Impacting Global Mindset Using International Case Studies

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1. Introduction

The global learner mindset, how engineers perceive and interpret the global environment, is assumed to be foundational in developing global engineering competence and skillsets. One example is how they define problems and formulate and implement solutions when working in an international setting. In this work, an international case study was developed for a quantitative analysis course as part of a broader research project investigating the relative strengths of global engagement interventions without extended international travel in helping engineering students develop a global learner mindset. Therefore, this study aspires to expand research into the development of global competencies in engineering beyond international study-abroad experiences. We focus on the development of a holistic and inclusive global engineering education process that can reach all engineering students, even when institutions are not able to provide extended opportunities to immerse them in other cultures, either because of global crises (such as a pandemic or violent conflicts), financial limitations, or the need for more sustainable methods of globally connecting.

2. Background and Motivation

Global Engineering Competency (GEC) has been defined as the attributes uniquely or especially relevant for cross-national/cultural requirements in the engineering practice [1]. The global nature of the engineering profession has led to a demand from industry for the development of GEC in future generations of engineers [1] - [6]. Thus the development of GEC is an important part of the formation of engineers [7]. Our study acknowledges that GEC manifests both internally and externally in engineers. Internal manifestations center on the engineer's perspective and worldview (mindset), which influence the external manifestations that take the form of appropriate and effective communication and behaviors (skillset).

The focus on the development of a global mindset, instead of global skillset, is more commonly found in engineering education literature. Mindset refers to how one perceives the world, one's beliefs and motivations, whereas skillset refers to how one behaves based on their knowledge, capability, and mindset [8]. A global mindset can include an awareness and openness to differences, an understanding of how their actions impact local and global communities, and an interest in collaboratively addressing global issues [9]. A global engineering skillset can include capabilities important to global engineering practice such as language and cultural skills, teamwork skills, knowledge of international business and engineering cultures, and knowledge of international variations in engineering practice [10]. Importantly, Deardorff [11] and Gupta's [12] research has found mindset to be as important, if not more so, than skillset as a success indicator for leaders and employees. This research project focuses specifically on developing a global learner mindset, with the expectation that improving the global learner mindset will lead to an increased global engineering skillset in engineering students.

Intercultural immersive experiences like study abroad programs have a significant impact on developing the global engineering competencies of students, as found through a formal assessment process [13], [14]. Unfortunately, Parkinson [15] found these experiences are not accessible to a large number of engineering students because of travel costs, the duration of the international immersion experience, and its impact on tightly sequenced engineering curriculums

and internship/co-op opportunities. The goal of this research is to assess global engagement interventions that are focused on developing students' global engineering competence without requiring extensive travel to other countries. Most intercultural competence research has focused on developing the global skillset of students through study abroad or lengthy immersive experiences. This research fills the gap in global engineering education related to the development of an engineering education process that is accessible to all engineering students, even when full immersion in other cultures is not possible.

Case-based instruction is one form of travel-free active learning that engages students and allows them to better relate course content to real-world problems. Studies have shown that the use of case-based instruction in engineering exposes students to the complexities of real-world problems (incomplete data, multiple sources of information, accounting for conflicting issues and contending with societal problems) and also provides the socio/cultural context that cannot be taught through standard procedure-focused lectures [16], [17]. Recent studies, including Knight et al. [18], have shown that short-term projects can effectively increase student's GEC by helping them recognize global challenges, technological problems, and contextual influences on engineering practices.

3. Methodology

A minimally intensive global engagement case study intervention was developed and piloted during the Spring 2023 semester. Improvements to the intervention were made based on preliminary results and the next implementation of the intervention occurred during the Spring 2024 semester. Pre and post assessment data was collected using the Global Engagement Survey (GES) instrument, a multidimensional assessment that measures multiple outcomes to better understand relationships between experiential learning program factors and global learning goals.

3.1. Implementation

An internationally-based case study was presented within a quantitative analysis course in an undergraduate industrial engineering technology program. The course presents an introduction to the mathematical techniques used to support decision making and managerial analysis. Content includes calculus based probability and statistics theory, decision theory, forecasting, linear programming, and queuing theory. Through this class, students are exposed to multiple decision making scenarios common to practicing engineers and the appropriate tools and approaches used to find the best solutions.

3.2. Participants

Fifteen students participated in the intervention including 10 males and 5 females. Twelve of the students identified as white. Thirteen of the students were enrolled in the Industrial Engineering Technology program and were required to take the course; the remaining 2 students were enrolled in the Mechanical Engineering Technology program and were taking the course as an elective. Class ranking included 1 sophomore, 9 juniors, and 5 seniors. Of the 15 students who participated in the intervention, 14 completed both pre- and post- GES surveys.

3.3. Case Study Scenario

Inspired by the historical seismic activity of the Middle East and the 2023 Turkey–Syria earthquakes, a case study was developed that applied concepts taught in the course (the transportation problem) to humanitarian engineering. The scenario was presented as follows:

"For the class project we will be developing a disaster relief plan to supply emergency relief supplies (such as water) to citizens of Turkey in response to a naturally occurring earthquake. To do this, we propose to use 4 - 7 distribution centers (DCs) spread out throughout the country to stockpile emergency supplies and then distribute them after an earthquake has occurred. *Where should we locate our DCs? What cities will the DCs need to supply? What quantity of supplies will each city need?*"

3.4. Procedure

The case study involved 5 assignments that students completed outside of class paired with 4 in-class discussion and work days where students shared what they learned and worked together to develop a network model. Research assignments introduced students to successful applications of humanitarian logistics, and required students to familiarize themselves with Turkey's geography and transportation infrastructure and the humanitarian relief efforts in response to the recent 2023 earthquake. For a 16 week semester, the schedule of assignments and work days is shown in Table 1. A brief description of each assignment is as follows.

- The Humanitarian Engineering Article Review Assignment required students to read an assigned article, [19] or [20], and determine: what is humanitarian logistics, what are prepositions facilities, and what part does transportation play in the solution?
- The Geography of Turkey Research Assignment assigned each student to one of Turkey's 7 geographical regions and asked them to identify its (1) major cities and their associated population, (2) seismic activity, and (3) airports, sea ports and train stations.
- The News Coverage of the 2023 Earthquake Assignment required students to find and submit 2 video and/or written news reports that covered the response to the 2023 earthquake.
- The DC Location Assignment required students to reflect on all the research they had done prior and make a preliminary list of criteria that should be considered when selecting DC locations for our project.
- The Transportation in Turkey Research Assignment required students to calculate a unit cost (per pound per mile) to transport supplies using one of three modes of transportation: roads (cars and trucks), air (helicopter and planes) or railway (trains). Students were assigned to 1 of 3 groups, each group was assigned a specific mode of transportation. Groups were required to identify a reasonable capacity (in pounds) for their mode of transportation and then use it along with their unit cost to calculate an estimated cost to ship 1 pound of supplies from each DC location to each serviceable city in Turkey.

Class discussion and work days allowed students the opportunity to reflect on their research, make joint decisions about the best locations for storage facilities and work together to find empirical data. At the end of the case study, students were asked to submit a written reflection by responding to the following prompts: Were you surprised by the results? What did you like about this project? What did you not like about this project? Was there anything you learned about Turkey, humanitarian engineering, or the transportation problem? And finally, how would you improve this project for future classes?

Table 1: Schedule of assignments and class days for the case study implemented in Spring ‘24

Item	Purpose	Assigned	Due (*Occurred)
Humanitarian Engineering Article Review Assignment	The purpose was to expose students to humanitarian logistics. Successful completion should result in a better understanding of how the transportation problem can be used as part of humanitarian logistics.	Week 3	Week 4
Geography of Turkey Research Assignment	The purpose was to research the geography and demographics of Turkey.	Week 3	Week 4
Class Discussion Day	We discussed the articles that the students read and what they discovered about the geography of Turkey.		Week 4*
News Coverage of 2023 Earthquake Research Asgmt	The purpose was to expose students to the actual efforts and challenges experienced after the 2023 Turkey earthquake with respect to distribution and logistics of relief supplies.	Week 7	Week 8
DC Location Assignment	The purpose was to identify the criteria that should be used to select locations in Turkey for the DCs (supply nodes).	Week 7	Week 8
Class Discussion and Work Day	We discussed and agreed on criteria used to select DC locations in Turkey. Based on the criteria, we selected cities to locate the DCs in. All remaining cities in Turkey were classified as supply nodes in need of servicing.		Week 8*
Transportation in Turkey Research Assignment	The purpose was to identify the costs for traveling between all DCs and serviceable cities in Turkey for various modes of transportation (roads, air, and rail).	Week 10	Week 13
Class Work Day	Students worked in groups of 5 to identify costs for a designated mode of transportation between all DCs and serviceable cities in Turkey.		Week 11*
Class Discussion Day	Data collected by students were used to solve the network distribution of supplies from DCs to serviceable cities. Results were discussed.		Week 15*
Reflection	Students reflected on the project and its results.	Week 16	Week 16

3.5. Data Collection

Growth in the participating students' global learner mindset during the case study was assessed using the GES tool. The GES is a multi-institutional assessment tool aimed at distilling the relationship between program outcomes and student learning with respect to the global learning goals established by the AAC&U [14], [21]. The GES comprises eight scales within the areas of cultural humility, global citizenship, and critical reflection (Table 2) and has been demonstrated to provide adequate reliability within various university programs to ensure valid results within this research program. An initial pre-intervention survey was administered to students in week 3 of the semester and the post-intervention survey was administered in week 16. Surveys were administered by a graduate student during class time after the instructor left the room. Survey data was de-identified by the graduate student prior to analysis.

Table 2: GES Conceptualization of Global Learning Components and Scales as reported in [22]

Global Learning Component	Scale and Definition	
Cultural Humility *A commitment to critical self-reflection and lifelong re-evaluation of assumptions, increasing one's capacities for appropriate behaviors and actions in varying cultural contexts.*	Openness to Diversity	One's comfort with and interest in learning from and interacting across various forms of cultural difference.
	Cultural Adaptability	One's awareness of oneself as a cultural being, working to adapt behaviors appropriately for varying cultural contexts.
Global Citizenship *A commitment to fundamental human dignity, couched in a critically reflective understanding of historic and contemporary systems of oppression, along with acknowledgment of positionality within those systems; it connects with values, reflection, and action.*	Civic Efficacy	One's comfort and confidence in respect to one's own capacity to make meaningful civic contributions, locally and internationally.
	Political Voice	One's intentions to use one's civic voice.
	Conscious Consumption	One's professed intentionality regarding the use of one's own economic resources to advance just outcomes through consumer practices.
	Global Civic Responsibility	One's belief in shared human dignity, as expressed through a global sense of community membership and civic identity.
	Human Rights Belief	One's belief in fundamental human dignity, coupled with governments' responsibility to promote and protect that dignity through human rights.
Critical Reflection	Engaging in a learning process that recognizes and critiques ideology (political, economic, social, and cultural), uncovers hegemonic assumptions, and examines relations of power with the goal of becoming critically aware of how each distorts our worldview. *One scale interrogates critical reflection.*	

4. Data Analysis & Results

Matched data from the pre and post GES assessments was analyzed. For each matched pair, the change in score from pre- to post-assessment for each of the GES scales was calculated and is shown in Figure 1. The scales are denoted as: openness to diversity (OD), cultural adaptability (CA), civic efficacy (CE), political voice (PV), conscious consumption (CC), global civic responsibility (GCR), human rights beliefs (HRB), and critical reflection (CR). The GES defines global learning in terms of 3 components: cultural humility, global citizenship, and critical reflection. The cultural humility outcome consists of the OD and CA scales, and the global citizenship outcome consists of the CE, PV, CC, GCR, and HRB scales (see Table 2).

Each scale measures a student's perceived mindset level for the respective component. These perceptions are based on the student's experiences in and outside of the classroom. The goal of the intervention was to provide experiences that would allow the student to grow in their mindset and increase in scale. Figure 1 shows the distribution of changes in each of the 8 GES scales for the 14 students with matched data. Surprisingly, both positive and negative changes were observed. Consultation with an advisory board surmised that negative change reflected a student's new awareness of their mindset whereas positive change indicated growth in their mindset, as shown in Figure 1. In other words, it is hypothesized that some students thought their global mindset was more advanced prior to the intervention, and participation in the intervention allowed them the opportunity to realize that they were not as high on the scale as previously thought.

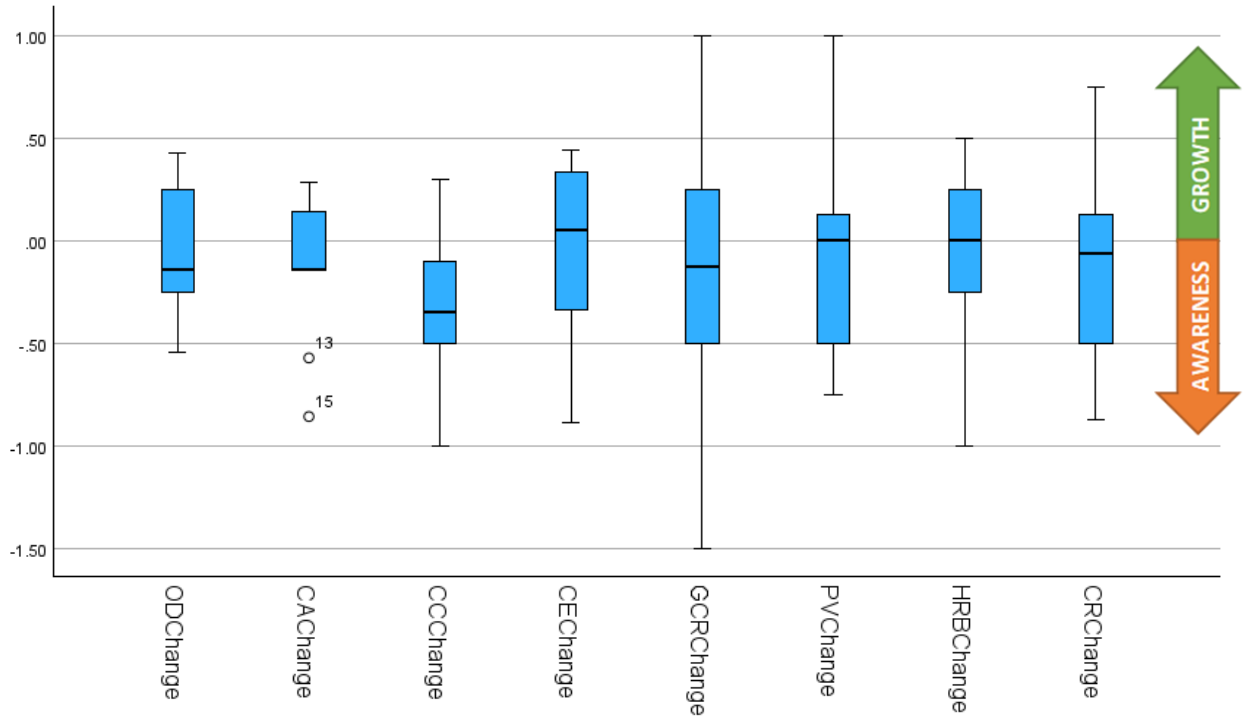

Figure 1: Distribution of change in GES scales from pre-implementation to post-implementation

Since the goal of the intervention was to develop a global learner mindset, movement in terms of growth or awareness demonstrates success of the intervention. To determine which components saw significant movement towards growth or awareness, we calculated the magnitude of change as the absolute value of change from pre- to post-implementation. A magnitude change of 0 indicates no change in mindset while a value of 1 indicates a change in growth or awareness of 1 level. We are interested in identifying which components show changes with magnitudes of 0.5 or greater, which we identify as substantial changes. Figure 2 shows the distribution of magnitude of change for each of the 8 GES components. The red line indicates a magnitude of 0.5. Notice that the largest changes occur for global civic responsibility (GCR), which shows the largest spread in values as well as the largest median value for change in scale.

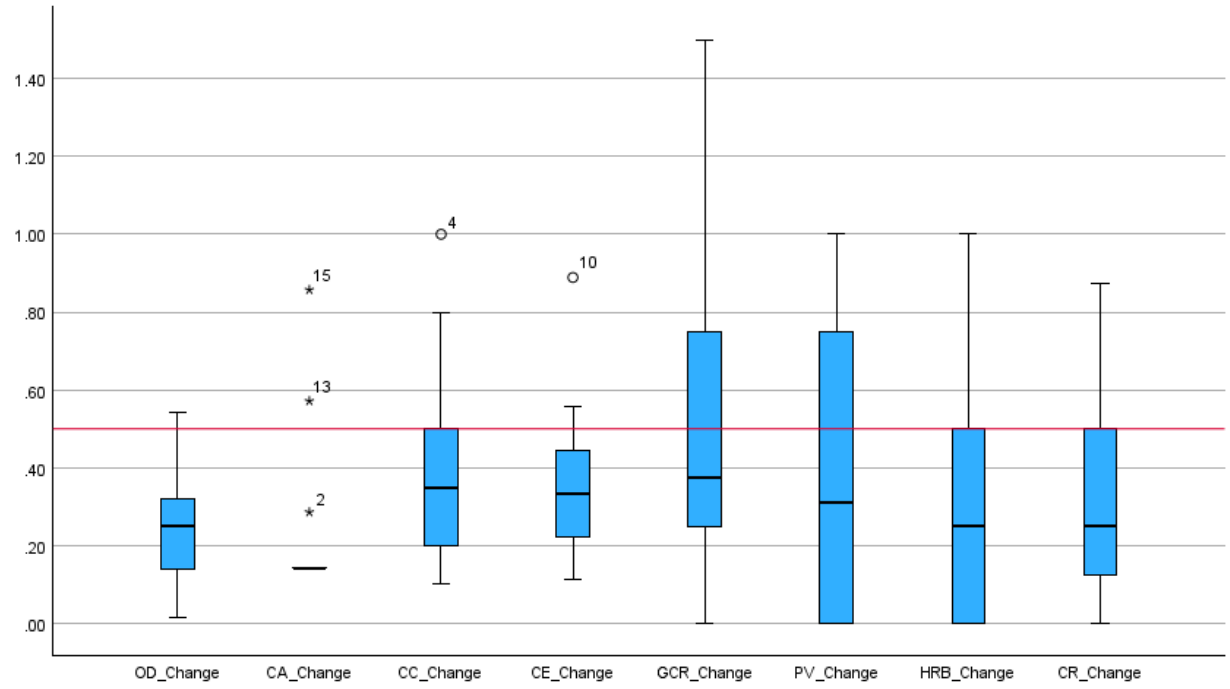

Figure 2: Distribution of magnitude of change in GES scales from pre- to post-implementation

The differences between the matched pairs were normally distributed, so a dependent t-test was performed to determine if the mean change in magnitude of each scale was less than or equal to 0.5 (H_1: $\mu_\Delta < 0.5$), indicating that there was not a substantial change in magnitude. The test was performed in SPSS and the results are shown in Figure 3. Of the 8 scales, no substantial change was observed for openness to diversity, cultural adaptability, civic efficacy, human rights beliefs, and critical reflection (all p-values < 0.05). The large p-values for conscious consumption, global civic responsibility and political voice (0.089, 0.379, and 0.085 respectively) indicate that it is reasonable to assume that a substantial change in magnitude of 0.5 or greater (either in awareness or growth) occurred. The effect sizes with respect to a change in magnitude of 0.5 were small to medium effect for conscious consumption and political voice (Cohen's d 0.38 and 0.39 respectively). The effect size observed in global civic responsibility is small as indicated by Cohen's d statistic (0.08).

The GES defines conscious consumption (CC) as one's professed intentionality regarding the use of one's own economic resources to advance just outcomes through consumer practices. Global civic responsibility (GCR) is defined as one's belief in shared human dignity, as expressed through a global sense of community membership and civic identity. Political voice (PV) is defined as one's intentions to use one's civic voice [22]. Considering the nature of the case study (natural disaster relief) and the presences of written and video news coverage of the 2023 Turkey earthquake, it seems reasonable that students would grow in, or become more aware of their beliefs in human dignity, the use of their civic voice, and the intentionality of how they use resources.

One-Sample Test

Test Value = 0.5

	t	df	Significance One-Sided p	Significance Two-Sided p	Mean Difference	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
OD_Change	-6.410	13	<.001	<.001	-.24405	-.3263	-.1618
CA_Change	-4.635	13	<.001	<.001	-.26531	-.3890	-.1417
CC_Change	-1.422	13	.089	.179	-.10000	-.2519	.0519
CE_Change	-2.665	13	.010	.019	-.14286	-.2587	-.0271
GCR_Change	-.314	13	.379	.759	-.03571	-.2816	.2101
PV_Change	-1.453	13	.085	.170	-.13393	-.3330	.0652
HRB_Change	-2.621	13	.011	.021	-.19643	-.3583	-.0345
CR_Change	-2.042	13	.031	.062	-.15179	-.3124	.0088

Figure 3: SPSS results of one-sample t-test on magnitude of change of GES scale from pre- to post-implementation. A p-value of 0.05 or less supports the claim that the mean change is less than 0.5 in magnitude.

5. Discussion & Future Work

This research investigated the impact an international case study had on the global learner mindset of undergraduate engineering students. Experience and research has shown that international immersion experiences have a significant impact on developing global engineering competencies, but these experiences are typically intensive in terms of time commitment and costs. This research demonstrates that minimally intensive interventions, such as case studies, can affect change in global mindset, either in terms of growth or awareness. The case study presented showed statistically significant change in student mindset with respect to GES components conscious consumption, global civic responsibility and political voice.

In their end-of-project reflections, students shared their feelings concerning the case study. Many appreciated the real-world application of the project. For example, a student quoted "*It was really cool to be able to research the different areas and not go out of a book.*" Students also discussed how surprised they were at the scale of practical applications of the course content: "*It was eye-opening to be able to connect this project on a larger scale, and see just how much goes into where [distribution centers], or other similar establishments are placed*." Some stated desires to pursue global relief efforts: "*I would love to get involved with programs like engineers without borders and other humanitarian aid organizations!*." Ultimately, students were able to connect course work to practical, global applications: "*I usually associate engineering with*

designing and building new things, but this project showed me that engineering can also apply more generally to solving large-scale logistics problems."

Future research will continue to investigate how the global learner mindset is affected by other minimally intensive interventions such as the intentional formation of multinational student design teams within a capstone design course, a Collaborative Online International Learning (COIL) research project, and an engineering short course coupled to a community engaged project. We will investigate the differences and similarities between interventions with respect to global mindset and also investigate correlations between demographic factors and mindset growth and awareness. Future research will also utilize qualitative methods. Qualitative responses to the GES survey will be analyzed and focus groups will be interviewed to help identify the impact of each intervention on the global learner mindset. Beyond these steps we hope to be able to expand our research to include more interventions, including a study-abroad experience, and a more diverse student sample.

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