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# Building Global Competencies in Biomedical Engineering Education through Virtual Exchange

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## ABSTRACT

Our world's most pressing biomedical challenges cross national boundaries and demand international cooperation. Engineers play a pivotal role in addressing these issues by applying their expertise to develop innovative technologies and systems that improve health outcomes globally. Preparing engineers to lead and innovate in this interconnected world requires pedagogical efforts that foster multicultural competencies. To address this challenge, we implemented an international virtual exchange between biomedical engineering graduate students at the University of Florida in the United States and bioengineering undergraduate students at Pontificia Universidad Javeriana in Colombia. This exchange, conducted over 6-7 weeks, tasked university students with designing an engineering solution to a critical health problem in their partner country. Through synchronous and asynchronous collaboration, students identified specific biomedical needs in each other's healthcare ecosystems and provided feedback on potential engineering solutions. Assessments included video summaries of identified health needs, 3-minute solution pitches, and reflections. Pre- and post-surveys revealed significant gains in students' critical thinking about global issues and intercultural communication skills. More specifically, students reported significant gains in their ability to manage when faced with multiple perspectives, think critically to interpret global and intercultural issues, recognize how different cultures solve problems, and articulate their points of view to members of other cultures. This work underscores the value of virtual exchanges in broadening access to internationalization opportunities among undergraduate and graduate students while fostering critical thinking, cross-cultural communication, and the ability to work collaboratively across borders to address global challenges.


## 1. INTRODUCTION

The recent COVID-19 pandemic shed light on the important role that biomedical engineers play in safeguarding the future of our planet. In fact, many of the challenges our world faces today are global in nature and require global cooperation. As stated by Dr. John Anderson, President of the National Academy of Engineering, engineers play a major role in addressing the dominant global problems of our age [1]. The 2022 Biennial Report to the U.S. Congress on International Science and Technology Cooperation highlights the need to maintain U.S. STEM leadership worldwide by supporting a workforce empowered to advance international partnerships [2]. This is not unique to the North American context. The Colombian National Ministry of Education emphasizes the importance of internationalization as a crucial component of higher education that prepares students to enter a globalized workforce [3]. Thus, it is imperative for engineering students to develop an understanding of cultures and problems at a global scale [4].

Historically, internationalization of higher education curricula has been primarily implemented through study abroad programs that require physical travel to another country [5]. Students who study abroad increase their global [6] and self-awareness [7], develop global competencies [8], and enhance their employability for jobs that involve international dimensions [9]. Thus, participation in study or work abroad experiences yields significant benefits for students, enhancing their personal, academic, and professional development.

Unfortunately, not all students benefit from these enriching experiences. The perceived and real costs of study abroad programs, combined with the sometimes limited access to financial aid

or scholarships, are a significant financial deterrent, especially for students from lower socioeconomic backgrounds [10]. Many students also juggle work commitments, family responsibilities, and other personal obligations that can make the prospect of studying abroad seem daunting [11]. Additionally, fear of the unknown, including concerns about language barriers and cultural adaptation, can deter students from pursuing international experiences [12]. In the context of engineering, students might face tightly structured course sequences with little room for flexibility [13]. The challenge of aligning study abroad programs with degree requirements can lead to a perception that such experiences are incompatible with their academic goals [14], [15]. Therefore, there is a pressing need for strategies that increase access to internationalization opportunities for all students regardless of disciplinary, financial, or personal background.

International virtual exchange, also known as collaborative online international learning (COIL), is the use of technology to connect classes with students, faculty, and researchers abroad to collaborate on assignments and acquire discipline-specific global perspectives [16], [17]. Students who engage in virtual exchanges develop cross-cultural communication skills and increased awareness of global dynamics and are more likely to later participate in study or work abroad [18], [19], [20]. Additionally, COIL experiences expand access to internationalization opportunities for all students regardless of socioeconomic and cultural background, work commitments, or prior experience with other cultures [21]. These gains also apply to engineering contexts. Several studies have demonstrated that engineering students who participate in short-term virtual exchanges grow their cross-cultural collaboration skills [22], increase their global awareness [23], and learn to communicate and work productively across cultures [24].

Here, we describe implementing a virtual exchange experience centered on engineering for global health between graduate and undergraduate students at two universities in Colombia and the United States. We demonstrate that establishing this collaborative peer exchange improves students' abilities to design engineering solutions tailored to specific biomedical problems, think critically about global issues, and communicate effectively in multicultural settings.

## 2. SCOPE OF THIS COLOMBIA-U.S. VIRTUAL EXCHANGE

In this virtual exchange, titled "Comparing Perspectives on Global Health Technology", graduate and undergraduate bioengineering students at Pontificia Universidad Javeriana (PUJ), a private university in Colombia, collaborated with graduate biomedical engineering students at University of Florida (UF), a public university in the United States. Students were divided into groups at both universities and paired with partners from the other country. They were then tasked with working with their partners to identify a health challenge in their partners' country and propose an engineering solution tailored to the local context. The instructors identified key themes for each country to better define the design space. The pedagogical approach was co-designed after both instructors participated in a 5-week training program facilitated by the Office of Global Learning at the University of Florida in the Spring of 2023. The version of the Virtual Exchange described here was executed during the Fall of 2023.

## 3. LEARNING OBJECTIVES

The student learning objectives for this virtual exchange were:

1. Design a biomedical engineering solution tailored to a specific global health problem.
2. Explore multiple perspectives on engineering and global health.
3. Communicate effectively across different cultures.

## 4. IMPLEMENTATION

For 7 weeks, 20 graduate students from UF, and 12 undergraduate and 2 graduate students from PUJ collaborated to identify a specific health problem in their partners' country and propose an engineering solution. The graduate students in the U.S. were enrolled in a graduate elective titled "Global Health in Biomedical Engineering", while the students in Colombia were enrolled in an undergraduate core class titled "Biomechanics" or a graduate elective titled "Innovation Practice". Thus, the students in Colombia were constrained to select a challenge specific to musculoskeletal disorders and the students in the United States were restricted to problems within one of the following biomedical themes: neglected tropical diseases, cardiovascular disease, or orthopedics.

As described below, our approach incorporated synchronous and asynchronous activities designed to foster students' ability to solve global health challenges while enhancing their cross-cultural communication and teamwork skills (**Figure 1**). Additionally, we leveraged various technological platforms to address anticipated challenges related to digital access, language barriers, scheduling differences, and varying levels of student seniority.

### Pre-Exchange

To foster initial interaction and create a sense of community, students participated in an asynchronous **icebreaker activity** on Padlet. Padlet was selected due to its ease of use, lack of financial cost, flexibility, and high capacity to enable interactive asynchronous collaboration [25]. Students were asked to introduce themselves by responding to the following prompt on a collaborative world map: *"Think of a specific place (or activity) in the world that you absolutely love that you would want to show your exchange partners. Include your name, a picture, and a short description"* (**Figure 2**). This activity helped students to get to know each other and set a positive tone for future teamwork.

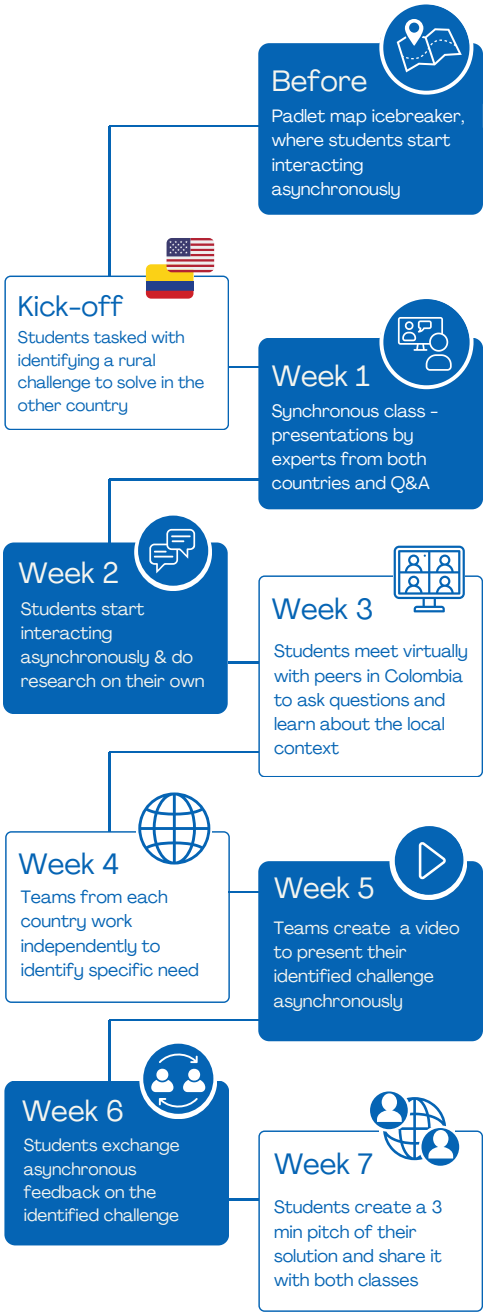


**Figure 1. Overview of the virtual exchange.** Over a period of 7 weeks, graduate and undergraduate students at Pontificia Universidad Javeriana and the University of Florida worked together to identify a health challenge that could be addressed with bioengineering solutions in their partners' country.


**Figure 2. Padlet Icebreaker Activity.** (**A**) Screenshot of the Padlet interactive icebreaker, where students introduced themselves and shared a part of the world they would want to show their exchange partners. (**B**) Example interaction between students in the Padlet.

**Weeks 1-2**

The exchange kicked off formally with an **introductory session and team formation**. Students from both universities met synchronously via MS TEAMS, where we introduced the program's objectives and explained the planned activities. Teams composed of students from both institutions were formed to ensure cross-cultural collaboration. Students were divided into four teams, each consisting of 4-6 UF graduate students and 3 PUJ undergraduates. Additionally, each team included a PUJ graduate student, who was ready to motivate the undergraduate students from the same institution when necessary; this motivation usually involved initiating a conversation or providing help when a language difficulty arose.

Following the introductory session, two **expert talks** were organized. Two guest faculty instructors (one from each university) prepared a virtual presentation to contextualize the students on two exchange themes: musculoskeletal disorders and neglected tropical diseases. Students were encouraged to prepare questions in advance, which helped them engage more actively during the talks and allowed the non-native English speakers to make their contributions confidently. This approach enriched students' understanding of the subject matter and provided a platform to contrast engineering practices and health challenges in different countries. To mitigate potential language barriers and ensure all students could follow the talks, subtitles were added to the Zoom sessions, and translated captions were included in the presentation slides.

**Weeks 3-4**

Next, students participated in **synchronous collaborative meetings**, where team members got to know each other and worked on identifying a specific health need in the other country. These meetings were facilitated using institutional platforms, such as MS Teams and Zoom. The students also used WhatsApp as an informal communication tool for meeting scheduling and general organization between teams. The instructors provided general guidelines on the structure of the first collaborative meeting. This structure included a suggestion for an icebreaker, best practices for interacting on Zoom/Teams, and a meeting outline. Students were also encouraged to prepare questions for their peers in the other country. Examples included what it is like to interact with the healthcare system in their country and significant health challenges they have identified among their family and friends. While the expectation was for the students to meet only once synchronously and continue the conversation via MS Teams, multiple groups opted to meet on Zoom more than once.

One of the challenges during this phase was the difference in the academic calendar between the two universities, which made scheduling synchronous sessions more complex than expected. To address this, asynchronous activities were introduced to complement the synchronous meetings, allowing students to continue working on their projects independently when live meetings were not possible.

**Weeks 5-7**

Once each team identified a specific health problem to address, they posted short videos on Flipgrid explaining their findings. This allowed other teams to provide **peer feedback asynchronously**, ensuring that all students could participate despite differences in time zones and availability. The asynchronous nature of this activity also helped address the challenge of unequal internet access, as students could engage at their own pace and within their own technological constraints.

After incorporating the feedback, students brainstormed **solutions** to the identified regional health problems. Teams worked separately in their respective universities to develop initial design ideas. Once again, they used Flipgrid to share their progress and receive further peer feedback. This iterative process encouraged critical thinking and collaboration, enabling students to refine their solutions with input from diverse cultural and technical perspectives.

## 5. ASSESSMENT

### Formative Assessments

**Flipgrid video discussion boards** were implemented to facilitate asynchronous interactions between students and assess whether the students were progressing toward designing a solution to a specific biomedical challenge. Students in both countries posted video summaries of their identified challenges and obtained feedback (in both written and video format) from their exchange partners. While the instructors provided input and guidance, this assignment was graded for completeness. After that initial round of feedback, students prepared a video consisting of a 3-minute pitch of their proposed solution. In both Flipgrid discussion boards, the students from both countries successfully demonstrated their ability to communicate the significance of their selected biomedical challenge, contextualize the issue to a local context, and ideate a potential engineering solution to the problem.

**Table 1. Reflection Prompts Used to Reinforce Student Learning.**

| Pre-Exchange | Middle | Post-Exchange |
|---|---|---|
| 1. How do you think your interaction with students from another country might impact what you learn in this course?<br>2. How do you think the way you see and understand the world might change by connecting with students in another country?<br>3. How would you describe your cultural background?<br>4. What do you want from this virtual exchange experience?<br>5. What aspects of the virtual exchange make you nervous or anxious? | 1. Provide two or more observations about your interactions with your partner(s) as you work with them in the online environment.<br>2. Describe how your course has been impacted by connecting with a class from another country.<br>3. Now that you have connected with students from another country, how are your views of your partner(s) culture changing?<br>4. How did your cultural background shape your interaction with your partners?<br>5. What surprises you (good or bad) about the virtual exchange experience? | 1. What was the most important thing you learned from this collaborative experience?<br>2. Please describe how doing this experience with international partners impacted your learning experience.<br>3. Given your online interactions with students from another country, describe any key changes that occurred in how you view the world (if any).<br>4. How did your cultural background shape your interaction with your partners?<br>5. Was there any aspect of this virtual exchange-enhanced course that was stressful in any way? If so, please describe this challenge and what you learned from it. |

### Pre-, During, and Post-Exchange Reflections

Intentional reflection is a critical component of applied and experiential pedagogies to reinforce and document student learning [26], [27]. In virtual exchange, reflection can help students identify and confront existing assumptions and worldviews, contemplate alternative viewpoints, recognize gains in their intercultural and personal development, and gain a deeper understanding of themselves and the world [28]. Thus, the students in the United States received **reflection questionnaires** before, in the middle, and after completion of the virtual exchange (**Table 1**). The middle questionnaire was completed after the students had met with their exchange partners on Zoom for the first time. The reflection questions were adapted from a report by The State University of New York COIL Center [29]. These questionnaires allowed the instructors to identify key concerns and challenges throughout the exchange, monitor the quality of the interactions, and assess whether the exchange had led to gains in students' global and multicultural competencies.

### IntCRIT and IntCOMM surveys

To assess gains in multicultural competencies, the students in the United States completed the **International Critical Thinking (IntCRIT) and International Communication (IntCOMM) Attitudes and Beliefs Survey** before and after participating in the exchange. Because of a delay in translation of the surveys, the Colombian students were only able to complete the post-exchange survey. This survey was previously validated by the Office of Global Learning at the UF International Center and consists of 26 items [30]. Critical thinking items assess judgment, analysis, reasoning, and solution finding, while international communication items evaluate sensitivity, production, awareness, adaptability, and acceptance. The items are rated on a

5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree) on a Likert scale. The Wilcoxon signed rank test was conducted to identify the statistical significance of the median differences between the pre- and post-test survey responses, using a significance level 0.05.

The survey was distributed to students by staff from the Office of Global Learning at UF and by the instructor at PUJ. Of the 20 students enrolled in the graduate elective at UF, 15 (75%) completed the pre-survey instrument. Of those students, 13 completed both the pre- and post-surveys. Within this participant sample, 8 students identified as female, 4 as male, and 1 student identified as non-binary (**Figure 3A**). Almost all the PUJ students (13 out of 14) who participated in the virtual exchange completed the post-exchange survey. Among them, 7 identified as female and 6 identified as male (**Figure 3A**). In total, only 2 PUJ students and 2 UF students (14% of all exchange participants) reported having previously participated in a study abroad program (**Figure 3B**).

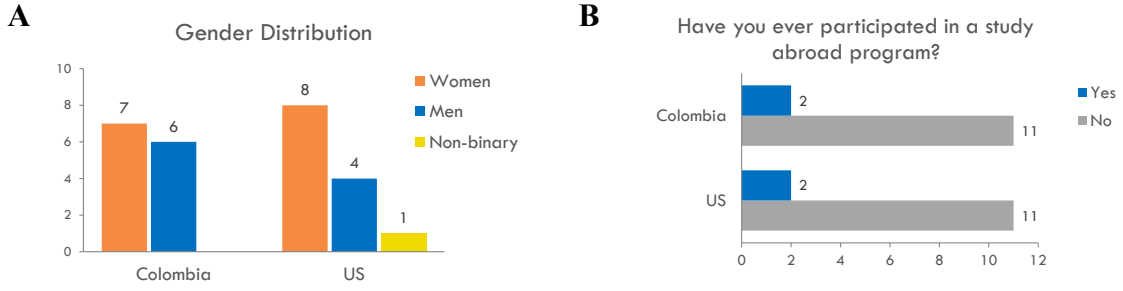


**Figure 3. Demographics of Pre- and Post- IntCRIT and IntCOMM Survey Responders.** (**A**) Distribution of gender among the students who completed both the surveys. (**B**) Responses to the question "Have you ever participated in a study abroad program?".

Among the students in the United States, there was an increase in the average responses for 24 out of 26 items in both surveys between the pre-and post-surveys (**Figure 4**). For almost all statements, the mean response shifted from the "neutral" to "agree" categories to the "agree" to "strongly agree" range. However, due to the small sample size, the Wilcoxon ranked test indicated that the mean difference between the pre- and post-surveys was statistically significant for only 4 items - highlighted in orange in **Figure 4**. These items include 1 item from the IntCOMM survey (**Figure 4A**) - "I can clearly articulate my point of view to members of other cultures" and three items from the IntCRIT survey (**Figure 4B**) - "I am able to manage when faced with multiple cultural perspectives", "I am able to think critically to interpret global and intercultural issues", and "I can recognize how different cultures solve problems".


**Figure 4. Mean Pre- and Post- Survey Results for the Students in the U.S.** 13 (out of 20) students at the University of Florida completed both the (**A)** IntCOMM and (**B**) IntCRIT surveys before and after participation in the virtual exchange. The data depicts the mean of the responses for both time points. Items with an asterisk and highlighted in orange indicate a statistically significant difference ($p<0.05$) between the mean pre- and post- responses.

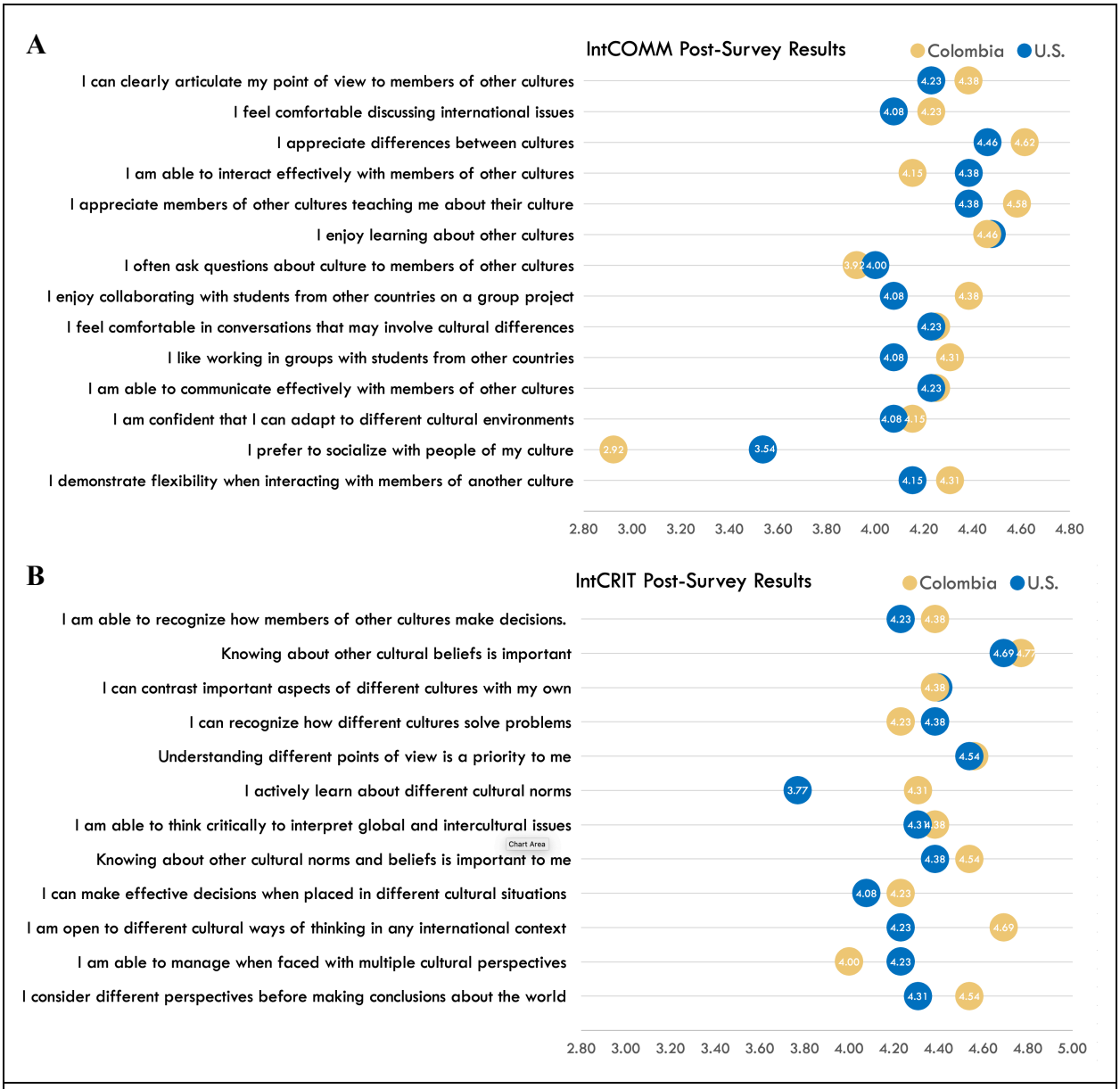


**Figure 5. Mean Post-Exchange Survey Responses.** Students from both UF (blue) and PUJ (yellow) completed (**A**) IntCOMM and (**B**) IntCRIT surveys after completion of the virtual exchange. Mean responses for the U.S. (blue) and Colombia (yellow) are depicted.

In comparing the post-exchange survey results between the students in Colombia and the United States, both sets of students demonstrated similar levels of agreement with both the IntCOMM (**Figure 5A**) and IntCRIT (**Figure 5B**) statements, with a mean difference between the responses of 0.19 and 0.17, respectively. Broadly speaking, students in both groups self-reported confidence in their intercultural communication and critical thinking skills after participating in the exchange. This confidence is reflected in agreement with statements like "I am able to interact effectively with members of other cultures", "I feel comfortable in conversations that may involve cultural differences", "I can contrast important aspects of different cultures with my own", and "I am open to different cultural ways of thinking in any international context". Interestingly, there

were two statements where more pronounced differences (>0.5 mean difference) were observed. These statements are: “I actively learn about different cultural norms” and “I prefer to socialize with people of my culture”. Without the pre-survey for the Colombian students, it is difficult to determine whether these differences arose due to underlying cultural differences between students or participation in the virtual exchange.

In summary, the results from the IntCRIT and IntCOMM surveys demonstrate that the students in both the United States and Colombia made significant gains toward the learning objectives of recognizing other perspectives and communicating effectively across cultures. Future iterations of the exchange will allow us to collect both pre- and post-responses for students from both countries, expand on this sample size, and draw more robust conclusions on its impact on intercultural critical thinking and communication.

## 6. LESSONS LEARNED & RECOMMENDATIONS

The implementation of this virtual exchange experience demanded open-mindedness and adaptability from both the students and instructors. The exchange evolved in real-time during the execution of the process as both students and instructors learned from this first virtual exchange experience. Below we summarize the key lessons learned and recommendations for the implementation of COIL in their engineering classrooms.

Because virtual exchanges involve coordination between classrooms across time zones, disciplines, and cultural norms, they can quickly evolve into complex projects. Thus, **flexibility is crucial** for the successful implementation of the experience. For example, the original plan for this exchange involved interactions between graduate students in both countries. However, low enrollment in the Colombian graduate course led us to pivot to also include undergraduate students. As a result, we observed dynamics that we had not previously anticipated but that also enriched the learning experience. Despite the varying levels of seniority among participants, the collaborative structure allowed graduate students to mentor undergraduates, fostering a mutually beneficial learning environment. This mentorship dynamic helped balance workloads and expectations, ultimately enriching the final outcomes by leveraging the participants' diverse experiences and expertise.

**Proper preparation of students before starting the exchange** was critical to its success. While students in both classes were excited about the idea of the virtual exchange, they were also intimidated by its premise. Providing clear instructions, setting expectations, and familiarizing students with the tools and platforms enhanced engagement and minimized confusion. Interestingly, students often adopted additional tools beyond those initially suggested, demonstrating adaptability and initiative in managing their collaborations. It was also important to prime these students to navigate intercultural collaborations prior to the exchange through short class activities that introduced the idea of intercultural competency and raised their awareness on the impact of cultural differences on communication and working styles.

Even though both of our courses were primarily focused on engineering and biotechnology, **the exchange evolved over time, resulting in a truly multicultural experience that extended beyond academic learning.** Through both reflection questionnaires and informal conversations, the students in both countries shared that the exchange allowed them to learn not only about their partner’s healthcare system, but also about their higher education systems and general way of life. As a result, students often reported challenging their own existing misconceptions and realizing they had more in common with their partners than previously thought.

As the exchange progressed, it also became clear that the use of exclusively synchronous activities was not realistic given students' schedules, internet access, and the difference in academic calendars between institutions. **The combination of synchronous and asynchronous** components allowed students to continue interacting despite the existence of these logistical barriers. In addition to the challenges of synchronous communication, students also expressed issues with the uneven distribution of team members between both countries and the large number of students in each team (ranging from 7 to 10 members per team). Thus, future implementations of this virtual exchange will focus on **smaller group sizes** to improve the quality of interactions and collaborations.

Despite these challenges, assessment results indicated that the students demonstrated significant improvements in their ability to articulate viewpoints and manage cultural differences. We recognize that the small sample size limits the ability to generalize these findings. Given student feedback and the instructional burden of implementation, rather than increasing the number of participants in a single exchange, repeating the experience across multiple iterations would provide a larger overall sample, helping confirm results and further refine the activities. Additionally, incorporating structured debriefing sessions after key milestones could help students better reflect on their progress and internalize their intercultural learning.

Lastly, it is important to both measure and motivate student participation in the virtual exchange. In this case, the incorporation of **low-stakes assessments**, such as the Flipgrid video discussions, encouraged participation and creativity without adding excessive pressure. Most of the exchange-related activities were graded for completion. This allowed the students to focus on the quality of the interactions without stressing about grades. These assessments provided valuable insights into student progress while maintaining a supportive learning environment.

## 7. CONCLUSIONS

This Colombia-U.S. virtual exchange program demonstrates the benefits of embedding international collaboration into engineering education. The experience equipped students with the skills and perspectives needed to address complex global health challenges without requiring physical travel to remote locations. By organizing the exchange in sequential phases and addressing potential challenges through the thoughtful selection of synchronous and asynchronous methods, the program successfully created a collaborative and inclusive learning environment for students of both countries. This approach fostered cross-cultural communication, critical thinking, and problem-solving skills, while empowering students to tackle global health challenges from diverse biomedical engineering perspectives. Despite challenges that included logistical coordination and varying team dynamics, the significant gains observed in students' intercultural competencies and engineering design skills underscore the value of virtual exchanges as an accessible and impactful approach to internationalize both graduate and undergraduate engineering education.

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