Engineering (IREE) 2010 China, a 10–12 week research abroad program (n = 57).

The first-year honors engineering group was selected as an appropriate baseline for comparison with the other groups. Students from the first three groups were enrolled at Purdue University, while those in the fourth group (IREE) were from a variety of US universities. Demographic characteristics are summarized in Table 1. Appropriate human subjects procedures were approved and followed under Purdue IRB protocol #1004009220.

Since the pre/post-experience data presented in this paper are focused on the IREE participants, it is worth providing some additional background information about this program. Funded by NSF and administered by Purdue University, the IREE 2010 China program sent 58 US engineering students to China for intensive 10 to 12 week research experiences in university and industry laboratories [37]. In addition to promoting research collaborations between the US and China, the program was designed to enhance the global competency of participating students. To support this objective, the IREE team delivered a comprehensive two-week orientation program that included introductory

Mandarin language training, as well as content related to general Chinese history and culture, Engineering Cultures China, and cross-cultural etiquette. As further scaffolds for learning, students were asked to complete two reflective writing activities while in China and participate in a 2-day re-entry meeting. While these components are described in more detail in other publications [e.g. 37], enhancing the cross-cultural competence of participants was a centrally important part of the program's major objectives.

3.2 Study instrument

The original Miville-Guzman Universality-Diversity Scale (M-GUDS) is a 45-item instrument designed to measure an individual's Universal-Diverse Orientation (UDO), defined as "an attitude of awareness and acceptance of both similarities and differences that exist among people" [38]. It uses three subscales to assess affective, behavioral, and cognitive dimensions of UDO. The development of the 15-item short form version of the survey (MGUDS-S) led to a minor refinement of the instrument subscales, which were defined as:

1. seeking *diversity of contact* with others (behavioral),
2. having *relativistic appreciation* of oneself and others (cognitive),
3. degree of emotional *comfort with differences* (affective) [39].

One sample question for each subscale is presented in Table 2.

The survey uses a six-point Likert scale ranging from strongly disagree to strongly agree, giving the

Table 1. Demographic characteristics for subject groups

Subject Group	ENGR195H	Maymester China	GEARE	IREE 2010 China
Description	First-year honors engineering course	1 month study abroad program (in China)	7+ month study and internship abroad program (multiple destination countries)	10-12 week research abroad program (in China)
Number of Students (n)	50	24	16	57
Academic Level	First-year: 34 Sophomore: 13 Junior: 3	First-year: 1 Sophomore: 9 Junior: 11 Senior: 5	Junior: 15 Senior: 1	First-year: 1 Sophomore: 2 Junior: 4 Senior: 14 Masters: 18 Doctoral: 18
Gender (No. of M/F)	44 / 6	18 / 8	11 / 5	32 / 25
Ethnicity (No. in each category)	White/Caucasian: 41 Asian: 4 Other/Multiracial: 5	White/Caucasian: 20 Asian: 4 African American: 1 Other/Multiracial: 1	White/Caucasian: 14 Asian: 1 African American: 1	White/Caucasian: 34 Asian: 13 African American: 2 Hispanic: 1 Other/Multiracial: 7
No. Who Have Lived Abroad (2+ months)	10	4	4	32

Table 2. Sample MGUDS-S survey questions [39]

Subscale (Dimension)	Sample MGUDS-S Survey Question
1—Diversity of Contact (Behavioral)	1. I would like to join an organization that emphasizes getting to know people from different countries.
2—Relativistic Appreciation (Cognitive)	2. Persons with disabilities can teach me things I could not learn elsewhere.
3—Comfort with Differences (Affective)	3. Getting to know someone of another race is generally an uncomfortable experience for me.

instrument a scoring range of 15–90 (if scale three is reverse scored), and with higher scores indicating higher UDO. The development of MGUDS-S has been very rigorous, and evidence of its reliability and validity is strong, including among college students [39, 40, 41]. The MGUDS-S instrument was a good fit for this study because it can be completed relatively quickly, is freely re-usable in unmodified form, and covers three major dimensions of cross-cultural competence. A separate survey form was also used to collect demographic details from our subjects, as summarized in Table 1.

3.3 Data collection and analysis

Data were collected from the first-year honors engineering students toward the end of their first academic semester. All other subjects completed the surveys during one of the first orientation meetings for their global program. For the IREE group, the MGUDS-S instrument was administered a second time more than five months later, at a mandatory re-entry meeting ($n = 55$). This event was held more than a month after participants had completed their research internships and returned to the US, allowing them to gradually assimilate their global experience into their daily lives and re-adjust culturally, socially, and psychologically. Participants also completed other surveys at the event, but MGUDS-S was the only instrument used to assess cross-cultural competence. All data were collected using paper forms, except for twenty IREE participants who submitted the pre-experience survey online. Data entry and analysis was performed using Microsoft Excel and SPSS, using multiple statistical techniques as described below. Preliminary results related to the first research question were presented in a previous conference paper [42].

3.4 Study hypotheses

To address our first research question, a set of hypotheses were formulated and tested with respect to the total MGUDS-S score, as well as each subscale score:

- **H1.** The IREE participants present greater openness to and appreciation of cultural diversity than the first-year engineering students
- **H2.** The Maymester participants present greater

openness to and appreciation of cultural diversity than the first-year engineering students.

- **H3.** The GEARE participants present greater openness to and appreciation of cultural diversity than the first-year engineering students.

To address our second research question, we used the IREE group as a targeted study sample and formulated and tested one main hypothesis with respect to the total MGUDS-S score, as well as each MGUDS-S subscale, and considering factors such as gender, academic level, ethnicity, and prior international experience:

- **H4.** The IREE participants present greater openness to and appreciation of cultural diversity after the IREE experience.

4. Findings

Our findings begin with a descriptive comparison of MGUDS-S scores across the four subject groups. We then present the outcomes of our hypothesis tests to discuss whether statistically significant differences in scores were found across the four groups. Finally, we report pre/post MGUDS-S results from the IREE group before and after their global experience, and present evidence showing how various factors appear to impact their performance. The paper concludes by discussing some practical implications of our findings and opportunities for further research.

4.1 Descriptive summary of MGUDS-S results by group

To begin addressing the first research question, descriptive statistics were compiled for the MGUDS-S subscale and total scores for all subject groups, as summarized in Table 2. As indicated, all three of the global groups in our study had higher average scores as compared to the baseline group ($\mu = 66.4$, $\sigma = 8.22$), increasing according to program intensity and duration, from Maymester China ($\mu = 70.4$, $\sigma = 8.55$) to GEARE ($\mu = 73.1$, $\sigma = 5.66$) and IREE ($\mu = 70.0$, $\sigma = 6.68$). The GEARE and IREE results are also characterized by smaller scoring ranges and standard deviations, suggesting greater homogeneity within these groups compared to the other two.

Table 3. Descriptive statistics for MGUDS-S subscale and total scores, by subject group

Group	N	Subscale 1: Diversity of Contact			Subscale 2: Relativistic Appreciation			Subscale 3: Comfort w/ Differences			Total MGUDS-S		
		μ	σ	Range	μ	σ	Range	μ	σ	Range	μ	σ	Range
ENGR195H	50	19.6	4.34	11–30	22.6	3.13	16–29	24.1	3.81	14–30	66.4	8.22	47–85
Maymester	24	22.0	4.53	13–29	23.0	3.39	16–29	25.6	3.21	18–30	70.4	8.55	47–87
GEARE	16	24.3	2.96	19–29	23.6	1.86	21–27	25.1	2.42	20–30	73.1	5.66	64–83
IREE	57	23.9	3.05	18–30	24.4	3.27	16–30	25.6	3.03	15–30	74.0	6.68	57–90
All Groups	147	22.2	4.24	11–30	23.5	3.19	16–30	25.1	3.33	14–30	70.7	8.11	47–90

As indicated in Table 3, the trends observed in the overall MGUDS-S scores are generally consistent across the three subscales. First, students in all three global program groups had higher average subscale scores compared to the baseline group. In addition, the subscale scores tend to increase according to the intensity and duration of each global program, although the largest differences are evident on Subscale 1 (Diversity of Contact). Further, the difference between the GEARE and IREE groups is small, which is expected since both programs are of similar intensity and involve lengthy sojourns abroad.

4.2 Hypotheses testing for MGUDS-S multiple group comparisons

We proposed and tested H1, H2 and H3 with respect to the total MGUDS-S score and each MGUDS-S subscale. Multiple comparisons of group means t-tests were performed for the testing of hypotheses. For each set of hypotheses, three one-tailed, planned contrasts were performed to compare results for each group of global program students (Maymester, GEARE, and IREE) with the baseline first-year student group (ENGR195H). Table 4 summarizes the test results, showing only significant outcomes.

As indicated, group comparisons of the total MGUDS-S scores concluded with three statistically significant results in support of hypotheses H1, H2 and H3. In summary, the students entering all three global programs demonstrated higher average

levels of openness to and appreciation of cultural diversity as compared to the baseline group of first-year engineering students. Significant results were also found when each MGUDS-S subscale was evaluated across the four groups, with all three global groups demonstrating broader Diversity of Contact (Subscale 1) than the baseline group, and the IREE students indicating higher levels of Relativistic Appreciation and Comfort with Differences (Subscales 2 and 3) as compared to the first-year students.

4.3 Pre/post-experience MGUDS-S results for IREE participants

To address the second research question, this study proposed and tested hypothesis H4 with respect to the MGUDS-S total and subscale scores for all IREE participants who submitted valid pre/post-experience results ($n = 53$ for the total and subscale 1 scores; $n = 55$ for subscales 2 and 3). To test the hypotheses more accurately and precisely, we controlled for other relevant factors. Mixed factorial ANOVA was performed with one repeated measure independent variable: pre-post IREE experience intervention in students' cultural orientation. In addition, four between-group independent variables were considered: gender (male vs. female), academic status (undergraduate vs. graduate), ethnicity (white/Caucasian vs. other), and prior international experience (subjects who had previously lived or visited a country outside the US for two or more months vs. those who had not). The dependent

Table 4. Subject group comparisons for MGUDS-S Subscale and total scores, significant results only

MGUDS-S Scale	Contrast	Value of Contrast	t	Sig. (2-tailed)*	Decision
Total	Maymester vs. ENGR195H	4.0367	2.177	0.031	Significant
	GEARE vs. ENGR195H	6.6825	3.115	0.002	Significant
	IREE vs. ENGR195H	7.5849	5.241	0.000	Significant
Subscale 1	Maymester vs. ENGR195H	2.3583	2.127	0.039	Significant
	GEARE vs. ENGR195H	4.7125	4.903	0.000	Significant
	IREE vs. ENGR195H	4.3474	5.919	0.000	Significant
Subscale 2	IREE vs. ENGR195H	1.7811	2.939	0.004	Significant
Subscale 3	IREE vs. ENGR195H	1.4565	2.283	0.024	Significant

*Significance defined as any result with $p < 0.05$.

Table 5. Pre/post-IREE tests of MGUDS-S within and between effects of subjects

MGUDS-S Scale	Source	Type III Sum of Sq.	df	Mean Square	F	Sig.*	Decision
Total	1. IREE	134.005	1	134.005	9.811	0.003	Significant
	2. IREE*Gender*PriorIntExp	102.680	1	102.680	7.518	0.009	Significant
	3. Gender	325.661	1	325.661	4.713	0.036	Significant
Subscale 1	1. Gender*PriorIntExp	64.964	1	64.964	5.032	0.031	Significant
	2. IREE*Gender*PriorIntExp	15.648	1	15.648	5.800	0.021	Significant
Subscale 2	1. IREE	43.599	1	43.599	9.944	0.003	Significant
	2. IREE*Gender*AStatus	22.573	1	22.573	5.149	0.029	Significant
	3. Ethnicity*PriorIntExt	104.929	1	104.929	7.636	0.009	Significant
Subscale 3	1. Gender	67.873	1	67.873	5.172	0.029	Significant

* Significance defined as any result with $p < 0.05$.

variable is students' MGUDS-S scores before and after their IREE experience. Table 5 presents a summary of statistically significant test results, with consideration of main effects and meaningful interaction effects among variables.

The results reveal statistically significant increases in IREE 2010 participants' overall UDO and Relativistic Appreciation (Subscale 2), which supports H4. For all study subjects, mean total scores increased from 73.6 to 76.4, as illustrated in Fig. 1. In addition, other factors and interactions of factors had significant effects on the students' openness to and appreciation of cultural diversity as measured by MGUDS-S. Particularly, the interaction effect of gender, prior international experience, and the IREE experience effected gains in both diversity of contact (Subscale 1) and total scores, as discussed in more detail below. Additionally, the interaction effect of gender and academic level impacted pre/post-IREE changes in relativistic appreciation (Subscale 2) scores, with female graduate students having much larger gains than their

undergraduate counterparts, and male undergraduate students indicating larger gains compared to their graduate counterparts.

Controlling for the IREE experience, gender differences were confirmed in the students' total MGUDS-S and Comfort with Differences (Subscale 3) results, with significantly higher scores for women. Finally, the interaction of ethnicity and prior international experience were relevant factors for Subscale 2, where white participants without prior international experience indicated higher levels of relativistic appreciation than those with prior international experience. Participants of all other races with substantial prior international experience demonstrated more relativistic appreciation than their peers who reported previous global experience.

Table 6 provides further insights about the interaction of gender, prior international experience, and the IREE intervention on MGUDS-S total and Diversity of Contact (Subscale 1) scores. First, we find that male IREE participants who had not

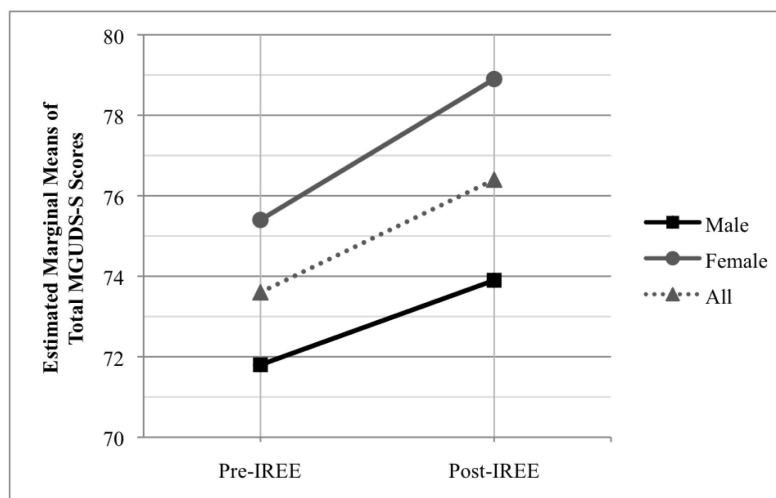


Fig. 1. Pre/post-IREE differences for MGUDS-S total score by all participants and gender.

Table 6. Sub-Group Means for MGUDS-S Total and subscale 1 scores by gender, prior experience living abroad, and pre/post-IREE

Gender	Prior Experience Living Abroad (2+ months)	Pre/Post Status	Mean—Total Score	Mean—Subscale 1
Male	Global subjects	Pre-IREE	71.1	24.6
		Post-IREE	75.5	26.0
	Non-global subjects	Pre-IREE	72.5	22.8
		Post-IREE	72.3	21.9
Female	Global subjects	Pre-IREE	76.8	24.8
		Post-IREE	77.6	25.2
	Non-global subjects	Pre-IREE	74.1	25.0
		Post-IREE	80.1	26.9

previously lived abroad indicated a slight decrease in their UDO after the IREE experience, while male subjects with prior international experience showed a notable increase in their MGUDS-S Subscale 1 and total scores. Conversely, female IREE participants lacking prior international experience indicated bigger gains in overall cultural outlook as compared to their female peers who had previously lived abroad. Figure 2 illustrates these patterns. Similar trends are also evident in Subscale 1, at statistically significant levels. In the section that follows we present possible explanations for some of these findings.

5. Discussion

Our results lead to four points of discussion. First, MGUDS-S scores from our baseline group ($\mu = 66.4$, $\sigma = 8.22$) are generally consistent with other studies of undergraduate students at US universities. For example, a study of first-year undergraduates at James Madison University ($n = 101$) reported a mean total score of 66.5 ($\sigma = 9.71$) [43]. Similarly, a sample of mainly female students (83 percent) at the junior or senior level (95 percent) from a regional university in Southern California had an average score of about 67.7 [41]. Another study found

moderately higher average scores among first-year students at the University of Illinois at Urbana-Champaign ($n = 589$, $\mu = 69.0$), with those identifying as Black/Latino scoring highest ($n = 116$, $\mu = 71.9$), followed by Asian Americans ($n=158$, $\mu = 69.9$) and Whites ($n = 315$, $\mu = 67.5$) [44]. Our results help establish that first-year engineering students at Purdue tend to have similar levels of openness to and appreciation of cultural diversity compared to other undergraduate populations.

Second, our study reveals significant differences in MGUDS-S total scores between students in the baseline group and those who opt into global programs. While these differences are not drastic—covering a range of about 7.5 points between the lowest and highest scoring groups—they are generally consistent across the subscales. We propose that these differences are indicative of self-selection, where students enroll in certain types of global programs (differentiated by duration and level of immersion) in part based on their levels of cross-cultural competence. This finding is synergistic with other research studies. For instance, Aljubran found that undergraduate business administration students ($n = 192$) with higher UDO were more likely to accept a hypothetical expatriate work assignment [45]. Additionally, a

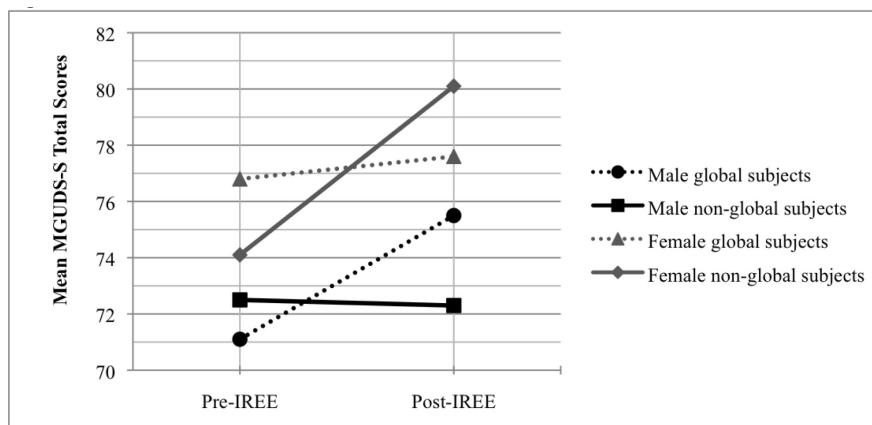


Fig. 2. Pre/post-IREE change in MGUDS-S total scores by gender and prior experience living abroad.

recent study of American college students ($n = 2,772$) identified a positive relationship between intent to study abroad and an “openness to diversity” construct, with the factor strongest among men [46]. Likewise, male students entering Georgia Tech’s International Plan had significantly higher average IDI scores compared to their non-IP counterparts [18].

These findings have a number of implications for those who plan and oversee global engineering programs and related initiatives. To begin, students with lower levels of cross-cultural competence are less likely to participate in highly immersive, long-term global programs that require greater independence. Hence, there remain many untapped opportunities to develop and expand “stepping stone” experiences that help students begin improving their openness to and appreciation of cultural diversity. These might include relevant activities “at home,” such as coursework or extracurricular experiences, or short-term academic travel programs. In addition, many different kinds of global educational programs might strategically target recruitment efforts at populations with lower levels of cross-cultural competence, e.g. men and women who have not previously lived abroad. Salisbury *et al.* similarly recommend “targeted marketing strategies that recognize and account for key differences between women and men in terms of both pre-college and in-college experiences that affect the formation of aspirations to study abroad” [46, p. 635].

As a third major point of discussion, we find significant increases in mean MGUDS-S total scores for students in the IREE 2010 China program. This outcome is especially notable since participants entered the program with relatively higher scores compared to other groups. We believe our study is one of the first to detect significant changes in UDO resulting from participation in a substantial learning experience abroad. Some additional confirmation of these findings can be found in self-efficacy evaluation data collected from the IREE re-entry meeting, including responses to global competency survey questions adapted from Downey *et al.* [8]. Of 55 respondents, for example, 26 agreed and the remaining 29 strongly agreed with the statement: “I will be able to work more effectively in diverse and multicultural environments.”

We also observe that the IREE program’s intentional focus on developing various aspects of global competency helped enable these gains in cross-cultural competence. From orientation to re-entry programs, we engaged students with reflective and experiential learning opportunities that encouraged them to identify, understand, and appreciate cultural differences. These findings are consistent with

pre/post studies involving other assessment instruments. Ongoing research at Georgia Tech, for instance, reveals significantly higher IDI scores for undergraduate students who complete some or all requirements of the school’s IP program, as compared to their non-IP peers [27]. Likewise, the Georgetown Consortium study found statistically significant pre/post increases in IDI scores for students participating in study abroad programs compared to a control group [20]. This same study also found that the largest gains in IDI scores were observed among students who participated in study abroad programs that were 13–18 weeks in duration, and they concluded that “students learn most effectively abroad given proactive learning interventions” in well organized programs [20, p. 2].

Fourth and finally, we observe that gender and prior international experience were especially important factors in our study. Women entered the IREE program with higher average MGUDS-S scores compared to their male counterparts. This finding is consistent with recent studies by Spanierman *et al.* [44] and Singley and Sedlacek [40], who discovered similar gender differences in UDO among undergraduate students, and research from Georgia Tech and Purdue showing higher IDI scores among female undergraduates [18–19]. Further, women in the IREE program had larger average gains in UDO compared to men. While similar studies using MGUDS-S have not been published, the Georgetown Consortium study found that females who studied abroad had significant gains in intercultural development as measured by IDI, while the average scores for males fell slightly [20]. Regarding prior international experience, the Georgetown study only detected significant gains in IDI scores among study abroad participants who had lived in another culture for less than a year, or never.

Yet the interaction of gender *and* prior international experience has not been explored in previous research on cross-cultural competence. Our research reveals that the biggest gains in MGUDS-S scores occurred among women *without* prior experience living abroad, and men *with* such experience. We propose two explanations for this trend, the first nicely summarized by Vande Berg *et al.*: “Participants who have the furthest to go, in terms of their intercultural learning, experience the greatest change” [20, p. 55]. Following this logic, our results reveal greater *potential* for gains among all male participants, who across the board had lower pre-experience MGUDS-S scores, and women without prior international experience. Yet in order to more fully account for differences across these groups, further explanations are needed. We propose that time spent living abroad

acts as a priming mechanism for many men, predisposing them to gains in cross-cultural competence on subsequent sojourns. Women, on the other hand, appear predisposed to gains in cross-cultural competence regardless of prior experience, and therefore tend toward a different—and probably more rapid—developmental trajectory. While additional research is needed to probe such dynamics, a growing body of literature suggests that underlying factors such as higher levels of empathy and/or motivation among women could help explain these differences in scores [47].

6. Conclusions

Our findings and discussion lead to three major conclusions. First, MGUDS-S is an appropriate instrument for assessing the cross-cultural competence of engineering students, especially in the context of global engineering programs. In particular, we have demonstrated the utility of MGUDS-S in detecting different levels of UDO among students opting into global engineering programs of varying intensity, as well as measuring pre/post-experience changes in UDO for students participating in an intensive research abroad program. MGUDS-S also has the advantage of being relatively easy and quick to administer, and is freely available for use in its unmodified form.

Second, we recommend that instructors and administrators should be mindful that different levels of cultural awareness and appreciation exist among participants in global educational experiences, and should tune program activities accordingly. Customized or targeted instructional strategies that acknowledge rather than ignore this diversity may help enable and maximize gains in cross-cultural competence and other relevant learning outcomes.

Third and finally, our investigation reveals many opportunities for further research. More and larger studies are needed to build up baseline results and track trends in the cross-cultural competence of engineering students, including thorough use of MGUDS-S and other instruments, and with more focused attention on each associated dimension of competence (affective, behavioral, and cognitive). Research is also needed on the utility of these instruments across countries and regions. Additionally, our analysis represents an important step toward identifying and understanding how multiple factors interact to inhibit or enable different developmental pathways toward increased cross-cultural competence. While gender and prior international experience were especially notable in our study, factors like ethnicity and academic level call for further investigation. In addition to confirming

and theorizing about such interaction effects, this kind of research may inform the development of global programs that aim to both promote participation and maximize impacts among especially “resistant” populations, e.g. men with minimal prior experience abroad. Such efforts are needed to help more engineers prepare to work effectively in an increasingly diverse and globalized world.

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