ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #37252

Connecting classrooms across borders to engineer a process to manufacture a Tequila bottle

Rodrigo Martinez-Duarte

Rodrigo Martinez-Duarte is an Associate Professor in the Department of Mechanical Engineering at Clemson University (USA) and Head of the Multiscale Manufacturing Laboratory www.multiscalemanufacturing.net. His group's expertise lies at the interface between micro/nanofabrication, carbonaceous materials, electrokinetics and microfluidics. Rodrigo is known as the pioneer of carbon-electrode Dielectrophoresis (carbonDEP), a technique for bioparticle manipulation using carbon electrodes and microfluidics devices with application to diagnostics and therapeutics. He is also internationally known for pushing the envelope on the use of renewable materials and non-traditional techniques such as origami and robocasting to manufacture shaped geometries that serve as precursors to architected carbon and carbide structures. At the nanoscale, his group is innovating ways to use microbial factories as nanoweavers of biofibers. A recurrent theme in his Multiscale Manufacturing Laboratory is assessing the effect of processing on the properties of carbonaceous materials and structures at multiple length scales, towards tailoring their performance. At Clemson University he teaches manufacturing processes and their application, as well as fundamentals of micro/nanofabrication. His pedagogical approach emphasizes teamwork, flipped classrooms, and project-based learning. Besides the US, Rodrigo has lived and worked in Switzerland, Spain, India, Mexico and South Korea and has a track record of service and leadership. He is currently the Chair of the Clemson University's Commission on Latino Affairs, Chair of the College of Engineering, Computing and Applied Sciences (CECAS) Committee on Global Engagement, Chair of the Organizing Committee of Dia de los Muertos at Clemson, and Guest Editor and an active Reviewer for leading journals in his field. He is also a Past President of the AES Electrophoresis Society. He is or has chaired several sessions and international meetings on Carbon and/or Electrokinetics within the Electrochemical Society, Society for Hispanic Professional Engineers and AES. He was the recipient of the Public Impact fellowship at UC Irvine in 2010, in 2019 both Junior Faculty Eastman Award for Excellence in Mechanical Engineering, and the Esin Gulari Leadership and Service Award in CECAS at Clemson University, and in 2021, the Impact Award from the Hispanic Latinx Heritage Month at CU.

Magda Guerra-Ayala

Maggie Guerra- Ayala specializes in international agreements, global partnerships, and multilateral international negotiation. Born in Guatemala, she speaks 5 languages and has lived in multiple countries including Guatemala, Mexico, Italy, Argentina, and the U.S. She arrived in Clemson University in 2017 and currently works in the Office of Global Engagement (OGE) in the Global Learning, Partnerships, and Initiative (GPLI) where she oversees and processes International Agreements in coordination with partners and campus stakeholders, as well as the logistics for different initiatives within OGE. She is also part of a select group in Clemson University who are Qualified Administrator of the Intercultural Development Inventory (IDI), a well-recognized tool to assess intercultural development. Before coming to Clemson, Maggie was a Diplomat for Guatemala. She began her Diplomat career at the Ministry of Foreign Affairs (MFA) of Guatemala in 2006 where she served for 6 years in different positions, including the Deputy Director for Bilateral Policy with Europe and Acting Chief of Staff to the Minister of Foreign Affairs. During this time she also coordinated the official visits to Guatemala of different world delegations including the Presidents of Colombia, Mexico, Venezuela, Nicaragua and Ecuador in 2007; the Minister of Foreign Affairs of the Russian Federation in 2010; and the UN Secretary General Ban Ki-Moon in 2011. She then served as Consul General at the Guatemalan Embassy to Argentina and as Counselor for the Interamerican Budgetary Commission and for Interamerican Council of Sustainable Development at the Guatemalan Permanent Mission to the Organization of the American States (OEA) in Washington D.C. At D.C. she served in leadership roles within OEA, including Vice-Chair of the Working group on General Standards and Programs of the Committee on Administrative and Budgetary Affairs in 2015-2016; and Chair of the Committee on Partnership for Development Policies of the Inter-American Council for Integral Development in 2016-2017. In her free time, Maggie enjoys traveling, learning different languages, crochet knitting, trying new and exciting dishes and boat rides with her husband and dogs.

Jaime Ivan Molina-Verdugo

Connecting classrooms across borders to engineer a process to manufacture a Tequila bottle

Abstract. International teamwork is a skill valued by employers with a global footprint. Development of the engineering workforce to meet the demands of an increasingly global industry includes skills beyond the mastering of the technical content. In this project, we connected groups from Clemson University (CU) in the US and ITESO Guadalajara in Mexico in a 9-week project to engineer a process to manufacture a commemorative Tequila bottle. We picked a Tequila bottle to emphasize its cultural background, degree of spread around the world, and familiarity to the students. All activities were online, and the project was framed as COIL. The course in CU, of 34 mechanical engineering majors, was Manufacturing Processes and their Applications; the course at ITESO, of 22 students total with 14 industrial engineering and the rest business administration majors, was Manufacturing Services and Strategies. The course was required for graduation for all engineering majors and optional for business majors. The project was split into 5 major team deliverables, mapping a COIL framework as follows: in week 1, emphasizing team building and the development of trust; in weeks 2, 3 and 5, comparative discussion, team organization; and in week 9, collaborative project work. Different speakers from industry facilitated discussion on international teamwork and supply chain. There were individual reflections in week 1 and 9, before and after the project. Assessment was done through these student reflections; as well as student reflections and course evaluations at the end of the semester when they compared the international project to other aspects of the class. In this presentation, we will report the analysis of the perspectives from the students, lessons learned, and plans to make this type of project scalable to larger classrooms, given the expected increase in size of the groups in the near future.

1. Introduction

International teamwork is a skill valued by employers with a global footprint and one of the key elements of organization success or failure. Teamwork has been shown to increase innovation, efficiency , and productivity [1,2], and when nurturing, boost higher employee morale. All these elements directly affect the bottom-line results of the company. The current strategy of global companies is to have a complete value stream across the globe, which is facilitated by international supply chain programs and the localization of manufacturing centers according to market demand and cost. Such a scenario thus creates the necessity for collaboration between employees of multiple backgrounds and located in multiple geographical locations. For example, to build a telecommunication server to meet a market in Canada, research and development may be done in the US; supply vendors may be located in China, Malaysia, and Korea; and manufacturing and assembly be done in Mexico, before the system is shipped to Canada. For this business model to be sustainable, human capital with problem solving skills, tolerance for ambiguity, adaptability, communication, curiosity, and time management are mostly required.

Furthermore, developing a global culture in a multi-national company requires team members with the motivation and skill to nurture intercultural communication as well as understanding world issues. Indeed, those individuals who demonstrate deeper cross-cultural knowledge and skills score higher with recruiters and are preferred by employers [3].

Hence, there is value in continuing integrating international education into traditional engineering curricula. Several surveys and studies developed by job recruiters, hiring companies and universities show the benefits of integrating global competencies to the educational curricula [4]. To this end, we connected groups from universities in Mexico and the US in a multi-week project to engineer a process to manufacture a commemorative Tequila bottle. All activities were online, and the project was framed as a Collaborative Online International Learning (COIL). We report the process followed to implement this pilot program, the analysis of the perspectives from the students, lessons learned, and plans to make this type of project scalable to larger classrooms, given the expected increase in size of the groups in the near future.

2. Program Description

2.1 Inception and Background

This program was implemented in the Fall Semester of 2021 between Clemson University in Clemson, South Carolina, US (UTC-5) and the Instituto Tecnológico y de Estudios Superiores de Occidente (ITESO) in Guadalajara, Mexico (UTC-6). The course instructors in ITESO and CU are childhood friends whose career paths led them to teaching complementary courses in their home institutions. Upon discussion of their teaching endeavors and cognizant of the importance of international teamwork, the possibility of a collaboration to link their classrooms emerged in Spring 2021. Through online collaboration and under the auspices of their home institutions, they developed the program based on a COIL framework [5] during the summer of 2021. The international expertise of the faculty is as follows: a professor of practice at ITESO who has more than 18 years experience in multiple global companies and a track record of collaborating with team members from the US, Canada, China, Japan, France, Brazil, Italy, Germany, Finland, England, Ireland, Malaysia, Korea, Israel, Hungary, Singapore, Argentina, Spain, Sweden, and Vietnam within the context of developing suppliers, acquiring equipment, sharing best practices and benchmarking, R&D and new product introductions, develop sales strategies, and final customer service; and an associate professor at CU with international experience in Mexico, India, Spain, Republic of Korea, and Switzerland where he lived and held different research appointments in interdisciplinary topics, including micro and nanofabrication processes.

The project was conceived as the engineering of a process to manufacture a commemorative tequila bottle. The choice of tequila bottle was done with the rationale that such a topic will help the students explore the different cultural, economic, and social contexts of tequila for both US and Mexico groups. The specification of commemorative was established to give freedom to the

students and incite them to identify a potential market. The official project language was set to English.

2.2 Implementation of

The duration of the project was set to 9 weeks during Fall 2021, corresponding to weeks 2-11 in a 16-week semester. The start week of the semester at CU and ITESO was the same. Given the disparity in the course scheduling due to constraints particular to each partner institution, this COIL project was implemented as asynchronous. The project activities were split into 5 major team deliverables (TD), mapping a COIL framework as follows: in project week 1, TD1 was evidence of an icebreaker emphasizing team building and the development of trust; in weeks 2, 3 and 4, the TD deliverables of the same number emphasizing comparative discussion and team organization; and in week 8, a TD5 in the form of a formal report that evidenced collaborative project work. Detailed description of each deliverable is presented in the appendix. Different speakers from industry facilitated discussion on international teamwork and supply chain throughout this time frame. Individual reflections in week 1 and 9, before and after the bulk of their collaborative work, were due. The COIL project represented 20% of the final grade for all students and the team deliverables were weighted as follows: TD1-4 10% each, and TD5 50%. Each of the individual reflections were worth 5% of the COIL project and full credit was awarded for thoughtful reflection, regardless of its content. The course in CU, of 34 mechanical engineering majors, focused on manufacturing processes and the delivery mode was in-person; the course at ITESO, of 22 students total with 14 industrial engineering and the rest business administration majors, focused on manufacturing services and strategies and the delivery mode was online. The course at their home institution was required for graduation for all engineering majors and optional for business majors. The course was a 3 credit hour in the US and equivalent in Mexico. Students did not know about the international project at the time of course enrollment. They were made aware of it and its weight on the course grade during the first day of the semester. 11 project teams were formed, with most teams including 3 students from CU and 2 from ITESO. Local sub-teams at CU and ITESO were formed by the students but the international teaming was done arbitrarily by the instructors.

A kickoff lecture was prepared in collaboration by the faculty and presented to each classroom independently. This 50-minute kickoff lecture presented the geographical location of both institutions, background of COIL, faculty background and connection, detailed explanation of the project, timeline, and deliverables; as well as tips of how to get started using the AIR (Activation, Interaction, Reflection) process [6].

2.3 Assessment and Data Analysis

Grading of all deliverables was done by both faculty in collaboration. The rubric used to grade all team deliverables, as well as the different components of deliverable 5, is presented here as an appendix.

Multiple reflections from all students were obtained. Students could submit their reflections in English or Spanish. The first individual student reflection before the project asked the student to elaborate on the following prompts: B1) Why is it important to nurture the skill of international teamwork? B2) Elaborate on the skills that are necessary to be a productive member of an international, multi-cultural team, and B3) How well prepared are you to work in an international team? The second reflection after the project included the prompts: A1) What skills/attitudes of yours contributed the most to the productivity/efficiency/cohesiveness of the team? A2) What skills/attitudes of yours did not always positively impact the productivity/efficiency/cohesiveness of the team? And A3) How has your perception of international teamwork changed during the project? The purpose of these surveys was to be able to compare if/what changed in the students' perspective after having the collaboration experience. The third reflection at the end of the semester asked students to elaborate on the impact of the different activities in the course, including the international project, when meeting the course objectives. This reflection was only gathered from CU students.

All reflections were first anonymized and then manually analyzed in search of patterns and insights. Reflections submitted in Spanish were translated using Google Translation services (https://translate.google.com/) to allow for direct comparison of all reflections. The translations were checked by the authors, who are all bilingual, to confirm the original meaning was preserved. Given that the information collected was mostly qualitative, word clouds were generated to aid in the comparative analysis of the students at CU and ITESO. Word clouds are "simple yet powerful visual representation object for text processing, which shows the most frequent word with bigger and bolder letters, and with different colors."[7] Word clouds were generated in Monkey Learn (https://monkeylearn.com/word-cloud/). Among the numerous electronic word clouds generators available online, Monkey Learn was chosen due to the possibility of going beyond simple word counting and identifying complete terms formed by two or three concept words, such as "language skills" and "team member".

One of the authors at CU presented this analysis to the CU students in-person and guided a discussion about their experience and potential steps the students could take to improve their role when working with international colleagues. Similar analysis was delivered online to the ITESO students by the ITESO faculty. Of note, the presenting author at CU was previously a diplomatic officer for the Guatemalan government, has over 12 years' experience in international negotiation, cross-cultural training and multilingual skills obtained during multiple assignments in Guatemala, Italy, Argentina, and the US.

3. Results and Discussion

3.1 Challenges observed during program implementation

Few challenges were observed throughout the semester. Differences in the class schedule, CU in the early morning and ITESO late in the evening, required the project to be conducted asynchronously and this impacted engagement between student teams as they reported it was hard to find times in common to schedule meetings. The majority of the students in CU were fully dedicated to their course load while ~80% of the ITESO students had regular jobs on top of their course load. This further accentuated the challenge of finding enough time to work together in the project. The difference in language was expected to be a barrier. ITESO students reported that it was challenging communicating all of their ideas in English, but that the CU students were empathetic and worked together to explain the activities. Few CU students were proficient in Spanish and those teams reported that such expertise greatly benefited initial collaboration. Of note, ITESO students must obtain an English certificate, i.e. more than specific number of points in TOEFL, to graduate. Faculty estimated that all ITESO students had at least a B1 English level per the Common European Framework of Reference for Languages. As noted above, the ITESO course was a requirement for industrial engineers and was also open to business majors. The lack of proper technical background of the business administration students was a challenge since this made a few of them feel out of context and not prepared to contribute as they were expected. The timeline of the project was a challenge as well. Students reported excessive workload for the first few weeks of the semester, which prevented them from engaging in more conscious social interaction with their international peers. The deadline for TD5 was extended for a week (project week 8 to 9) to accommodate student requests for more time. This change also affected the deadline for the second individual reflection. Considering such changes, the project effectively had a duration of 10 weeks.

3.2 Grades

The mean of the grades achieved by the group in all team deliverables, TD1-TD5, are shown in Table 1. Note that TD5 included three main components as specified in the appendix. TD4 was a group reflection of the status of their team at the middle of the project. Full credit was achieved by submitting a thorough reflection, regardless of its contents. Comparison of the mean grades to previous semesters is not reported since the conditions of the courses as delivered in previous semesters do not grant basis for comparison.

3.3 Student Feedback

The comparative analysis of student reflections showed a pattern of commonalities between the two groups that helped determine that the international collaboration experience affected both sides in a similar way, even when some relevant differences were identified.

Table 1. Mean of the grades achieved by the group in all team deliverables

Deliverable	TD 1	TD 2	TD 3	TD 4	TD5			TOTAL
					Manufacturing Process	Discussion	Communi cation	
Weight in project	10	10	10	10	28	12	10	90
Mean grade from all groups	9.4	7.9	7.6	10	23	10.2	8.7	77

3.3.1 Individual reflections before project

Detailed analysis of the reflections to question B1 showed that the majority of the students agreed that nurturing the skills of international teamwork was positive, in some cases essential, for one's professional and personal development. The reflections revolved around the benefits the experience could bring: exposure to a different cultural background, opportunities to learn and improve their own perspective and their knowledge of another language. Both sides agreed that having a broader view of the world through their teammates' eyes opens opportunities for their future, but were also cautiously optimistic about the results of this collaboration, acknowledging the potential issues they could find. As shown in figs. 1A and D, "teamwork", "experience", "culture" "team member" and "language" were the most common aspects students on both sides mentioned in their answers to the question of why it is important to nurture the skill of international teamwork. Less frequent but still mentioned several times on the answers among both sides, was the anxiety towards a common project that was going to be designed and carried out taking in consideration more than their own perspective. In that sense, the most common words were "point of view", "different place/background", and "language barriers". Of note, the most common words illustrated in figs. 1A and D are well correlated to the key terms introduced to the students during the kick-off lecture before the project.

Fig. 1 *Word clouds showing the most common words in the individual reflections before the project for all students: Question B1 for A) CU and D) ITESO; Question B2 for B) CU and E) ITESO; and Question 3 for C) CU and F) ITESO.*

Regarding question B2 where students were asked to elaborate on the skills that are necessary to be a productive member of an international, multi-cultural team, students agreed that communication was the main skill they should foster. Both sides also acknowledged that communication can be challenging when not all the members speak the same native language, live in the same time zone or have similar schedules. The reflections to question B2 were less uniform than those on the first question, as the focus for ITESO students' responses showed that their main concerns were time related and English proficiency. Their answers matched the group description, in which it was highlighted that ITESO students took the class in the afternoons, usually after work and not all came from the same major. Another interesting highlight from the ITESO students' feedback is the positive approach towards learning from a different culture and their personal relation with their team members. In contrast, time management was not a recurrent concern to CU students, though they all mentioned their will to be a productive member to their teams. In addition, some students also recognized that patience and a proper management of potential language barriers should be counted as skills they all should develop and foster during this process. As shown in figs. 1B and E CU's most frequent words were "communication", "team", "language" (or language barriers), "productive member", "different time zone", "culture" and "patience". ITESO's most frequent words were "communication", "English language", "responsibility"," culture" and "teamwork".

In regard to question B3: How well prepared are you to work in an international team?, both sides agreed on being fairly well prepared to work on an international team, though their

approaches were significantly different. CU students expressed more confidence in their preparation, most of them even mentioned previous experiences in high school or college, and most considered themselves very well equipped to face the challenge. For some students, this was an opportunity to practice the Spanish they learned in school and were looking forward to it. ITESO students were more cautious at the moment of evaluating their own preparedness, emphasizing that the language barrier could be a big challenge, and some indicated not having any previous experience but willing to learn and adapt if necessary. One aspect that all students emphasized was their confidence in online tools and dynamics to aid their communication and facilitate coordination. The students mentioned words such as "google translator" or working online, as reliable resources for their teamwork. The word clouds, figs. 1C and F, capture these sentiments. For CU students, the word cloud shows the same pattern, highlighting (past) "experience" and the names of companies and/or the geographical location of previous opportunities they might have had (i.e. Bosch, San Luis Potosi, international internships). For ITESO students, the words that appeared more frequently were "experience", "challenge", "language" and not as frequent but relevant, "first time" (see red arrow in fig. 1F).

3.3.2 Individual reflections after the project

The second set of questions, collected after the completion of the international collaboration project, was analyzed following the same methodology used for the first survey. The results can be visualized on the fig. 2, and discussed below.

Fig. 2 *Word clouds showing the most common words in the individual reflections before the project for all students: Question A1 for A) CU and D) ITESO; Question A2 for B) CU and E) ITESO; and Question A3 for C) CU and F) ITESO.*

Detailed analysis of the reflections to question A1, about how the student's personal skills/attitudes contributed to teamwork, showed that the students on both sides considered their communication abilities and time management were their strongest contributors to teamwork. In addition, ITESO students also mentioned their commitment and responsibility to attend the working meetings was key. All students identified their competent usage of communication platforms such as Zoom as a strong skill during this process. The most frequent words shown for CU students were “communications” (or communication skills), “time management”, (positive) “attitude”, and “Zoom meeting”. As per ITESO students, the most frequent words were “time”, “responsibility”, “good communications”, “efficiency”, “commitment” and “Zoom meeting” (figs. 2A and D).

Question A2, about the students’ personal skills and attitudes that did not contribute to teamwork, the responses showed different perspectives and challenges that CU and ITESO students faced during the collaboration project and not all the challenges were necessarily related to personal skills, but more to external issues, such as different time zones or working schedules. The word clouds in this particular question highlight these different perspectives and not the common ground, as the previous did. With this in mind, the analysis focused on identifying the main differences to take in consideration for further occasions. CU students considered that their least beneficial skills/attitudes were the lack of constant communication, the difficulty to match schedules and short patience in cases of frustration. They also recognized that the language barrier added an extra challenge while working in coordination (fig. 2B). ITESO students, on the other hand, expressed that the limited knowledge of the technical language was a challenge, especially for those who also struggle with communicating in English language. Several ITESO students opened up about a characteristic they considered cultural: procrastination and “leave things to the last minute” (expressed in different ways, highlighted with red arrow on fig. 2B), which clashed with CU students’ intention to do things in advance or with what was considered plenty of time. Most common words on CU students’ feedback for this question were “time management”, “time”, “deadline” and “patience”. For ITESO students the most common words were “time”, “technical language”, “doubt”, “lack of motivation” and “greater procrastination” (both highlighted by red arrows in fig. 2E).

In regard to question A3, about how their perspective changed during the project most of the students on both sides agreed that their perspectives did change during the project. Most ITESO students acknowledged that prior to the collaboration, they stressed over the potential reactions of teammates from the other institution to what they considered a personal challenge (complicated schedules, language difficulties, different ideas) and that during the project, they discovered that their peers were more considerate, patient and empathetic than they expected. ITESO students also considered the project a valuable experience and some even mentioned it gave them the chance to make new friends in the US. CU students, on the other hand, also expressed that their perspective changed during the project and acknowledged that the

experience was more challenging than expected and that it required a deeper compromise on their part, as well as learning to see things from a different perspective. Students also recognized the main challenges they faced and how they resolved them while working with ITESO students. Another relevant aspect found in their feedback is that most of the students considered the project a positive experience that taught them important life and work-related skills. As shown in figs. 2C and F respectively, the most frequent words for CU students were “international teamwork”, “perception”, “time”, “language barriers”, “cultural difference” and “time zone difference”; for ITESO students, the most frequent words were “experience”, “way of working”, “good communications”, “clash of culture” and “great satisfaction”.

3.3.3 Individual reflections of the international project in the context of the entire course

CU students responded to one last question in which the instructor requested their feedback on the international project in the context of the whole class, to determine the impact this specific assignment had for their overall learning. In general, CU students concluded that the international collaboration project was novel, valuable and it was a good learning experience, though they acknowledged that the project was more complicated than initially expected and required an intentional effort to learn from a different culture, different practices and even significant communication challenges. Other students highlighted the specific aspects of the manufacturing process learned on each step of the project, mentioning specifically glass manufacturing, blow process and bottle design. Another group of students considered that the main lesson was learning from a real-life experience and context, to develop valuable skills that will be useful when they graduate and may join transnational companies and multicultural teams.

Fig. 3 *Word clouds showing the most common words in the individual reflection from CU students at the end of the semester.*

One relevant aspect that came from this final reflection is that the CU students considered that the international project had a heavier load of work and shorter time to comply than other deliverables during the rest of the course. In general, students gave a high score to the learning outcomes of the international collaboration in the context of the whole class, but for future occasions they would like to have some additional time to coordinate and interact with the teammates from ITESO. The most frequently mentioned words were “manufacturing process”, “glass manufacturing”, “process”, “different culture”, “learning experience” and “valuable experience” (fig. 3)

4. Concluding Remarks

Development of the engineering workforce to meet the demands of an increasingly global industry includes skills beyond the mastering of the technical content. As the world becomes more globalized and the physical boundaries fade, especially in the past 20 years, authors have focused on identifying and understanding the necessary skills to be competitive in a diverse and dynamic environment [8]. These skills, known in the education field as “Global Competence” refer to “multi-dimensional construct that requires a combination of knowledge, skills, attitudes and values successfully applied to global issues or intercultural situations”. More specifically for engineering education, previous authors have identified five categorical topics comprising global competence: cross-cultural communication, cross-cultural disposition, world knowledge, cross-cultural teams, and engineering-specific cross-cultural competencies[9]. Cross-cultural communication refers to an evident knowledge and ability to communicate in a second language and cultural communication rules, while representing their own. Cross-cultural disposition refers to a desire to understand cultures beyond one's own and the development of cross-cultural attitudes and beliefs. World knowledge refers to nurturing an awareness of world events, different cultures, languages, geography, and related social components. Cross-cultural teams refers to the ability to work in an international team towards a common goal, addressing cultural diversity in a positive manner. Lastly, engineering-specific cross-cultural competencies refer to the student’s demonstrated understanding of the influence of culture on the engineering profession practices. Within this scope, few lessons learned in this pilot program are described next.

The formal team deliverables incentivized students to find ways to establish team communication. Challenges included language barriers, disparate course schedules, and time conflicts with other student activities, including full-time jobs. Multiple tools for online collaboration exist nowadays and the students made extensive use of them. However, students reported that the compressed timeline of the project on top of other activities in the course prevented them from engaging with their international peers as much as they would have liked. Future iterations will benefit from a timeline that is better distributed across a longer time span than 10 weeks. This can release time that can be used by the students to learn more about each

other to increase their world knowledge, improve their cross-cultural communication and continue to nurture their cross-cultural disposition. However, spending such time release for these activities should be further incentivized, perhaps in the form of extra credit for evidence of activities that show how the students are deepening their relationship beyond working together towards a common project deliverable. A framework for students to continuously assess their improvements on communication skills should also be facilitated at the beginning of the project.

Language barriers were an expected challenge. However, the fact that English proficiency is a requisite for graduation for ITESO students significantly diminished such a challenge. However, future iterations of this program will benefit from actions that boost the confidence of non-English speakers early on the program towards identifying their needs early and minimize the time a team would spend assessing the real language proficiency of each other. Empathy must be continuously emphasized to help the team reach a working collaboration as a base to develop a durable connection. The formation of cross-cultural teams would benefit from a more methodical approach. As mentioned above, assessing in advance how many (if any) of the CU and ITESO students are fully bilingual can allow for optimal placement across all groups. The presence of a bilingual team member could support the group to keep communication channels open and assist others struggling with language challenges.

Analysis of the first reflection shows that most of the students were already predisposed to make the best out of this novel international experience and reflected an overall positive attitude, even though anxiety about the outcome was mentioned by several students. Although cross-cultural disposition might have waned right after the delivery of TD5, it was again strong at the end of the semester when students evaluated the international project among other class activities. Reinforcing disposition throughout the project is crucial. An appropriate weight of the international project on the final grade must be determined, not too low to keep students engaged despite the challenges that will arise, and not too high to maintain the process to overcome challenges as a learning experience rather than a frustrating exercise that is perceived as an impossible barrier, that will then likely be labeled as unnecessary, to a desired grade for the course. Clearly defining the expected workload for each deliverable, will also enable the instructor to better structure the deliverables and for students to better manage their resources. Besides the modified timeline and extra credit incentives proposed above, periodic check-ins should be implemented that emphasize activities that help students continuously internalize the experience and help them deal with feelings, perceptions, and challenges that have arisen. This is important as few students reported feeling frustrated during the process, and others perceived that their teammates did not commit as much. While such feelings are common in the workplace, it is important for faculty not to underestimate them and provide tools to help students improve their emotional intelligence. Implementation of a tool to facilitate self-assessment of one's collaboration skills [10] would also be beneficial, coupled with time that encourages the team members to discuss their self-assessments in a safe space.

Towards increasing the skill of nurturing an awareness of world events, different cultures, languages, geography, and related social components, the project assignment, i.e. a process to manufacture a commemorative Tequila bottle, and description of team deliverables could be further refined to obviate the need for students to learn more about the context of the product and better incentivize the discussion of the implications of the manufacturing process beyond technical specifications.

Though the word clouds are useful to highlight commonalities among teams responding the same questions, it also limits the analysis of the students' responses as a whole. To be able to discuss in detail with the students, a thorough and continuous review of their responses was necessary, which also allowed the possibility to identify similar ideas and identify further insights that may have been overlooked in initial review. However, this process can take significant time. In future iterations, we aim at determining in advance the purpose of the information that will be collected via students' feedback to identify potential challenges while processing and analyzing the data. This will also help finding the most useful tools to represent the results. While translation of Spanish to English was necessary to consolidate all data, in the future we will consider the impact of limiting all answers to English. In this case, students could use translation services before submitting their answer. However, maintaining the meaning of their reflections through a translation will be crucial. Alternatively, we are in the quest for analytical techniques and tools that provide the same value regardless of the input language.

We agree that teaching global competencies as part of the engineering curricula is associated with challenges [8] including establishing an instructor team with the proper motivation and expertise, finding available time for planning and implementation, and benefiting from institutional resources and encouragement to lower the implementation curve. While the perception of significant challenges to incorporating global competencies into the engineering curricula still remains a common argument against internationalization of the curriculum among hesitant faculty, the students appreciate and largely enjoy such learning experiences. Furthermore, employers continue to value them. We thus argue that the incorporation of these real-life experiences into the curriculum is worth the extra effort as they allow for students to nurture useful skills and tools to face future challenges with confidence.

Acknowledgements
The authors would like to thank Danny Weathers, Ryan Thrasher, Tim Guggisberg, Fran Cardona, and Rodrigo Gutierrez for facilitating various class activities during the implementation of this program.

References

1. Holland, S.; Gaston, K.; Gomes, J. Critical success factors for cross-functional teamwork in new product development. *Int. J. Manag. Rev.* **2000**, *2*, 231–259, doi:10.1111/1468-2370.00040.
2. Mengoni, M.; Germani, M.; Peruzzini, M.; Mandolini, M. Supporting virtual teamwork in Collaborative Product Development. *Int. J. Prod. Dev.* **2011**, *15*, 90–114, doi:10.1504/IJPD.2011.043663.
3. Glick, N.D. The relationship between cross cultural experience and training, and leader effectiveness in the US Foreign Service. *Int. J. Cross Cult. Manag.* **2002**, *2*, 339–356, doi:10.1177/147059580223004.
4. *Culture at Work, The value of intercultural skills in the workplace*; 2013;
5. What is COIL Available online: https://online.suny.edu/introtocoil/suny-coil-what-is/.
6. Marturet, C. Virtual Dual Immersion Program AUSJAL-AJCU.
7. Arora, I. Create a Word Cloud or Tag Cloud in Python Available online: https://www.analyticsvidhya.com/blog/2020/10/word-cloud-or-tag-cloud-in-python/ (accessed on Oct 12, 2020).
8. Herling, D.; Herling, A.; Peterson, J. Integrating engineering and global competencies: A case study of Oregon State University's International Degree Program. *Proc. - Front. Educ. Conf.* **2001**, *2*, F2B/4-F2B/7, doi:10.1109/FIE.2001.963695.
9. Ball, A.G.; Zaugg, H.; Davies, R.; Tateishi, I.; Parkinson, A.R.; Jensen, C.G.; Magleby, S.P. Identification and validation of a set of global competencies for engineering students. *Int. J. Eng. Educ.* **2012**, *28*, 156–168.
10. Collaboration self-assessment tool Available online: https://www.stcloudstate.edu/oce/_files/documents/coteaching/CollaborationtoolCSAT.pdf (accessed on Feb 8, 2022).

Appendix. Rubric used to grade deliverables from students.

	Possible points	Excellent, a thorough and valuable work– 90-100%	OK, but limited scope/usefulness- 80-89%	Fair, but needs significant improvement – 60-79%	Unacceptable <60%
Communicates effectively *Note: cite journal publications and other scholarly work as such, not as websites.* *Communication is an important factor in ALL your deliverables. 20% of your grade in all deliverables will be focused on communication.*	20% of the grade in ALL deliverables	An engaging read. Language clearly and concisely communicates ideas. Strong evidence of extensive proofreading. Errors and typos are minimal. Style is appropriate for an engineer audience. Organization is clear; nuanced transitions between ideas enhance presentation. Consistent use of appropriate and professional format. Proper symbols for all units are used, i.e. °C, kg, MN, µm, %, etc. All sources are cited in ASME style, are referenced correctly (i.e. journal publications cited as such and not as websites) and used correctly. High quality drawings/schematics/figures that convey required information effectively and are aesthetically pleasing.	Language clearly and concisely communicates ideas but the documents is not engaging. Evidence of extensive proofreading. Errors and typos are minimal. Optimized organization is apparent; transitions connect ideas, although they may be mechanical. Format is appropriate although at times inconsistent. Proper symbols for most units are used, i.e. °C, kg, MN, µm. Most sources are cited in ASME style, are referenced correctly (i.e. journal publications cited as such and not as websites) and used correctly. High Quality drawings/ schematics/figures that convey required information effectively but are not aesthetically pleasing	Overall, language communicates ideas but can be confusing at times. Some evidence of extensive proofreading. Errors and typos are minimal. Basic organization is apparent but format is poor. Proper symbols for most units are used, i.e. °C, kg, MN, µm. Most sources are cited in ASME style, are referenced correctly (i.e. journal publications cited as such and not as websites) and used correctly. High quality drawings /schematics/figures convey required information, albeit in a confusing way and are not aesthetically pleasing	In many places, language obscures meaning. Grammar, syntax, or other errors are distracting or repeated. Little evidence of extensive proofreading. Work is unfocused and poorly organized; lacks logical connection of ideas. Format is absent. Proper symbols for units are not used, i.e. spelling degree centigrades instead of using °C, spelling micrometer instead of µm. Few sources are cited, referenced or used correctly. Equations/calculations are pictures of hand-written notes. Figures/schematics/drawings are pictures of hand-drawings or low-quality digital drawings. Schematics lack reference dimensions. Scholarly work is referenced as websites. Information is included in the wrong section. Figures are oversized to fill space. Figures do not add value to the content of the document. Excessive white space is present around the figures.
TEAM deliverable 1					
ICEBREAKER Get to know your teammates in a deeper level and jump start the development of trust on each other. *You might need to do more than one icebreaker. Submit evidence of the one that worked the best!*	10	A video that evidences that members have developed a meaningful personal bond between them. Such video is likely to require close cooperation in all aspects required to make the video, such as drafting, recording and editing. The nature of the icebreaker reported encourages team members to open up to the rest of the team towards developing a strong base from where to develop trust on each other.	A video that evidences that members have developed a working relationship but not necessarily a meaningful bond between them. All team members participated in the drafting, recording and editing of the video but the nature of the icebreaker reported was not conducive to team members opening up to each other towards starting to develop trust on each other.	A video that evidences that members consciously attempted to develop a working relationship but such relationship has not been achieved. For example, there is evidence that all team members participated in the drafting, recording and editing of the video but execution is poor.	A video that does not show evidence that team members are taking conscious steps to develop a working relationship. For example, a mere recording of the first time team members connected with each other; an icebreaker that emphasizes exchange of basic information only; a collage of pictures of the team members.

TEAM deliverable 2					
INTRODUCTION and MARKET ID Elaborates on the context of the problem to provide a rich background that will allow for the derivation of meaningful specifications and market identification. Provides a complete and nuanced picture of the different ways the piece/product is currently made	10	Insightful. Infers all relevant information around the situation and adequately justifies validity of assumptions by referencing quality and diverse sources of information, i.e. reputed web articles, blogs, reputed journals, interviews. Presents a well-documented analysis of how current manufacturing processes are used to meet the desired performance of the product/piece.	Infers some information from the situation but fails to adequately justify the validity of assumptions. All references are reputable sources of information. Presents a well-documented review of how current manufacturing processes are used to make the piece/product but fails to analyze how such processes meet the desired performance.	Only considers information that is explicitly provided or is obvious, i.e. the ball must be round. Only lists current manufacturing processes used to make the piece/product. All references are reputable sources of information.	Presents a random collection of information that is related to the situation or Omits information provided by the situation. Does not provide a background of how the piece/product is currently made. Lacks references or does not reference reputable sources of information.
TEAM deliverable 3					
PROBLEM STATEMENT AND SPECIFICATIONS Synthesizes a problem statement and list of specifications from a valid context	10	Effective and Purposeful. Presents a concise and correct problem statement. All specifications are unambiguous and clearly address the needs exposed from exploring the context provided in the introduction. The rationale for each of the specifications presented is valid and properly justified by quality and diverse references and/or calculations.	Presents a concise and correct problem statement. Few specifications are unclear, vague or ambiguous, i.e. lack of specific values, but they all address the needs exposed from exploring the context in the introduction. The rationale for most of the specifications presented is valid and properly justified by quality and diverse references and/or calculations.	Presents a correct but confusing/convoluted problem statement. Most specifications are unclear, vague or ambiguous but still attempt to address the needs exposed from exploring the context in the introduction. The rationale for most of the specifications presented is confusing/convoluted. Quality references and/or calculations are still provided in the attempt to justify specifications.	Presents an incorrect problem statement (For example the team deviates from *designing a manufacturing process*). Alternatively, it omits a problem statement and instead provides a long explanation of the context that may or may not be already discussed in the introduction. Attempts a set of specifications that do not reflect the problem at hand or the context of the situation, even if those specifications are well referenced/justified.
TEAM deliverable 4					
Critical Evaluation of Team Performance	10	An honest, candid, and nuanced reflection of the situation in their teams. Evidence of thoughtful reflection about how to best move forward. Evidence of reflection when addressing questions such as What is making your team function properly? Why? What can make it work better? Why? If not functioning properly, what needs to be improved? What skills are each of you developing or honing that	An honest, candid, and nuanced reflection of the situation in their teams. However, the deliverable might only describe a way to move forward without providing rationale behind such plan.	An honest, candid description of the challenges, benefits, activities, etc. that the team has encountered but lacks evidence of reflection about the entire situation. The deliverable might describe a way to move forward but fails to provide the rationale behind such plan.	A simplistic reflection that underestimates the nuances and challenges of team building and teamwork. For example: "the team is working well, all team members get along, we are overcoming challenges, and we are good to proceed with the last part of the project"

		will make you a better team player in the future?			
Team deliverable 5					
MANUFACTURING PROCESS AND STRATEGY FOR PRODUCTION Applies a method to generate results (this must be *your* process and strategy, not a literature review of values used in current processes used to make the product/piece)	35	Thorough and Reflective. Clearly articulates and structures the process to obtain the solution presented. The solution is well justified based on data and/or theoretical analysis, as appropriate. Clearly justifies numerical values for all parameters required in the process(es). Applies formulas, procedures, principles, or themes accurately, appropriately and/or creatively in new contexts when required Provides strong evidence of reflective thought about the effect of processing parameters and strategy factors on the result, i.e. speculates on the consequences of increasing or decreasing the value of processing variables. All relevant calculations are provided in a clear and structured way to facilitate replication.	Clearly articulates an incomplete process to obtain the solution presented. The solution is not fully justified based on data and/or theoretical analysis. Clearly justifies numerical values for most parameters involved in the process(es). Applies formulas, procedures, principles, or themes appropriately and accurately in familiar contexts but fails to provide reflective thought on the effect of processing parameters on the result. Most relevant calculations are provided in a clear and structured way to facilitate replication.	Lists, describes a reasonable solution, but does not clearly articulate the process used to obtain such solution or why numerical values chosen for different parameters involved in the process make sense. Applies appropriate formulas, procedures, principles, or themes with minor inaccuracies. Most relevant calculations are provided in a clear and structured way to facilitate replication.	Fails to provide a reasonable solution. Applies formulas, procedures, principles, or themes inappropriately or inaccurately, or omits them. Calculations are missing or do not facilitate replication. Lacks analysis. OR Only presents a well-documented and thorough literature review of values used in manufacturing processes used to make the product/piece.
DISCUSSION Justifies why the chosen approach is the best solution to the problem presented	15	Organizes a well-structured conclusion that clearly justifies why the chosen approach best meets the list of desired specifications by providing a critical, valid and well-supported analysis of why other solutions, positions, or perspectives would not have worked as well as the chosen approach to *meet specifications*. Provides in-depth reflections on possible ways to further improve the solution within the realm of the chosen approach, i.e. what future work would be necessary to make the proposed solution even better?	Organizes a well-structured conclusion that clearly justifies why the chosen approach best meets the list of desired specifications by providing a critical, valid and well-supported analysis of why other solutions, positions, or perspectives would not have worked as well as the chosen approach to meet specifications. Fails to provide in-depth reflection on possible ways to further improve the solution within the realm of the chosen approach.	Organizes a well-structured conclusion that is complete, logical, and consistent with the desired specifications. However, only analyzes its own alternatives, positions, or perspectives. Alternatively, it might describe or explain other potential solutions in detail but lacks a critical analysis/comparison among them.	Presents abbreviated or simple conclusions that fail to justify why the chosen approach meets all the desired specifications. Analyzes or explains or describes alternatives that are not viable just to fill space. Attempts a conclusion or evaluation that is illogical or inconsistent with the desired specifications, or omits a conclusion or solution altogether