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First-Year Engineering Study Abroad Experience: An Engineering Design Course That Enhances Student Development in Multiculturalism and Entrepreneurial Mindset

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Keywords: Entrepreneurial Mindset, EM, Connectedness, Creating Value, Curiosity, International experience, Study Abroad, Global awareness, Multiculturalism, First-Year Engineering

Abstract: International experiences are high-impact opportunities for undergraduate engineering students to cultivate the development of entrepreneurial mindsets (EMs) in relation to place. Engagement in hands-on experiences during an engineering design course abroad aligns with the grand challenges themes of security, sustainability, health, and joy of living, linking experiential learning, disciplinary knowledge, multicultural awareness, and EM development. Previous studies suggest that short-term international experiences can be highly motivating, transformative, and effective in fostering students' cultural awareness. A strong connection to place may enhance first-year engineering (FYE) students' approach to their end-of-year design projects. Each team of four students creates, develops, and tests their assigned design project at their respective international location. This research study explores the impact of international experiences on the development of FYE students' EM and multiculturalism, grounded in Mezirow's Transformative Learning Theory (TLT). We are conducting a qualitative research study at an R1 southeastern public institution, consisting of two cohorts of FYE students participating in in-person international experiences in Ecuador and the Czech Republic during their week-long spring break. Each cohort of students will enroll in the same course led by their home institution's instructors, differing only in their international travel destination and the final First-Year Engineering Design Day (FEDD) project. This research seeks to bridge transformative learning theory, emphasizing multiculturalism and the three Cs of EM: connectedness, creating value, and curiosity, with first-year international experiences. Concept maps and pre-/post-surveys are used to qualify student responses, assessing changes in multicultural awareness, overall perceptions, and growth in the three Cs. Analysis of this data aids in understanding how students' EM and multicultural competencies develop during their experience. The key findings of this work include enhanced student perception through engaged learning, growth in students' EM three Cs, and students' increased appreciation of multiculturalism through in-person cultural immersion experiences.

Introduction

As engineering demand rises and globalization intensifies, fostering multiculturalism is vital for global solutions. Transformative learning theory (TLT), developed by Dr. Jack Mezirow in the 1970s, explains how adult learners shift perspectives when confronted with challenging experiences [1,2]. While TLT guides culturally responsive teaching in international teacher training, it remains underutilized in science, technology, engineering, and math (STEM) contexts [1]. This research study explores the impact of international experiences on the development of first-year engineering (FYE) students' entrepreneurial mindset (EM) and multiculturalism, grounded in Mezirow's TLT. To achieve this, the study integrates TLT with multiculturalism through two short-term FYE study abroad programs at a leading R1 public research university in the southeastern United States. It emphasizes the interconnectedness of the three C's- connectedness, creating value, and curiosity- within The KEEN Framework for Entrepreneurial Mindsets [3].

Short-term study abroad experiences influence students' perspectives as they engage in their Introduction to Engineering coursework at home and abroad. To assess potential growth, we proposed two research questions for the first cycle of short-term study-abroad students in Spring 2024:

1. How do international experiences impact the entrepreneurial mindsets (EM) development of first-year engineering students, particularly regarding connectedness and multiculturalism?
2. To what extent do students link their international experiences to real-world engineering applications, specifically in sustainability, security, health, and the joy of living, as outlined by the National Academy of Engineering's grand challenges?

To answer these questions, we evaluated students' pre- and post-assessments, including surveys and concept maps, to assess growth in the areas of connectedness specifically, as well as the broader EM using all 3C's, and multiculturalism. During the spring semester, students attend up to six 2-hour in-person lectures at the home institution and participate in an eight-day study abroad experience in either Quito, Ecuador, or Prague, Czech Republic. The abroad component includes lectures, hands-on data collection and analysis, and excursions, all guided by instructors from the home and international institutions. The Quito and Prague study abroad programs aim to cultivate more conscious and intentional engineers who are better prepared to apply their EM to global contexts and challenges.

Partnership Development

All first-year engineering students at the host university are required to complete Engineering 101 (E101) as part of their major curriculum. In Spring 2024, two E101 sections included a study abroad component during spring break: one cohort of 19 students in Quito, Ecuador, which focused on water sanitation and insecurity, and another cohort of 48 students in Prague, Czech Republic, which focused on transportation infrastructure development. Students in both sections were invited to participate anonymously in this research study through informed consent.

The research components were intended to be administered consistently across both cohorts through direct coordination between instructors. While a communication flaw regarding concept map development occurred in the Prague cohort, discussed later, the overall administration remained uniform. Students were asked to complete a survey and a concept map during the first and final weeks of their E101 course experience.

Background

The EM is a dynamic framework that cultivates critical thinking, creativity, and adaptability by integrating technical and soft skills to address complex engineering problems. Grounded in the "three Cs" of engineering education- connectedness, creating value, and curiosity- this framework was developed by the Kern Engineering Education Network (KEEN), a partnership of 28 engineering institutions dedicated to producing graduates with the professional, social, and personal skills necessary for lifelong learning and meaningful work [4].

Connectedness emphasizes interdisciplinary relationships and the interdependence of ideas and stakeholders, particularly within multicultural and global contexts. Creating value encourages students to design solutions that provide tangible benefits to communities and tackle real-world challenges. Lastly, curiosity drives learners to explore beyond the textbook, fostering an attitude of lifelong learning and a deeper understanding of the "why" behind their work [5].

In global learning environments like study abroad programs, EM plays a transformative role. Immersion in diverse and unfamiliar cultures enhances students' multicultural competence and encourages holistic thinking about engineering challenges from new perspectives. Intercultural experiences strengthen students' connection to global issues, spark curiosity about different worldviews, and develop their ability to create meaningful solutions. This approach, known as "engineering in relation to place," emphasizes designing context-specific solutions that consider the unique aspects of each location.

Previous research also indicates that hands-on and immersive learning experiences, including but not limited to study abroad programs, strengthen technical, professional, and interpersonal skills. This team's prior research successfully used concept maps as a tool in research experiences to discern and interpret growth from non-traditional learning experiences [2]. This extension further highlights the importance of non-traditional learning experiences in developing entrepreneurially minded engineering students prepared to apply their knowledge to global contexts.

Research shows that short-term international experiences are motivating, perspective-shifting [6], and effective in increasing students' cultural awareness [7]. For engineering students, study abroad programs significantly enhance technical skills, global perspectives, and motivation, leading to greater engagement in coursework [8]. Short-term study abroad programs have also been shown to improve motivation among financially at-risk and underrepresented community college students, highlighting their potential to make engineering education more accessible to diverse learners [9]. Hands-on, immersive learning experiences- including study abroad- further strengthen students' technical, professional, and interpersonal skills. This team's previous work successfully employed concept maps to capture growth from such non-traditional learning experiences [2]. Building on that foundation, this study emphasizes the importance of

international experiences in developing entrepreneurially minded engineers equipped to apply their knowledge to global challenges.

Methods

During the Spring 2024 semester, 19 FYE students participated in the Quito, Ecuador short-term study abroad program, while 48 FYE students participated in the Prague, Czech Republic short-term study abroad program. Students applied through the institution's Study Abroad Office during the fall semester, where they could also seek financial support.

At the start of each program, students were invited to participate in this study, which aimed to assess their growth through the study abroad experience. In total, 15 students from the Quito cohort and 46 students from the Prague cohort consented to participate. However, not all consenting students completed every assessment tool, as participation in each component was voluntary under the Institutional Review Board (IRB) approval and the principle of participant beneficence.

Throughout the multicultural study abroad experience in Quito, students immerse themselves in a culturally rich setting, applying engineering design to local water quality and pollution challenges. The program emphasizes practical application of engineering concepts through hands-on laboratory experiments, guest lectures, and multiple industry site visits, facilitated in partnership with Universidad San Francisco de Quito (USFQ). Students also deepen their understanding of Ecuadorian culture through excursions such as a Quito city tour, a USFQ campus tour, a visit to Quito's artisanal market, and a visit to the Papallacta hot springs. Combined with classroom discussions and extensive First-Year Engineering Design (FEDD) project experimentation and work time, the Quito program aptly integrates a blend of cultural activities and technical experiences.

During the multicultural study abroad experience in Prague, students participate in a variety of enriching activities. They engage in cultural immersion through walking tours of historic Prague, language and cultural workshops, and a welcome dinner at a traditional Czech restaurant. Educational site visits include trips to the Terezín memorial, Skoda Factory and Museum, an underground laboratory, a water treatment plant, and the National Technical Museum. Academic components are integrated through classroom discussions and FEDD data collection sessions. The program also features leisure activities such as a lunch cruise on the Vltava River and attending a ballet at the National Theatre, offering a well-rounded cultural and academic experience.

All participating students signed an IRB-approved informed consent form and selected a pseudonym for use throughout the study. The consent forms were stored separately from the collected data to maintain confidentiality. Using pseudonyms ensured student responses remained anonymous and unlinked to their identities while allowing individual responses to be traced consistently across assessments, promoting candid participation.

Pre- and Post-Surveys as an Assessment Tool

During the Spring 2024 semester, students in both the Quito and Prague cohorts completed a pre-survey during the first week of their course and a post-survey during the final week. These

identical, ungraded surveys contained 39 validated questions: 37 of which used a 5-point Likert scale (1 = least confident, 5 = very confident) and two of which used open-ended responses (see Appendix A) [10, 11]. Students had the option to skip any question.

The surveys were specifically designed to measure students' EM and multiculturalism growth. The competency categories of the survey questions, found in **Appendix A**, can be grouped into three larger themes- multiculturalism, entrepreneurial mindset, and cognitive and functional skills, with connectedness as a common thread linking them.

Multiculturalism, which encompasses global interdependence and intercultural awareness, fosters empathy and collaboration by helping students understand cultural differences and global systems [8]. Study abroad experiences strengthen such competencies, enhancing students' ability to navigate diverse environments and deepening their sense of connectedness [10]. EM skills- curiosity, creating value, and curiosity support- innovation and opportunity recognition [3]. Connectedness bridges these areas, enabling students to apply ideas to real-world challenges in collaboration with diverse stakeholders [11]. Aligned with TLT [1], this integration prepares students to tackle global issues with empathy and entrepreneurial thinking.

In engineering education, strengthening cognitive and technical skills boosts EM by fostering creative thinking, effective problem-solving, and practical application of knowledge [5, 12]. These skills help students think creatively, solve problems effectively, and apply technical knowledge to create valuable solutions, highlighting the importance of cognitive and functional skill-based questions.

To evaluate changes in students' confidence, a paired, two-sided t-test was run for each Likert-scale question, comparing pre- and post-survey means. Data from unanswered questions were excluded. In total, 41 students, 15 from the Quito cohort and 26 from Prague, completed both surveys.

The open-ended response survey questions were analyzed using thematic analysis to identify patterns and assess changes in themes between pre- and post-surveys. Some students received a post-survey with wording intended for pre-experience use, which influenced their open-ended responses. Misaligned responses were omitted to preserve the accuracy and integrity of the findings. Thematic coding, the qualitative analysis method used in this study of first-year engineering students who studied abroad, involved identifying recurring patterns, organizing them into themes, and refining those themes to gain deeper insights into students' experiences [13]. Specifically, questions 38 and 39 of the pre- and post-surveys were analyzed to evaluate the study abroad programs' impact and outcomes.

Concept Maps as an Assessment Tool

In addition to the surveys, students created concept maps at the beginning and end of the semester, each centered on the core engineering theme of their respective course sections. Concept maps serve as an effective tool for assessing specific development in connectedness within EM [14]. The Quito cohort focused on *Water Insecurity*, while the Prague cohort explored *Transportation Infrastructure*. These themes served as central nodes of each respective cohort’s pre- and post-concept maps.

Students were given unlimited time to complete their maps and had the option to draw them on paper or use the online C-map software interface. They were instructed to include concepts related to their central theme and were encouraged to build upon their pre-concept maps when creating their post-concept versions. This approach provided a visual representation of students' evolving understanding and the interconnectedness of key concepts.

The concept maps were scored using the traditional scoring method [15, 16], which evaluates three components to determine student connectedness: the *Number of Concepts* (NC), the *Highest Hierarchy* (HH), and the *Number of Cross-Links* (NCL). The NC represents the total number of distinct concepts included in the map, with each concept contributing one point to the total score. The HH refers to the number of concepts in the highest hierarchical level of the map, which is multiplied by five and added to the total score. The NCL accounts for the number of connections between different hierarchical levels, with each cross-link multiplied by ten and added to the total. Higher concept map scores indicate a stronger connectedness of ideas surrounding the central theme. To ensure reliability and consistency in scoring, two reviewers independently evaluated each concept map, and the final score was determined by averaging their assessments.

Findings

As described in the methods, students completed pre- and post-surveys (37 Likert-scale questions, two open-ended responses) and concept maps to assess how international experiences influence first-year engineering students' connectedness, broader EM, and application of engineering concepts to global challenges. The findings highlight changes in these areas.

Survey Likert-Scale Responses

Among the 41 students from both cohorts who completed the pre- and post-surveys, average confidence increased for all prompts except question 13. Nineteen out of 37 questions showed statistically significant differences ($p < 0.05$), labeled with a star in **Figure 1**. The labeled questions are: 1-5, 9, 13-16, 20, 22, 23, 25, 28, 31, 32, 35, and 37. While significance indicates changes unlikely due to chance, a general trend of increased confidence in tested skills between pre- and post-surveys was seen across nearly all questions. **Figure 2** shows how each student's Likert-scale responses shifted- whether scores increased, decreased, or stayed the same. The full survey appears in **Appendix A.**

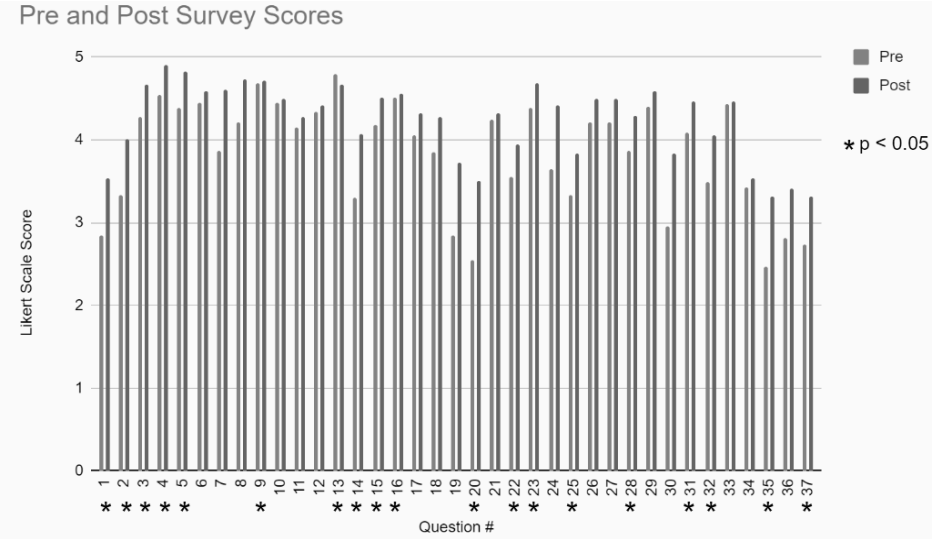


Figure 1: Pre- and post-survey mean score comparisons for each survey question administered across both study-abroad cohorts, with statistically significant differences denoted.

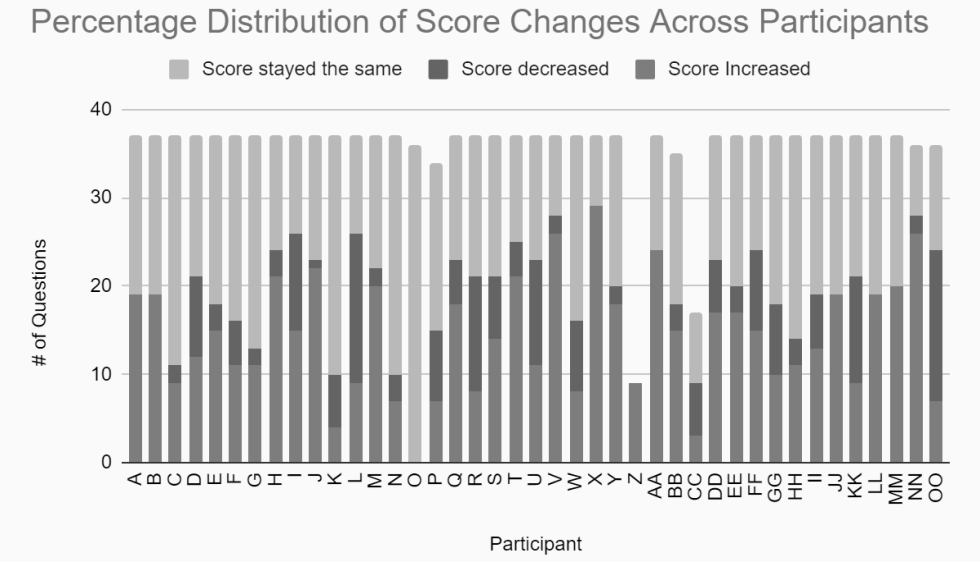


Figure 2. The distribution of score increases, decreases, and no change among participants who completed both the pre- and post-surveys.

From the data in **Figure 2**, it is evident that 31 out of 42 students experienced more score increases than decreases when comparing their post-survey responses to their pre-survey responses. In contrast, only eight students had more score decreases than increases, while two students had an equal number of increases and decreases. Notably, among the 31 students with score increases, 27 of them had at least five more questions showing an increase than those showing a decrease, indicating a strong overall trend of improved confidence in skills tested across the survey.

Survey Open-Ended Responses

Questions 38 and 39, included in both the pre- and post-surveys, explored students' expectations and perceived outcomes from the E101 study abroad course. Thematic coding revealed shifts in student perceptions, highlighting developments in global perspective, technical abilities, and personal growth. As Creswell (2016) notes, thematic analysis provides insight into evolving student mindsets [13].

Question 38 asked students about expected vs actual gains from the study abroad experience. In the pre-survey, both the Quito and Prague cohorts anticipated gaining hands-on learning, technical and interpersonal skills, cross-cultural understanding, and global perspectives. Quito students initially focused on real-world problem-solving and confidence-building, while Prague students initially emphasized adaptability and innovation. Post-survey responses revealed that Quito students reported improved global awareness, collaboration, and technical application, while Prague students highlighted transformative growth in global perspectives, real-world application, and interdisciplinary thinking. All respective themes and thematic shifts are shown in **Table 1**.

A key observation was the shift from expected personal skill development (e.g., teamwork and communication) to a broader appreciation for global interconnectedness and real-world engineering applications. Students moved from individualistic goals to more communal and global perspectives, indicating that the study abroad experience reshaped how they viewed engineering within global contexts.

Table 1. Q38 Theme Frequency Table

Theme from responses	Prague Pre-	Prague Post-	Prague Δ	Quito Pre-	Quito Post -	Quito Δ	Average Δ
Soft Skills	1	0	-1	8	6	-2	-1.5
Personal Development	3	4	+1	5	2	-3	-2
Cultural Awareness	5	4	-1	5	5	--	-0.5
Global Perspectives	10	12	+2	4	5	+1	+1.5
Technical Skills	2	0	-2	3	1	-2	-2
Real-World Applications	2	4	+2	2	2	0	+1
Critical Thinking	4	1	-3	2	0	-2	-2.5
Interdisciplinary Perspectives	0	1	+1	1	1	0	+0.5

Table 1. Theme Scoring findings across Quito and Prague cohorts for Question 38: **Pre:** What do you think you will gain from taking a first-year engineering course (E101) with a study abroad experience? **Post:** What did you gain from taking E101 with a study abroad experience?

Question 39 asked students how the E101 study abroad experience could contribute to their future careers. Thematic coding, following methods outlined by Naeem et al. (2023) [17], revealed shifts in career-related expectations and outcomes. In the pre-survey, both cohorts expected to develop global perspectives, enhance professional skills, and explore career paths. Students anticipated improvements in teamwork, communication, and adaptability, along with

exposure to real-world engineering projects and cross-cultural environments. Post-survey responses showed that students gained a clearer understanding of how international experiences inform engineering careers. All respective themes and thematic shifts are shown in **Table 2**.

Table 2. Q39 Theme Frequency Table							
Theme from responses	**Prague Pre-**	**Prague Post-**	**Prague Δ**	**Quito Pre-**	**Quito Post -**	**Quito Δ**	**Average Δ**
Broadened Perspectives	7	12	+5	8	10	+2	+4.5
Desire for Travel	4	5	+1	4	2	-2	-0.5
Personal Growth	4	3	-1	4	3	-1	-1
Technical Knowledge	3	0	-3	3	0	-3	-3
Cultural Awareness	3	5	+2	3	4	+1	+1.5
Soft Skills	2	3	+1	2	3	+1	+1
Independence	2	0	-2	2	1	-1	-1.5
Job Prospects	2	2	0	2	2	0	+1

Table 2. Theme Scoring findings across Quito and Prague cohorts for Question 39: How do you think this experience can contribute to your future career goals?

Quito students reported increased confidence, stronger problem-solving abilities, and a greater appreciation for global challenges and teamwork. Prague students noted transformative growth, highlighting the experience's role in shaping international career aspirations, adaptability, and practical application of engineering principles. Both cohorts emphasized enhanced marketability, resilience, and preparedness for global engineering challenges.

Ultimately, using thematic coding to analyze responses to survey Questions 38 and 39, the researchers identified shifts in students' perceptions of what they expected to gain versus what they ultimately gained from the E101 study abroad experiences in Quito and Prague. As Creswell (2016) highlights, thematic analysis reveals nuanced changes in attitudes and experiences over time [13]. While students initially anticipated developing technical knowledge, post-survey responses indicated a shift toward broader perspectives, with a greater emphasis on their broadened perspectives leading to soft skills, cultural awareness, and job prospects. Such changes suggest that even over the short eight-day study abroad experience, students gained valuable insights into global engineering contexts, adaptability, and the importance of interpersonal and professional skills in their future careers.

Concept Map Scores

Concept maps created at the beginning (pre-concept maps) and end (post-concept maps) of the course were scored using the traditional scoring method [15], with score comparisons shown in **Figure 3**. Not all students completed both concept maps; therefore, their growth in the three Cs could not be fully assessed using this tool. However, 12 students from the Quito, Ecuador cohort who provided both maps are included in the figure.

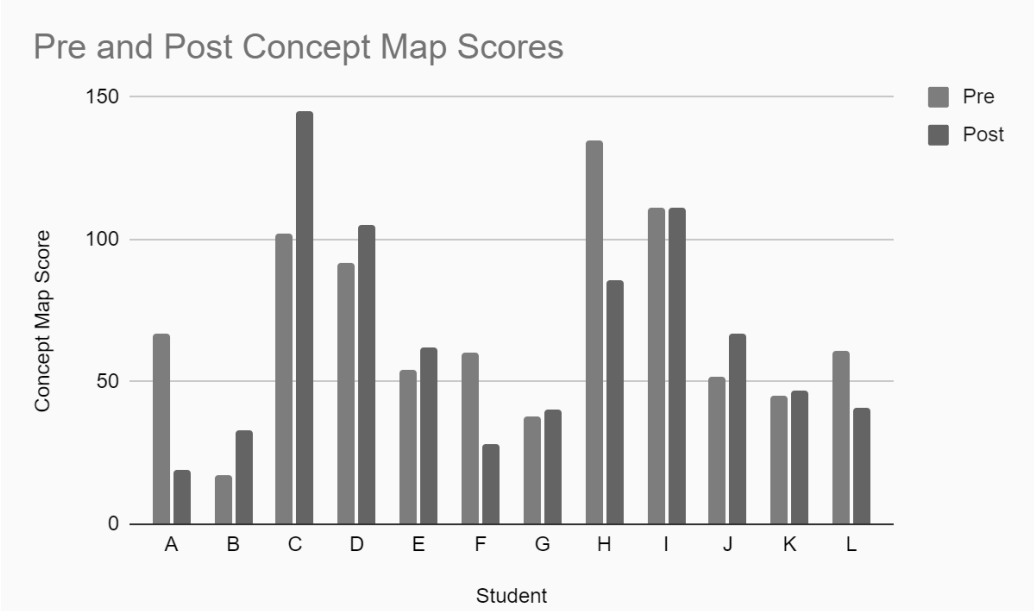


Figure 3. Pre- and Post-Concept Map scores for students who submitted both maps from the Quito cohort.

Concept maps served as a cognitive tool to track growth in EM connectedness over the course. As shown in Figure 3, 7 of 12 students improved their scores, one stayed the same, and four saw decreases. Despite some declines, the overall trend indicates increased connection to the course's central theme.

Students could build on their pre-concept maps for the post-assessment to reflect their evolving understanding. However, some opted to create new maps, leading to lower scores. Since the scoring method emphasizes quantity over quality of connections, deeper, more meaningful links may not have been fully recognized.

Discussion and Future Work

Previous research shows that transformative learning often stems from novel experiences, such as short-term study abroad programs, prompting students to critically examine their beliefs. Our findings support TLT, showing growth in multiculturalism, connectedness, and EM among FYE students. Pre- and post-surveys track changes in perceptions, attitudes, and confidence, highlighting shifts in global awareness, cultural understanding, and EM. Likert-scale questions capture incremental changes in self-reported competencies, while open-ended responses reveal how students reinterpret their worldviews and professional goals.

Concept maps serve as visual tools to track the development of connectedness, a core EM component, and illustrate how students restructure their understanding during the abroad experience. TLT suggests that learners integrate new information with prior knowledge, and comparing pre- and post-concept maps reveals changes in concept quantity, connection complexity, and hierarchical organization, indicating deeper comprehension.

Survey results showed significant increases in students' confidence across competencies like global interdependence, intercultural awareness, personal growth, curiosity, problem-solving,

and value creation. The only decline was a slight drop in confidence related to anticipating technical developments, counterbalanced by improvements in related areas. With 18 statistically significant changes, the data strongly supports the program's role in fostering EM and multiculturalism. Most students demonstrated more score increases than decreases, reinforcing the program's positive impact.

Open-ended responses revealed a shift in focus: pre-survey expectations centered on technical skills, whereas post-survey reflections emphasized global awareness, cultural understanding, and personal growth. This suggests that integrating EM with multicultural experiences encourages broader competencies beyond traditional technical skills.

Future research should examine how short-term study abroad experiences influence the application of technical skills in real-world engineering contexts. With the program expanding in Spring 2025 to include Nairobi, Kenya, alongside Quito and Prague, ongoing data collection will enable long-term analysis of global learning's educational impact on engineering students.

Concept Maps and Challenges

Using concept maps as an assessment tool to track student growth proved less effective than anticipated. Many students struggled to understand or follow the instructions for creating the maps, making it challenging to accurately monitor their development. The compressed timeline of the international experiences and the limited structure and face-to-face interactions with instructors further hindered students' understanding of the procedures. Consequently, relying solely on concept maps produced ambiguous findings.

Although similar instruction and support were provided as in successful settings like the research group's Research Experience for Undergraduates (REU) program [2], the study abroad context posed unique challenges. Some students showed lower scores on their second concept maps, often because they created new ones instead of building on their originals. Burnout at the end of the semester and after travel likely affected map quality, despite gains in understanding. Low submission rates were also tied to a lack of clear incentives, making it difficult to assess growth in the three Cs of the Entrepreneurial Mindset.

To improve the use of concept maps as an assessment tool, instructional materials were clarified, and an external researcher now provides a live in-class demonstration. Additionally, the instructional materials for concept mapping have been revised for clarity from previous publications, with the revised version in **Appendix B** [2, 14]. To encourage participation and motivation, concept maps are now a required assignment, with all students receiving a participation grade. While only consenting participating students' maps are analyzed, all students receive completion credit. Students now use *Lucidspark.com* [18] to create their concept maps and submit digital PDFs through the course webpage, ensuring easy access to initial maps and facilitating effective revisions. To boost engagement, instructors now hold regular check-ins during study abroad to clarify instructions and offer support. The aforementioned changes aim to better track growth in the three Cs of the Entrepreneurial Mindset, ease end-of-semester burnout, and improve submission rates.

In conclusion, we will continue to use a combination of concept map evaluations, Likert-scale surveys, and open-ended response prompts to assess student development. This integrated approach offers a more comprehensive understanding of how short-term study abroad experiences shape students' growth. Early results indicate a promising positive impact on FYE students' development in EM and multicultural competencies.

Appendix A

Pre- and post-survey questions and associated factor interpretation and response types. Students were asked to complete a survey responding to the following questions during the first and last week of their Engineering 101 course [10, 11]**.**

Survey Question Breakdown			
Question #	**Competency Category**	**Question**	**Response Type**
1	Global Interdependence	I know how foreign manufacturing affects price.	five-point Likert-type scale
8	Intercultural Awareness/ Global Interdependence	I have thought about why other countries have different perspectives than the U.S.	five-point Likert-type scale
3	Intercultural Awareness	I have thought about the differences between myself and people in other countries.	five-point Likert-type scale
5	Intercultural Awareness	I thought about similarities between myself and people in other countries.	five-point Likert-type scale
7	Intercultural Awareness	I have thought about a current issue important to people in a developing country.	five-point Likert-type scale
2	Intercultural Awareness/ Personal Growth and Development	I have consciously withheld judgment on international events/issues.	five-point Likert-type scale
4	Functional Knowledge	I have looked up something on a map of another country.	five-point Likert-type scale
6	Functional Knowledge	I have looked up non-English words in the dictionary.	five-point Likert-type scale
9	Intrinsic curiosity	I have a keen sense of curiosity.	five-point Likert-type scale
10	Intrinsic Curiosity	I always actively seek as much information as I can in a new situation.	five-point Likert-type scale
11	Intrinsic Curiosity	I consider myself to be a person who takes action when I'm curious about something.	five-point Likert-type scale
12	Intrinsic Curiosity	I find myself being curious about a lot of things and people I encounter in life.	five-point Likert-type scale
13	Ability to anticipate technical developments	I have at least one area of interest that I am passionate about in my life.	five-point Likert-type scale
19	Ability to anticipate technical developments	I have the ability to anticipate technical developments by interpreting surrounding societal trends.	five-point Likert-type scale
20	Ability to anticipate technical developments	I have the ability to anticipate technical developments by interpreting surrounding economic trends.	five-point Likert-type scale
14	Value Creation (risk management)	I am able to define an engineering problem in terms of value creation.	five-point Likert-type scale
15	Ability to learn	I am able to learn from failure.	five-point Likert-type scale
16	Ability to learn	I believe the ability to cope with failure can be	five-point Likert-type

		improved through practice.	scale
21	Ability to learn	I agree creative thinking skills can be acquired through training.	five-point Likert-type scale
17	Problem-solving/logical thinking	I am able to act effectively and creatively in difficult situations.	five-point Likert-type scale
18	Problem-solving/logical thinking	I am able to use the means at my disposal to handle situations effectively.	five-point Likert-type scale
24	Problem-solving/ logical thinking	I am able to apply systems thinking to solve complex problems.	five-point Likert-type scale
25	Problem-solving/ logical thinking	I am able to tell if it is technically feasible to develop a new product or service.	five-point Likert-type scale
26	Problem-solving/ logical thinking	I am able to apply logical thinking to gathering and analyzing information.	five-point Likert-type scale
27	Problem-solving/ logical thinking	I am able to apply logical thinking to designing and solving problems.	five-point Likert-type scale
31	Problem-solving/ logical thinking	I am able to substantiate claims with data and facts.	five-point Likert-type scale
32	Problem-solving/ logical thinking	I have a clear plan for my professional development.	five-point Likert-type scale
28	Managing complex tasks	I am confident in leading a team to work on a project.	five-point Likert-type scale
33	Gain entrepreneurial mindset	My career goal is to become an excellent engineer.	five-point Likert-type scale
34	Gain entrepreneurial mindset	My career goal is to become an engineer with an entrepreneurial mindset.	five-point Likert-type scale
37	Gain entrepreneurial mindset	I'd like to take some entrepreneurship courses in college.	five-point Likert-type scale
35	Prior exposure to entrepreneurship	I have had exposure to entrepreneurship before entering college.	five-point Likert-type scale
36	Prior exposure to entrepreneurship	There is/are entrepreneur(s) among my relatives.	five-point Likert-type scale
22	No clear themes emerge	I sometimes have innovative ideas for products or services.	five-point Likert-type scale
23	No clear themes emerge	I believe a problem can be understood better if it is considered in relation to the whole.	five-point Likert-type scale
29	No clear themes emerge	I always maintain a good interpersonal relationship in a team.	five-point Likert-type scale
30	No clear themes emerge	I am able to communicate an engineering solution in economic terms.	five-point Likert-type scale
38	N/A	**Pre:** What do you think you will gain from taking a first-year engineering course (E101) with a study abroad experience?	Short Answer
		Post: What did you gain from taking a first-year engineering course (E101) with a study abroad experience?	
39	N/A	How do you think this experience can contribute to your future career goals?	Short Answer

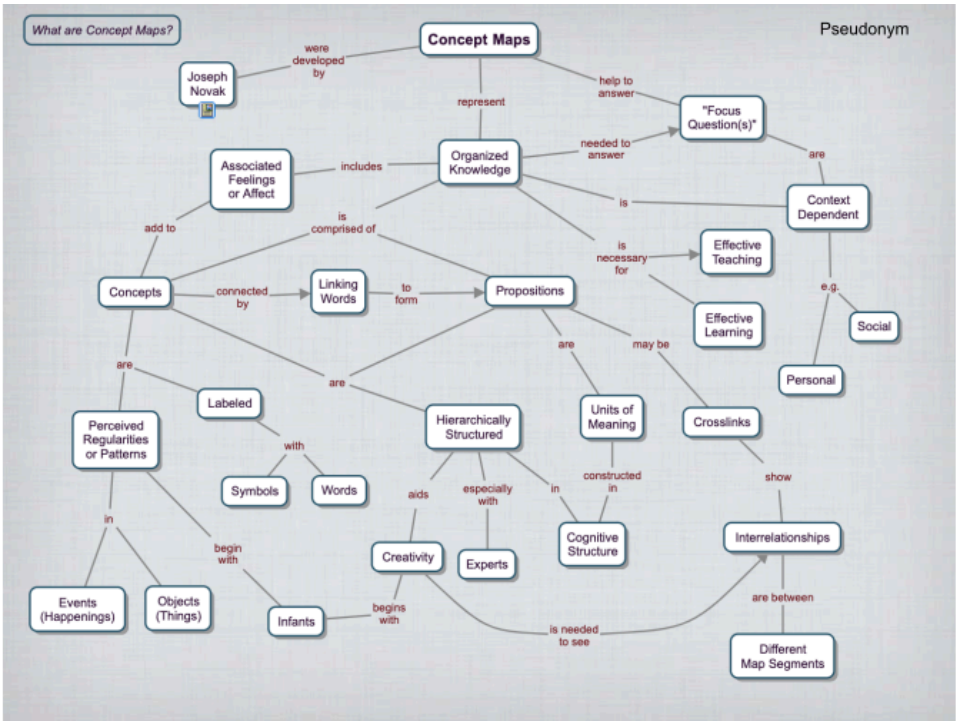
Appendix B

The following instructions are given to students to complete their concept maps, adapted from West *et al*., 2021 [14].

Concept Map Direct Assessment Prompt

A concept map is a tool used to visualize the relationships between different topics and concepts. It includes concepts connected with lines. The lines of a concept map include words to describe the relationship between the two connected items.

Here is an example of a concept map, as depicted below.



Please create a concept map for your research experience as outlined in the instructions below.

Instructions:

1. Create a concept map for this FEDD Study Abroad experience electronically that fits on one page using Lucidspark.com. Save as a PDF to submit.
2. Include your pseudonym in the top right corner of your concept map document.
3. Use the name of your FEDD project topic (water solution, transportation solution, health solution, or security solution) as the central topic that all other topics and concepts branch from.
4. Connect concepts that relate to each other and save as a PDF.

Your concept map should contain concepts that relate to your E101 experience and your understanding of engineering in relation to place.

Adapted from Ita, M. E., West, M. E., Rumreich L., Kajfez, R. L., Kecskemety, K. M. (2022). Concept Maps as a Direct Assessment for Measuring Students' Ability to Make Connections. Engineering Unleashed. https://engineeringunleashed.com/card/2784.

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