WIP - Exploring the Impact of International Collaborative Engineering Design Projects on Freshman Students: Cultural Awareness and Sustainability

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Dr. Garcia leads efforts to secure and steward external funding, including competitive grants and philanthropic investments, to create sustainable scholarship opportunities, mentoring programs, and experiential learning initiatives. She partners closely with faculty and staff to align these resources with curricular and co-curricular priorities, ensuring that programs are pedagogically sound, scalable, and responsive to student and departmental needs.

A core responsibility of her position involves working alongside faculty, advisors, and professional staff to develop initiatives that support students' successful transition to college life, persistence in engineering majors, and preparation for graduate study and professional careers—particularly for students historically underserved in STEM and engineering. Through cross-functional collaboration, she helps foster inclusive learning environments that promote retention, academic excellence, and student well-being.

Additionally, Dr. Garcia collaborates with faculty to integrate practitioner-informed and community-engaged components into academic programming, connecting industry, government, nonprofit, and research partners with classroom and experiential learning. Her work strengthens the bridge between theory and practice, enriching engineering education while advancing workforce readiness and civic responsibility.

Dr. Garcia also contributes to the College's scholarly and institutional mission by engaging in research, assessment, and dissemination of best practices related to student success, inclusive pedagogy, and organizational change in engineering education. She works with faculty and staff to analyze program outcomes, support accreditation and reporting efforts, and produce publications and presentations that inform institutional decision-making and national conversations.

Through sustained collaboration with students, faculty, staff, and external partners, the Assistant Dean for Advancement and Community Development plays a pivotal role in advancing the College of Engineering's mission, strengthening its academic community, and expanding its long-term impact.

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Abstract – This study explores the role of international collaboration in shaping freshman engineering students' awareness of cultural considerations in the design process. During the Fall 2025 semester, students from [U.S. institution] partnered with peers from [Mexican institution] to develop engineering design projects aligned with the United Nations Sustainable Development Goals (SDGs). The 16 students from [U.S institution] are members of a one credit hour First Year Odyssey Seminar (FYOS). All first-year students are required to take a FYOS. The 11 students for the [Mexican institution] are registered in an optional class as part of their advanced pre-university curriculum named Global Citizens. We will report on initial successes and challenges. Preliminary findings from this ongoing study indicate that early exposure to cross-border teamwork enhances students' recognition of how cultural contexts influence design decisions, while also strengthening collaboration, communication, and problem-solving skills.

This project builds on prior cohorts' assessments of student projects addressing global and local needs, including: (a) the design of a solar-powered study table for energy-limited contexts, (b) the development of a stroke prevention and awareness kit, (c) sustainable solutions for water harvesting and storage, and (d) the promotion of hands-on STEM activities for K–5 students through the creation of a practical teaching manual. Data from these projects highlighted students' growing ability to frame problems in relation to sustainability, adapt solutions to user needs, and consider the cultural dimensions of technology adoption.

The Fall 2025 cohort extends this work by explicitly embedding international collaboration into the freshman design experience. The plan for data collection methods include pre- and post-surveys, reflective journals, and analysis of design artifacts, with a mixed-methods approach guiding interpretation based on Deardorff's intercultural competence model. Preliminary evidence suggests that engaging students in culturally diverse, sustainability-driven projects early in their academic journey fosters both technical and intercultural competencies. Full findings will inform recommendations for incorporating international, SDG-focused projects across the engineering curriculum.

Keywords – Bilingual, International, Zoom, Engineering Identity, Professional Skills, International Engineering

I. INTRODUCTION

Contemporary engineering practice is increasingly influenced by various factors, such as, globalization, sustainability imperatives, and cross-cultural collaboration. Engineers are now routinely expected to design solutions for complex, ill-structured problems that cross national boundaries and require sensitivity to social, cultural, economic, and environmental factors. Addressing contexts and challenges such as climate change mitigation, access to clean water, public health infrastructure, and equitable technological development requires not only technical expertise but also the capacity to collaborate with diverse stakeholders across cultural and geopolitical contexts [1-2]. Consequently, professional organizations, accrediting bodies, and engineering education scholars have underscored the necessity of preparing engineers to integrate cultural awareness and global perspectives into the design process.

Despite general agreement on the importance of global competence, engineering education has always prioritized technical program solving while treating cultural, social, and contextual considerations as supplemental [3]. This imbalance is particularly evident in early undergraduate curricula where first-year engineering experiences often highlight foundational technical skills, disciplinary orientation, and academic survival rather than sociochemical thinking or intercultural engagement. An as a result, many students encounter cultural considerations in engineering design only much later in the academic programs, often by elective courses, study abroad experiences, or extracurricular activities. Late exposure and/or delayed exposure limits students' ability to develop integrative habits of mind that connects technical decision making with human and cultural contexts from the outset of their engineering education.

A large and growing body of scholarship are challenging the notion of engineering as purely a technical endeavor, instead, as an inherently sociotechnical practice. Bucciarelli [4], argues that engineering design emerges through negotiations among multiple stakeholders, each bringing distinct values, priorities, and cultural perspectives. Similarly, Downey et al. [2] also argues that global engineers must be capable of recognizing how engineering solutions are shaped by cultural assumptions and how those assumptions influence the acceptance, adaptation, and/or rejection of technologies in different contexts. And therefore, from this perspective, cultural awareness in engineering is not an ancillary but a core component of responsible engineering practice.

Research in engineering education supports this view, demonstrating that those students who engage with contextualized and human-centered design problems, are more likely to consider ethical implications, user needs, and long-term societal impacts [5-6]. Nonetheless, scholars have also noted persistent challenges in helping students to meaningfully integrate cultural considerations into design work, particularly when curricula frame such considerations as constraints rather than as sources of innovation [3]. And therefore, these challenges underscores the need for pedagogical approaches that explicitly foreground cultural context as a central element of engineering design.

International collaborative learning has been identified as a high-impact educational practice with the potential to promote intercultural competence, communication skills, and global awareness [7-8]. In engineering education, international collaborations have taken various forms, including virtual global teams, study abroad programs, and multinational design projects. Research indicates that such experiences can enhance students' ability to navigate cultural differences, manage ambiguity, and collaborate across disciplinary and national boundaries [11].

Nevertheless, access to international experiences in engineering education remains uneven. Study abroad opportunities are often limited by financial, curricular, or logistical constraints, and participation rates among engineering students remain relatively low compared to other disciplines [1]. Virtual or hybrid international collaborations offer a promising alternative, enabling students to engage with peers from different cultural contexts without the barriers associated with travel. Yet, scholars caution that simply placing students in international teams is insufficient; meaningful learning requires intentional scaffolding, reflection, and theoretically grounded assessment [8].

Intercultural competence provides a useful lens for examining how students develop the ability to interact effectively and appropriately across cultural differences. Deardorff's [9] process-oriented model conceptualizes intercultural competence as an iterative development of attitudes, knowledge, skills, and internal outcomes that manifest in effective external behavior.

The first year of engineering education plays a critical role in shaping students' perceptions of the discipline, their sense of belonging, and their emerging identity as engineers [5]. Introductory courses and first-year seminars are increasingly recognized as important entry points for introducing students to authentic engineering practices, including teamwork, communication, and ethical reasoning [10]. However, the limited credit hours typically allocated to first-year engineering curricula often constrain the inclusion of additional competencies such as intercultural awareness, despite its growing importance in global engineering practice. First-Year Odyssey Seminars (FYOS), and similar first-year seminar models, provide a promising framework to address this gap. These seminars emphasize inquiry, reflection, and engagement with complex societal issues, creating opportunities to integrate global and cultural dimensions without displacing core technical content. Within this context, the present study is guided by the hypothesis that introducing intercultural awareness during the first year of engineering education, particularly through structured international collaboration embedded in a FYOS environment, can support the early development of intercultural competence while reinforcing foundational engineering skills and sociotechnical understanding.

II. BACKGROUND

Course details

"Program Name" is a project-based course in a Spanglish environment about a relevant scientific/engineering topic where engineering students enrolled in the US-University collaborate with students from a Spanish-speaking university (i.e., Mexico, Puerto Rico, Spain). For students from the US, this course is a 1-credit course that is offered either as part of a freshman seminar. The course requires a basic understanding of the scientific method and/or engineering design process. For students from Mexico, this course is part of their elective class "Program Name2" (Trayectoria Académica Especializante, TAE, Specialized Academic Trajectory), where students focus on developing their command of spoken English by designing and building STEM projects. The course is set up to have one session per week, where every other week sessions is dedicated to a virtual meeting (Zoom) with the international partner, and the other session is conducted intranational (i.e., US and Mexico meet separately) to discuss the progress of the project and topics that help teams stay accountable.

III. DATA COLLECTION

Surveys

Students complete a survey at the end of the semester to measure their perception in intercultural attitudes, self-perceived competence, and culturally responsive design awareness. Survey items are mapped to Deardorff's domains (e.g., openness and curiosity as attitudes; confidence in intercultural teamwork as an external outcome indicator). Likert-scale items are paired with open-ended prompts to capture both intercultural competence and student explanations for perceived growth.

The three qualitative questions included were:

1. Describe the experience in which you learned something important from someone with a different cultural background.
2. What challenges do you face when interacting with people from other cultures?
3. How do you think college can help you become more interculturally competent?

Engineering Journals

Students submit engineering journals during the midterm and final. Entries are analyzed to seek for alignment with Deardorff's domains and emphasize the connection between intercultural teamwork and design practice. Example prompt categories include:

- Attitudes: willingness to revise assumptions about users or teammates
- Knowledge/Skills: recognition of culturally situated constraints and communication strategies
- Internal Outcomes: evidence of perspective shifts or increased cultural self-awareness
- External Outcomes: examples of effective intercultural collaboration and conflict resolution

Design Artifacts and Team Deliverables

Design artifacts are collected as evidence of how intercultural learning manifests in engineering decision-making. Artifacts include problem statements, stakeholder/user descriptions, requirement lists, concept selection matrices, prototypes or sketches, testing plans, and final reports or presentations. These materials are analyzed for explicit consideration of cultural context, user needs, sustainability constraints, and SDG alignment.

IV. RESULTS

Student responses to the three intercultural experience questions were analyzed using a deductive coding scheme based on Deardorff's Process Model of Intercultural Competence. Across the 12 participants, themes related to attitudes, knowledge and skills, internal outcomes, and external outcomes emerged consistently. Table 1 summarizes the frequency of coded themes for each question. Additionally, average results with standard deviation are reported on Figure 1.

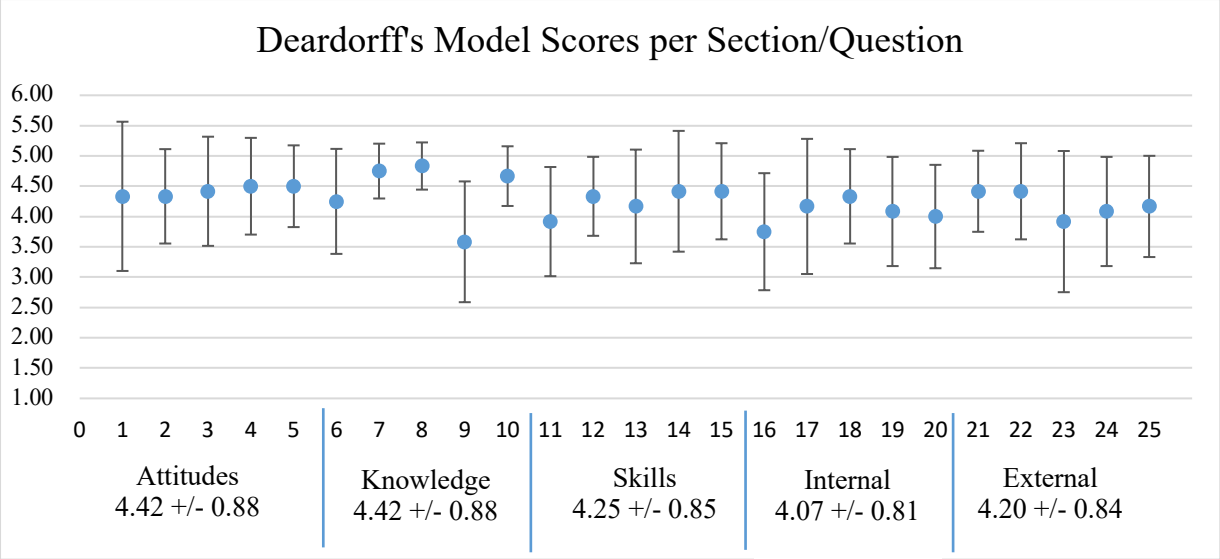

Figure 1. Average scores +/- standard deviation for 25 questions on Deardorff's model. Scores per section are reported below the x-axis.

Q1: Learning from Cultural Differences. When asked to describe an experience in which they learned something important from someone with a different cultural background, students reported 40 coded instances of intercultural learning.

- Knowledge & Skills (n = 11/12): Nearly all participants identified specific cultural practices or worldviews they had learned (e.g., traditions such as Mexican celebrations, Chinese New Year, regional cuisine). This category reflected knowledge acquisition about cultural norms and contextual differences.
- Attitudes (n = 9/12): Many responses demonstrated openness, respect, and curiosity toward cultural differences. Students expressed appreciation for perspectives different from their own.
- Internal Outcomes (n = 7/12): Several students reported a shift in perspective or increased empathy as a result of these interactions (e.g., recognizing socio-cultural reasons for food practices or values).
- External Outcomes (n = 5/12): A subset of learners described how these experiences manifested in concrete interaction behavior or adjustments in their approach to collaboration.

Example coded excerpts:

- Knowledge & Skills: "Learned about the meaning of Chinese New Year…"
- Attitudes: "I got to learn about what Halloween is like in Mexico."
- Internal Outcomes: "Understanding and empathizing my own perspective…"
- External Outcomes: "In my FYOS class, we work with students from Mexico, so we must cater to them meaningfully."

Q2: Challenges in Intercultural Interaction

When asked about challenges faced when interacting with people from other cultures, responses yielded 32 coded instances related to intercultural competence challenges.

- Knowledge & Skills (n = 10/12): The most frequently reported difficulty was intercultural communication, including language barriers, accents, dialect differences, and understanding social references.

- Attitudes (n = 6/12): Some students acknowledged predispositions that reflect challenges in withholding judgment or managing assumptions (e.g., stereotyping).
- Internal Outcomes (n = 5/12): Reflection on personal limitations and awareness of challenges was evident, indicating emerging metacognitive understanding of intercultural interaction constraints.
- External Outcomes (n = 3/12): A smaller number of responses indicated how these challenges manifest in interaction behaviors (e.g., difficulty achieving effective collaboration due to communication barriers).

Example coded excerpts:

- Knowledge & Skills: "Language barrier and social references barrier is definitely a challenge."
- Attitudes: "Sometimes, I assume people are certain ways… I stereotype."
- Internal Outcomes: "Language barriers have two levels: the language itself and regional dialects."
- External Outcomes: "We may share different beliefs that can lead to disagreements."

Q3: Perceived Role of College in Developing Intercultural Competence

Responding to how college can contribute to becoming more interculturally competent, students produced 38 coded instances aligned with developmental outcomes.

- External Outcomes (n = 11/12): Most participants linked collegiate experiences to enhanced intercultural competence through increased opportunities for interaction with diverse peers and structured collaboration.
- Attitudes (n = 8/12): Several learners expressed that exposure to diverse backgrounds would cultivate openness and willingness to engage.
- Knowledge & Skills (n = 7/12): Students articulated that college settings provide contexts for practicing communication skills and cultural learning.
- Internal Outcomes (n = 5/12): Students anticipated internal growth such as perspective broadening and adaptation through diverse encounters.

Example coded excerpts:

- External Outcomes: "College is a connection of people from various backgrounds…"
- Attitudes: "By interacting with different cultures I will be more experienced…"
- Knowledge & Skills: "College has people from many cultures so interacting with these people will help me."
- Internal Outcomes: "The more people you meet from diverse backgrounds, the more interculturally competent you become."

Summary of Coded Themes

Across all questions, students demonstrated a developmental trajectory consistent with Deardorff's model: initial encounters and exposure (knowledge/skills and attitudes) were frequently reported, followed by recognition of internal shifts and expectations for effective future interaction. Communication challenges (particularly language barriers) were the most cited impediments to intercultural interaction, aligning with the knowledge/skills domain. College was most often conceptualized as a setting for external outcome development through structured and informal intercultural engagement.

Table 1. Frequency of coded domains for the 3 open-ended questions.

Domain	Q1. Experience	Q2. Challenges	Q3. College Role
Attitudes	9	6	8
Knowledge and Skills	11	10	7
Internal Outcomes	7	5	5
External Outcomes	5	3	11

Quantitative Results (Deardorff Framework Alignment)

Quantitative survey results were analyzed using subscales aligned with Deardorff's intercultural competence model, including attitudes, knowledge and comprehension, skills, internal outcomes, and external outcomes. Overall, students reported consistently high perceived intercultural competence across all five domains. Mean scores (out of 10) were: attitudes = 8.8, knowledge and comprehension = 8.8, skills = 8.5, internal outcomes = 8.1, and external outcomes = 8.4. These findings indicate that students perceived the strongest development in attitudes and knowledge/comprehension, with slightly lower perceived growth in internal outcomes, which aligns with Deardorff's model that internal shifts often require sustained experience and reflection.

Highest-Scoring Items (Top 10%)

The highest-rated survey statements (top 10%) reflected strong student awareness of cultural difference and its impact on interaction and decision-making. Specifically, students rated the following items most highly: "I understand that people from other cultures may communicate and behave differently" (M = 4.75/5) and "I am aware that cultural values influence how people make decisions" (M = 4.83/5)
These results suggest that students developed strong recognition of intercultural variation and the role of cultural values—outcomes closely aligned with Deardorff's knowledge/comprehension and attitudes domains.

Lowest-Scoring Item (Bottom 10%)

The lowest-rated item (bottom 10%) was: "I can feel comfortable even when I don't fully understand the cultural situation" (M = 3.75/5)
This lower score indicates that while students recognize cultural differences and their importance, they may still experience discomfort in ambiguous intercultural contexts. This finding is consistent with Deardorff's emphasis on tolerance for ambiguity as a key attitudinal and internal outcome component that often develops more gradually through repeated exposure and guided reflection.

Summary Interpretation

Taken together, the quantitative results suggest that students are developing strong foundations in intercultural awareness (attitudes and knowledge), while still needing support in navigating uncertainty and ambiguity during intercultural interactions. This pattern aligns with the developmental progression described in Deardorff's model, where internal outcomes (e.g., comfort, adaptability) may lag behind early gains in recognition and understanding.

Analysis of Student Reflective Notebooks an Artifacts

Qualitative analysis of student reflective notebook comments provided further evidence of intercultural competence development consistent with Deardorff's Process Model of Intercultural Competence. Student reflections revealed growth across multiple domains, including intercultural communication skills, cultural knowledge and awareness, attitudinal openness, and internal perspective development. These findings complement the survey results and provide additional insight into how students experienced and interpreted international collaboration within the freshman engineering design context.

A prominent theme across student reflections was the development of intercultural communication skills. Students described the need to adapt their communication practices to ensure mutual understanding, particularly when interacting with peers from a different linguistic and cultural background. For example, one student noted the importance of adjusting speech pace, selecting words carefully, and using clarification strategies when communicating with international partners. Although students observed that their collaborators demonstrated strong English proficiency, they recognized that effective intercultural communication required intentional effort beyond shared language fluency. This reflects the development of competencies associated with Deardorff's skills domain, including active listening, message adaptation, and clarification to support shared understanding.

Additionally, one student expressed a desire for increased opportunities to engage with international peers, indicating that initial assumptions regarding language barriers were less restrictive than anticipated. This suggests growing confidence and willingness to participate in intercultural interaction, representing progress toward Deardorff's external outcome of effective and appropriate communication across cultural contexts.

Student reflections also demonstrated increased cultural knowledge and awareness, particularly through structured cultural exchange activities. One student described a classroom activity in which students from both institutions presented on culturally significant holidays, highlighting differences in interpretation and meaning between Halloween in the United States and Día de los Muertos in Mexico. The student noted that traditions perceived as familiar and self-evident within their own cultural context were not universally understood, emphasizing the importance of explicitly communicating cultural assumptions. This recognition aligns with Deardorff's knowledge and comprehension domain, particularly the development of cultural self-awareness and understanding of alternative cultural perspectives. Importantly, the student further connected this realization to engineering practice, noting that misunderstandings in cultural contexts underscore the importance of clear communication and shared understanding in collaborative engineering environments. This reflects early evidence of external outcomes, where intercultural awareness informs professional and technical interaction.

Student reflections also revealed evidence of attitudinal shifts consistent with increased openness and curiosity toward intercultural engagement. For example, one student reported that attending an informational event featuring study abroad participants increased their interest in pursuing an international academic experience. This indicates that exposure to intercultural narratives and opportunities may positively influence student motivation to engage in global learning experiences. Similarly, the expressed desire for additional interaction with international collaborators suggests increased willingness to participate in intercultural communication. These responses align with Deardorff's attitudes domain, which emphasizes

openness, curiosity, and respect as foundational elements of intercultural competence development.

Several student reflections demonstrated internal developmental outcomes, particularly in the form of perspective-taking and recognition of cultural relativity. Students acknowledged that cultural traditions and practices may be interpreted differently depending on social and cultural context. This awareness represents a shift away from ethnocentric assumptions and toward a more culturally relativistic perspective, consistent with Deardorff's internal outcomes domain.

Collectively, these findings indicate that structured international collaboration within a freshman engineering design course can facilitate early-stage intercultural competence development. Students demonstrated growth in intercultural communication skills, cultural knowledge, openness to intercultural engagement, and perspective-taking. Notably, students also recognized the relevance of intercultural competence to engineering practice, particularly in the context of teamwork and collaborative problem solving.

These results suggest that integrating international, project-based collaboration into first-year engineering curricula can provide meaningful opportunities for students to develop competencies that support effective participation in globally distributed engineering environments. Early exposure to intercultural teamwork may help establish foundational competencies that can be reinforced and expanded throughout the undergraduate engineering experience.

Contextual Differences in Design Approaches Across International Student Cohorts

Previous cohorts demonstrated that student design approaches were influenced by location-specific cultural, infrastructural, and operational factors, highlighting the importance of contextual awareness in engineering problem-solving. For example, in a prior cohort focused on recycling systems, students observed that recycling centers in Mexico emphasized compressing aluminum cans to optimize storage and transportation efficiency, whereas recycling practices in the United States prioritized cleaning cans to reduce contamination and improve material processing quality. These differences reflected variations in local infrastructure, labor practices, and material handling systems, and required students to adapt their design considerations accordingly. In contrast, observations from the current cohort revealed fewer location-specific divergences in technical approach. While most teams focused on water collection and filtration systems, their proposed solutions did not substantially differ based on geographic or cultural context, suggesting that students may have approached these problems from a more generalized technical perspective rather than tailoring solutions to localized constraints. One notable exception involved a team that developed a biodegradable ink formulation to complement the paper-based design work of their international collaborators, demonstrating an awareness of how supplementary solutions could support broader project objectives across contexts. The relative absence of location-specific differentiation in the current cohort may reflect the need for more explicit scaffolding to help students identify and incorporate contextual variables such as infrastructure, resource availability, user practices, and environmental conditions into their design processes. These findings suggest that while international collaboration provides opportunities for intercultural engagement, intentional instructional strategies may be necessary to ensure that students translate intercultural awareness into contextually responsive engineering design decisions.

V. CONCLUSIONS AND IMPACTS ON ENGINEERING EDUCATION

Findings from the open-ended survey responses (n = 12) suggest that early international collaboration in a first-year engineering context supports intercultural competence development in ways consistent with Deardorff's Process Model of Intercultural Competence. Students most frequently described intercultural learning as gaining new cultural knowledge and awareness (11/12), particularly through exposure to cultural traditions, values, and lived experiences shared by peers from different backgrounds. Several responses reflected growth in attitudes such as openness and respect (9/12), and a smaller but meaningful subset demonstrated internal outcomes such as empathy and perspective-shifting (7/12).

When describing challenges in intercultural interaction, students overwhelmingly emphasized communication-related barriers (10/12), especially language, accents, dialects, and differences in cultural references. Importantly, one response explicitly acknowledged stereotyping as a barrier, suggesting that the experience may also prompt students to recognize their own biases—an essential step in intercultural development.

Finally, students strongly identified college as a setting that can foster intercultural competence through repeated opportunities for diverse interaction (11/12). Collectively, these results indicate that embedding international collaboration into freshman engineering design can create early, authentic conditions for students to begin building intercultural competence alongside foundational engineering skills.

Impacts on Engineering Education

These preliminary results provide several implications for engineering education, particularly for first-year design experiences and sustainability-oriented curricula.

1. Intercultural competence can be intentionally developed in first-year engineering courses.
   Students reported meaningful learning from cross-cultural peer interactions, demonstrating that intercultural competence development does not need to be delayed until upper-division coursework or study abroad programs. Instead, early exposure through structured collaboration may serve as a scalable model for broad participation.

2. Communication skills emerge as a primary leverage point for instructional design.
   The most common challenge reported was communication across language and cultural differences. This suggests that international design collaborations can function as a practical context for students to develop communication strategies (e.g., clarification techniques, visual explanations, confirmation of understanding), which are directly relevant to professional engineering practice.

3. Team-based SDG projects offer a natural pathway for linking culture and design decisions.
   Student responses indicate that cultural learning occurred through concrete comparisons of traditions, values, and user contexts. This aligns well with sustainability-driven design problems, where engineering solutions must be technically feasible while also culturally acceptable and adoptable. As a result, SDG-framed projects may strengthen students' ability to connect design requirements to real-world constraints and stakeholder needs.

4. College environments can reinforce intercultural competence through repeated exposure and structured interaction.

Students viewed college as inherently supportive of intercultural growth due to diversity in peers and teamwork opportunities. This reinforces the importance of designing early curricular experiences that require purposeful interaction, rather than relying on passive exposure alone.

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