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Building Intercultural Skills in Engineering Students through Study Abroad

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Abstract

As the world becomes increasingly interconnected, developing intercultural competence (ICC) in higher education is essential, particularly in STEM fields where global challenges demand collaborative solutions. Study abroad programs are a key avenue for fostering ICC, but their effectiveness requires ongoing evaluation to ensure meaningful outcomes for participants. This study explores the experiences of 15 senior-level engineering students who participated in a semester-long study abroad program. Students wrote a final reflection as a part of the study abroad. The reflections were analyzed using a mixed-method approach. A rubrics was created to score each reflection quantitatively across five key dimensions: Identification and Awareness of ICC, Self-Examination and Reflection, Critical Assessment and Reframing of Assumptions, Exploration and Adoption of New Roles, and Development of a Plan for Action and Skill Acquisition. Further qualitative coding was performed to identify patterns and student quotes pertaining to each rubric criteria. The findings reveal that students demonstrated strong awareness of ICC and the ability to reflect on its significance within the engineering profession. They recognized the importance of ICC in improving teamwork, communication, and innovation in multicultural contexts. Students also highlighted how ICC could enhance their professional prospects by fostering better cross-cultural collaboration. However, areas for growth were identified, including the ability to critically reassess cultural assumptions, adopt new perspectives, and develop actionable strategies for skill acquisition. While students acknowledged the importance of these competencies, their reflections indicated a need for deeper transformation and integration of ICC into their engineering practice. This study highlights the importance of refining study abroad programs to provide more structured opportunities for experiential learning, critical reflection, and actionable skill development. Emphasizing the application of ICC in engineering-specific contexts can better prepare students to navigate diverse teams and design solutions that address the needs of varied communities. These findings highlight the potential for structured study abroad programs to equip engineering students with the intercultural skills necessary for success in an increasingly globalized workforce, where culturally sensitive problem-solving is crucial for addressing complex challenges.

Keywords: Study abroad, engineering, STEM, reflection, intercultural competence

1. Background

1.1 Intercultural Competence (ICC) in Higher Education

Intercultural Competence (ICC) refers to the ability to communicate and collaborate effectively and appropriately in intercultural contexts [1] . It encompasses skills such as cultural awareness, sensitivity, adaptability, and the capacity to view cultural differences with an open and empathetic mindset [2]. In higher education, developing ICC is crucial to preparing students, faculty, and staff for success in a globalized world. Higher education institutions (HEIs) serve as hubs of cultural exchange, with diverse student populations and international collaborations.

Embedding ICC into higher education curricula helps foster inclusivity, enrich learning experiences, and prepare students to address global challenges [3], [4]. Faculty and staff with ICC can design and implement culturally responsive teaching methods, while students gain the intercultural skills necessary for careers requiring global collaboration, particularly in STEM fields. HEIs play a key role in cultivating ICC through various initiatives, such as intercultural learning courses, experiential learning opportunities, and mentorship programs [5]. These efforts not only contribute to personal growth but also prepare graduates to navigate multicultural workplaces, making ICC an essential competency for the 21st-century workforce [6].

1.2 Study Abroad for ICC Development in STEM

Study abroad programs provide unique opportunities for ICC development by immersing students in new cultural contexts. Nationally there was an increase by 49% in the year 2022-2023 for the students studying abroad [7]. These programs foster cultural awareness, flexibility, and holistic thinking, which are integral components of ICC [8]. Despite the significant benefits, engineering students represent only 5% of study abroad participants. The barriers for engineering students include demanding course loads and a professional emphasis on technical over soft skills [9]. However, when engineering students do participate, studies show an increase in ICC, including enhanced cultural sensitivity and adaptability [10], [11]. These skills are highly valued in the globalized STEM workforce, where international cooperation is essential. Programs with structured curricula and reflective components are particularly effective in fostering ICC [12]. For example, thematic analyses of reflection journals and assessments like the Intercultural Development Inventory (IDI) have demonstrated significant growth in ICC among STEM students who participate in well-designed study abroad programs [10], [13]. Structured programs that integrate cultural preparation, mentorship, and reflective activities are critical for STEM students [14]. They allow participants to connect intercultural experiences to their academic and professional goals, demonstrating how ICC enhances their ability to contribute to global STEM challenges.

1.3 Gaps in Research and Literature

Despite the growing emphasis on study abroad programs, several gaps remain in the research and literature [10], [12]. First, while the benefits of study abroad for ICC development are well-documented, the specific needs and outcomes for STEM students remain underexplored. Most existing research focuses on general student populations or fields like humanities and social sciences, leaving a gap in understanding the unique challenges and opportunities for STEM students [15]. Second, there is limited research on the long-term impact of study abroad programs on ICC development. While studies like those by Jackson [16] and Bittinger et al. [17] demonstrate gain in ICC through short-term study abroad, more research is needed to assess impact of semester long study abroad in shaping ICC over time, particularly in professional STEM contexts. Additionally, there is a need to evaluate how tailored programs, such as pre-departure training and reflective exercises, influence ICC outcomes compared to traditional study abroad models. By addressing these gaps can help refine study abroad programs to better align with the academic and professional needs of STEM students. This study seeks to fill these gaps by investigating the experiences of engineering students who participated in an intentionally structured, semester-long study abroad program. Specifically, it aims to understand how these

students perceive the relevance and impact of ICC within their academic discipline and future professional roles. By focusing on their qualitative experiences, this research will explore how structured study abroad programs influence the development of ICC among engineering students.

Therefore, through this study we intend to answer the following research question (RQ): How do engineering students in a semester-long study abroad program perceive intercultural competence in their discipline and in future career?

2. Methods

2.1 Context & Participants

The Semester Abroad Intercultural Learning (SAIL) Scholarship Program at *[Blinded]* offers students the opportunity to participate in a semester-long study abroad experience. Participants for this study were 14 engineering students, including 5 female and 9 male students who studied abroad in Spain and France for the Fall 2023 semester. The program began with a pre-departure orientation designed to prepare students for their time abroad. During the orientation, students were introduced to the course structure, expectations, and the intercultural development tools they were supposed to use. During the study abroad, students were required to complete a Growing, Learning, and Understanding Everyone (GLUE) curriculum [10], which is grounded in key theoretical frameworks such as the Intercultural Development Continuum (IDC) [18], the IKC-VALUE Framework [19], and Sorrell's Praxis model [20]. Through the GLUE curriculum, students were engaged in various activities designed to improve their intercultural understanding and communication skills. While studying abroad, students participated in live virtual mentoring sessions led by interculturally trained mentors. These sessions were held after every two units of the GLUE curriculum. During the session mentors engaged students in various intercultural activities and provided students with feedback on their reflections, experiences, and assignments completed as part of the program. These mentoring sessions helped students critically reflect on their time abroad, deepening their intercultural competencies, and navigating the challenges of living and studying in a new cultural environment. The program's goal was to equip students with the skills and knowledge needed to thrive in diverse, global contexts.

2.2 Data Collection

Data was collected in the form of student reflections, where participants explored the connection between ICC and their engineering profession. This connection is crucial as the engineering field increasingly requires professionals to work in diverse, globalized settings. In their reflections, students were asked to 1) describe how being interculturally competent could enhance their ability to contribute to their discipline, recognizing that cultural awareness and 2) reflect on their ability to navigate diverse perspectives are essential for effective teamwork, problem-solving, and innovation in engineering projects that often involve international collaboration or address global issues. 3) Lastly, students asked to reflect on the potential negative impacts of low intercultural competence on their future careers. This exercise encouraged students to critically reflect on their personal and professional growth, emphasizing the importance of ICC in navigating complex global challenges. For this study, only qualitative data from these reflections were analyzed, and IDI data was not included.

2.3 Rubric Creation

The rubric used in this study was developed by an expert in the field of study abroad and ICC, see Table 1. The constructs within the rubric were specifically chosen to evaluate the key aspects of ICC that are most relevant to engineering students studying abroad. These criteria—a) identification and awareness of intercultural competence in engineering, b)self-examination and reflection, c) critical assessment and reframing of assumptions, d) exploration and adoption of new roles and perspectives, and e) development of a plan for action and skill acquisition. The inclusion of *identification and awareness of intercultural competence in engineering* was critical as it assessed students' understanding of how ICC directly impacts their ability to collaborate and succeed in the engineering field. As engineering is a highly collaborative discipline, particularly in a global context, understanding how cultural competence affects teamwork and communication is essential [21]. Similarly, the rubric's focus on *self-examination and reflection* encouraged students to engage with their own beliefs and values, which is an important part of developing ICC. By reflecting on personal experiences, students could critically assess their actions and reactions in intercultural situations, an essential skill for engineers working in diverse environments [22]. The criteria of *critical assessment and reframing of assumptions* and *exploration and adoption of new roles and perspectives* aligned with the goal of fostering deeper cultural awareness and adaptive behavior. These criteria addressed the need for students to recognize cultural differences and also embrace and adopt new perspectives to enhance their professional and personal growth. Finally, the *development of a plan for action and skill acquisition* was crucial for ensuring that students not only reflected on their learning but also created actionable plans for continuous development of intercultural competence—a key outcome of the SAIL program.

Table 1. Rubric for Scoring Student Reflections

Constructs	Level 3: High	Level 2: Medium	Level 1: Low
Identification and Awareness of intercultural competence in Engineering	Clearly identifies and deeply understands the importance of intercultural competence in engineering, with detailed contextual examples. Demonstrates a strong grasp of how intercultural competence enhances professional contributions.	Identifies intercultural competence's importance with some understanding of its role in engineering, but lacks depth in examples or contextualization.	Mentions intercultural competence in engineering without specific examples or a clear understanding of its relevance to the field.
Self-Examination and Reflection	Deeply reflects on personal beliefs, values, and emotions, and understands how these impact intercultural interactions in engineering. Provides specific examples from their experiences.	Reflects on personal beliefs and values with some awareness of their influence on intercultural interactions, but examples may lack depth or specificity.	Provides limited reflection on personal beliefs, showing an initial understanding of their impact on intercultural competence.
Critical	Thoroughly questions	Questions some	Recognizes

Assessment and Reframing of Assumptions	and reframes assumptions, showing a significant shift in perspective regarding intercultural competence. Demonstrates sophisticated understanding of the impact of cultural norms.	assumptions but demonstrates only a partial shift in perspective. Shows some recognition of cultural differences but lacks depth in critical analysis.	assumptions but offers limited exploration or reframing. Understanding of cultural differences is basic and not fully developed.
Exploration and Adoption of New Roles and Perspectives	Actively adopts new perspectives and roles in intercultural contexts, demonstrating a transformative approach to integrating these into their engineering practice.	Explores new perspectives and roles, but has not fully integrated them into practice. Shows some willingness to adopt new behaviors but lacks consistency.	Shows initial curiosity about intercultural perspectives but struggles to adopt new behaviors or integrate them into practice.
Development of a Plan for Action and Skill Acquisition	Develops a comprehensive actionable plan for acquiring and applying new intercultural skills, demonstrating clear strategies for future growth.	Creates a plan with some actionable steps but lacks clarity or specific strategies for acquiring intercultural skills.	Provides a vague or incomplete plan, with minimal effort to acquire or develop new intercultural skills.

2.4 *Data Analysis*

Rubric Scoring

To analyze the student reflections, each reflection was scored using the rubric. Descriptive statistics, including mean and standard deviation (SD), were calculated to summarize the overall perception of students for each rubrics construct. This statistical analysis provided insight into the general level of ICC understanding among the students. Further, the mean scores for each construct was categorized into low, medium, and high levels. This categorization was based on the rubric itself, with the following criteria: mean scores between *0 and 1.0* were classified as *low*, mean scores between *1.1 and 2.0 as medium*, and mean scores between *2.1 and 3.0 as high*. This system was designed to provide a clear and consistent method for interpreting the degree of ICC demonstrated by students.

Thematic Analysis

A deductive thematic analysis was conducted to identify patterns and specific quotes that aligned with each rubric construct [23]. Deductive thematic analysis is guided by pre-existing theories or frameworks. In this case, the rubric's constructs served as a guiding framework. The researchers used the rubric constructs to systematically identify and code specific examples from the reflections that corresponded to the rubric's definition. This approach ensured that the analysis

remained focused on the key areas of ICC that were of interest to the study. The reflection were coded independently by three raters. Each rater was provided with the rubric and trained to identify relevant themes and student quotes based on the rubric's criteria. The raters initially worked independently. After the initial coding, the raters met to compare their findings, discuss discrepancies, and reach a consensus on any inconsistencies. This process helped ensure that the analysis was consistent.

Trustworthiness: To ensure the trustworthiness of the qualitative data peer debriefing was conducted. The peer debriefing process involved regular meetings between the raters and an external researcher, who reviewed the coding and provided feedback on the interpretation of the themes. This external perspective helped to ensure that the analysis was not biased and that the interpretations were grounded in the data. The peer debriefing process also allowed the team to reflect on their own assumptions and make adjustments to the coding process as needed. By using a combination of independent raters, consensus discussions, and peer debriefing, the study ensured that the analysis of the student reflections was consistent and trustworthy.

3. Results

3.1 Rubric Scoring Results

The quantitative findings revealed varying levels of ICC development among students across the assessed rubric constructs. The constructs were categorized into low, medium, and high levels, following the categorization discussed in the data analysis section. The score for the construct *Identification and awareness of intercultural competence in engineering* was (Mean= 2.38, SD=0.65) placing it in the high category. The construct of *Self-examination of experiences and reflection* received a score of (Mean= 2.15, SD=0.80) also falling into the high category. In *Critical assessment and reframing of assumptions,* the score was (Mean= 1.69, SD=0.75), placing it in the medium category. For *Exploration and adoption of new roles and perspectives in engineering*, the score (Mean= 1.85, SD=0.99) also categorized as medium. Lastly, the construct of *Development of a plan for action and skill acquisition* had a score of (Mean= 1.46, SD=0.52) placing it in the medium category. Figure 1 showcases the mean and SD for each construct.

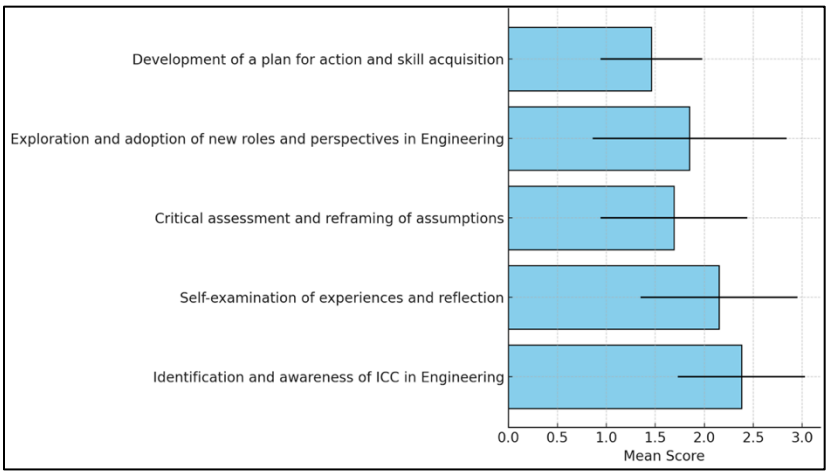

Figure 1. Mean and SD for all constructs

3.2 Thematic Analysis Results

The paragraph below showcase the rubric construct (RC) and the themes that emerged for each construct.

RC 1: Identification and Awareness of Intercultural Competence in Engineering

Theme 1: ***Recognition of positive contributions****:* Students demonstrated an understanding of how ICC enhances teamwork, collaboration, and employability in diverse engineering contexts. For example, Student 9 noted, *"In mechanical engineering, being culturally competent improves collaboration within diverse teams, making one an attractive job candidate"*.

Theme 2: ***Awareness of negative consequences****:* Students recognized the risks associated with a lack of ICC, such as misunderstandings, miscommunication, and potential project failures in engineering teams. This was emphasized by Student 1, *"Having low intercultural competence in environmental engineering, or any type of engineering for that matter, can lead to misunderstandings, miscommunication, and potential project failures."*

RC 2: Self-examination of Experiences and Reflection

Theme 1: ***Recognition of cultural influence on interpersonal dynamics****:* Students reflected on how their understanding of cultural differences shapes their ability to navigate complex interpersonal interactions. For instance, Student 1 highlighted this by stating, *"By better understanding people's beliefs and work styles related to their backgrounds, I can better understand how to have difficult conversations on topics ranging from design alterations to supplier changes".*

Theme 2: ***Application of intercultural understanding in real-world contexts****:* Students demonstrated the ability to connect their reflections and intercultural experiences to practical scenarios, such as internships or professional environments. As Student 10 shared, *"Sharing a specific example from a past internship with a German supervisor, I would emphasize how intercultural competence allowed me to understand her expectations early on, leading to a positive and productive work relationship."*

RC 3: Critical Assessment and Reframing of Assumptions:

*Theme 1:****Awareness of the importance of cultural understanding****:* Students demonstrated an initial recognition of the need to understand cultural values and practices to maintain respectful and effective interactions in professional settings. For example, Student 12 stated, *"If you work with a multinational company and have to work with people from different countries, you need to be able to understand their values. If you do not understand their cultural practices then you may severely disrespect them and potentially get fired."*

Theme 2: ***Acknowledgment of cultural differences in workplace dynamics****:* Students identified specific ways cultural differences, such as norms around timeliness or communication styles, can affect collaboration and project outcomes. Student 8 explained, *"Intercultural competency is particularly crucial in project management, where understanding teammates' cultural norms helps prevent miscommunications and enhances cooperation. Recognizing cultural differences in perspectives on timeliness can avert unnecessary anxiety and misunderstandings."*

RC 4: Exploration and Adoption of New Roles and Perspectives in Engineering: *Theme 1: **Exploration of ICC in professional roles**:* Students demonstrated an ability to recognize and explore the relevance of ICC in engineering roles, particularly in areas like project management and collaboration. For example, Student 2 noted, *"Intercultural competency is particularly crucial in project management, where understanding teammates' cultural norms helps prevent miscommunications and enhances cooperation"*.

*Theme 2: **Recognition of local contexts and sustainability**:* Students explored the importance of considering local contexts and cultural values in engineering solutions, particularly in fields like environmental sustainability. For example Student 8 reflected, *"The consideration of local contexts is important in environmental affairs because different people have different ways of looking at sustainability and how sustainable solutions respect local cultures and their values."*

Construct 5: Development of a Plan for Action and Skill Acquisition: *Theme 1: **Acknowledgment of the need for ICC development**:* Students recognized the importance of developing ICC and its role in fostering effective communication and collaboration. For instance, Student 4 stated, *"Keeping these things in mind as well as keeping an open mind will help in any discipline."* For this theme we noted that students demonstrated awareness but lacked specificity in terms of actionable strategies.

*Theme 2: **General understanding of ICC's importance without specific planning**:* Students expressed a general understanding of how ICC skills contribute to professional success but fail to outline concrete steps for skill acquisition. For example Student 10 stated, *"I would highlight its crucial role in fostering successful collaboration and communication, drawing from personal experiences."* While this shows recognition of ICC's value, it does not detail how to acquire or enhance these skills.

4. Discussion

The results from the quantitative and qualitative analysis provide valuable insights into students' development of ICC within the context of engineering as a discipline. The categorization of scores into low, medium, and high levels, based on a clear rubric, provided a systematic method for evaluating students' engagement with various aspects of ICC. This framework allowed for a structured interpretation of their reflections, revealing both strengths and areas for growth in their intercultural development. Engineering, as a global discipline, increasingly requires professionals to work within diverse teams, manage international projects, and address challenges that impact communities worldwide [21]. The high scores observed in *Identification and Awareness of Intercultural Competence in Engineering* and *Self-examination of Experiences and Reflection* suggest that students recognize the importance of ICC in the engineering profession. This indicates that the SAIL program successfully encouraged students to reflect on how ICC plays a critical role in improving teamwork, communication, and innovation in a multicultural context, which are essential skills for engineers working on global projects [6]. The qualitative analysis further highlighted how students were able to articulate how developing ICC could enhance their collaboration abilities and professional prospects, particularly in global engineering environments where cross-cultural communication and cooperation are vital [10]. However, the medium scores in *Critical Assessment and Reframing of Assumptions, Exploration and Adoption of New Roles and Perspectives in Engineering, and Development of a Plan for*

Action and Skill Acquisition point to areas where students still need further development, particularly in integrating ICC into their engineering practice. While students were able to identify the *importance of reassessing their cultural assumptions and adopting new perspectives*, their reflections indicated a lack of deep transformation in their personal views. STEM is a discipline that relies heavily on collaboration and problem-solving. The ability to critically assess one's assumptions and understand the perspectives of others is crucial to navigating complex, diverse teams and designing solutions that meet the needs of varied communities [24]. The medium scores suggest that while students grasp the importance of these skills, they have yet to fully adopt or integrate them into their professional practice. In addition, the lack of specific, actionable plans for skill acquisition reflects a gap between awareness and action. While students acknowledged the need for continuous improvement in ICC, they did not consistently provide detailed strategies for how they would develop these competencies further. This is particularly important in engineering, where the ability to engage effectively with diverse perspectives is essential for designing solutions that are culturally relevant and ethically sound.

Providing students with more guidance on creating actionable development plans could help bridge this gap and ensure that they are well-prepared to apply ICC skills in real-world engineering scenarios. The qualitative findings also suggest that while students are *exploring new roles and perspectives related to ICC,* they are still in the early stages of adopting these insights into their engineering practice. This gap indicates a need for further emphasis on fostering the integration of ICC into engineering-specific contexts, where intercultural learning is not just explored but actively applied in decision-making, design processes, and teamwork. The findings highlight potential areas for enhancing the SAIL program to better equip students with the intercultural competencies necessary for success in the engineering discipline, where global collaboration and culturally sensitive problem-solving are essential to addressing the complex challenges of the 21st century.

Conclusion, Limitations, and Future Work

The findings of this study highlight the importance of identifying the need of conducting and refining semester long study abroad programs to enhance students' intercultural competence. Intentionally structured programs, such as those integrating targeted mentoring, reflective practices, and experiential learning, can play a pivotal role in preparing STEM undergraduates for the demands of a globalized workforce. By fostering the ability to communicate and collaborate effectively across cultures, these programs equip students with essential skills for success in diverse professional environments. However, this study has certain limitations. It relied solely on qualitative data, primarily student reflections, to explore the impact of study abroad programs on the development of intercultural competence. While these reflections offered meaningful insights, conducting interviews would have provided in-depth understanding of student experiences. To address this limitation, we plan to conduct focus group interviews of the student experience and further validate the themes identified in this study. Future work will focus on designing a longitudinal study is planned to evaluate the long-term impact of study abroad experiences on students' intercultural competence and career readiness. By employing a mixed-methods approach, future research can provide a more comprehensive understanding of how to optimize study abroad programs to develop essential intercultural skills in STEM undergraduates.

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