# Board 130: An International, Bilingual Engineering Design Course: Faculty/Student Experiences and Lessons Learned

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# An International, Bilingual Engineering Design Course: Faculty/Student Experiences and Lessons Learned

*Abstract* – **Early in 2023, the University of Georgia (UGA), located in Athens, Georgia, United States, and the Universidad de Guadalajara (UG), located in Guadalajara, Jalisco, México conducted a bilingual, international design course via Zoom, called "ACTIVA tu Speaking (AtuS)." The USGA students spoke Spanish while MexicanUG students spoke English. The students jointly chose two projects, performed necessary research, and designed prototypes to meet the design needs of their respective communities. This course was not originally conducted as an engineering education research project; thus, this is a retrospective summary. Using a promotional video that the USGA students produced about the course and the course reflection paragraph that each USGA student wrote, we performed a word frequency analysis. Based on the word frequency analysis, we conclude that the students' identification as engineers increased, students connected their academic engineering to real-world problems, the students developed professional skills necessary for working on international engineering projects, and students developed greater international engineering awareness and confidence in working in a global environment. Courses like the one presented herein offer opportunities for students to collaborate internationally without the financial and time commitment of regular study abroad programs. The authors aim to continue the research on understanding the impact that this type of course can have as an intermediate alternative to immersive programs.**

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

## I. INTRODUCTION

Educating engineers to work on a global and multilingual scale is a critical need in contemporary higher education. In 2009, The Newport Declaration—resulting from the NSF (National Science Foundation) funded National Summit Meeting on the Globalization of Engineering Education—stated that the globalization of engineering education is urgently needed [1]. Additionally, engineering students with international experience are increasingly being sought by engineering firms [2]. To meet this demand, universities in the United States, including the University of Rhode Island, Valparaiso University, the University of Georgia, and many others, have developed international engineering programs that include earning undergraduate degrees with an engineering major and a foreign language major [2]. Many of these programs include a year of studying and working in a foreign country (traditional immersive programs). These international engineering programs have significant drawbacks: 1) an extra year of study and 2) a financial cost associated with an extra year of study, the cost of living in another country, and 3) the loss of wages from full-time employment as an engineer [3]. Thus, students from lower economic backgrounds often cannot take advantage of these dual-degree immersive programs.

Financial considerations are the most reported barrier by students in participating in study abroad programs [4]. Warnick, Call, and Davies argue that financial barriers are probably overstated but also indicate that lower-income students are less likely to participate in study abroad programs than higher-income students [4]. This paper reports on a novel course

allowing students from the U.S. and Mexico to collaborate across national and lingual boundaries without leaving their home campuses, lowering the financial barriers typically associated with international experiences.

## II. REVIEW OF RELEVANT LITERATURE

The need for engineers to solve complex problems with international peers has been reiterated in many studies and reports. A most recent report by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) highlights the importance of building engineering capacity across national borders for sustainable development of our global world [5]. Additionally, our fast-paced global economy places an unending demand for engineers who can work effectively in global environments [6]. The development of global competency in engineers and technical knowledge has become a focal point of many engineering programs across higher education institutions in the US. Giovannelli & Sandekian [7] operationalizes a global engineer as one who has an appreciation for international colleagues, poses cultural sensitivity, and has a forethought of physical and social design consequences. Our research project goals align with this definition as we sought to foster cultural awareness in students' engineering design process while working with international colleagues.

Effectively teaching engineering design in a globalized economy presents several challenges, such as assessing student learning, developing culturally aware design skills, and engaging diverse student populations [8]. Addressing these challenges is pivotal for enhancing the quality of engineering design education. To better equip engineering students for the global workforce, educational institutions have introduced bilingual/international engineering design courses, study abroad programs, and courses with a large global component [9-11]. These initiatives aim to cultivate students' cross-cultural communication and collaboration skills and their proficiency in working within multilingual environments. With the financial implications/additional requirements of study abroad programs and the COVID-19 pandemic, institutions have begun to explore options for students to foster inclusion among diverse student groups. One such option is that described by Giovannelli & Sandekian [7]. The course offers an immersive experience within the institution bringing together students from diverse ethnic groups to discuss course content in relation to their cultural beliefs. This served as a student-equipping gateway for the meaning and consequences of global engineering. as well as others to foster knowledge of complexity in global engineering. The course, however, does not involve culturally sensitive engineering design projects. Similarly, Joshi et al., [12] explored students' responses to challenges in global virtual teams while working on global engineering design projects. They uncovered relevant insights on navigating teamwork challenges within global virtual environments and recommended time investment in conflict resolution strategies education by instructors before and during the course. In their study, projects were selected by instructors and a single solution was required for each project.

These studies reflect a largely overlooked aspect in the design of courses across international context as an alternative to study abroad programs. Courses have either been designed with no engineering design component or with requirements for the same solution irrespective of student context. As consumers' demand for personalized products increases, engineers must be equipped to adapt design needs to applicable cultural contexts; on-size-fits-all no longer works [13]. Following from prior work showing the promise of virtual international collaboration in engineering education [14], our project, Activa tu Speaking seeks to redress this gap by providing students with an opportunity to work on an engineering design project with international peers to develop solutions relevant to both contexts, as is obtainable in the

workforce while developing competency, confidence, and a sense of cultural sensitivity in speaking the primary language of international peers.

## II. BACKGROUND

### A. The origins of the course

"Activa tu speaking," the precursor to our course, was initiated in 2018 as an exchange program between high schools in Mexico and the US, in the regions of Guadalajara and South Carolina, respectively. Upon the pandemic lockdown in 2020, the program moved into connecting college students in a virtual environment via a course by the same name. In this environment, students from the US and Mexico practiced their language skills while learning about a meaningful scientific topic with the expectation of broad public dissemination via videos, presentations, and infographics. Table 1 shows the list of project names and the number of students from the US and Mexico that participated in the course in the previous three years.

Table 1. A summary of the projects since the course's inception. The semester, project names, and the number of US and Mexican students.

| Year, semester | Project name | # US | # MEX |
|---|---|---|---|
| 2020, Fall | Stress during the pandemic | 3 | 3 |
| 2020, Fall | Facts and Myths about cayenne pepper and peppermint | 3 | 5 |
| 2020, Fall | Music to my Ears | 3 | 4 |
| 2021, Spring | The effect of aloe vera on Hair | 3 | 4 |
| 2021, Spring | Infectious happiness, the effect of the pandemic of self-satisfaction | 3 | 4 |
| 2021, Spring | Reduce carbon footprint | 3 | 5 |
| 2021, Fall | You are what you eat | 3 | 5 |
| 2022, Spring | Caffeine consumption in college | 3 | 5 |
| 2022, Fall | Teen Smoking | 2 | 6 |
| 2023, spring | Trash management | 4 | 4 |
| 2023, spring | Sustainable Energy | 4 | 4 |

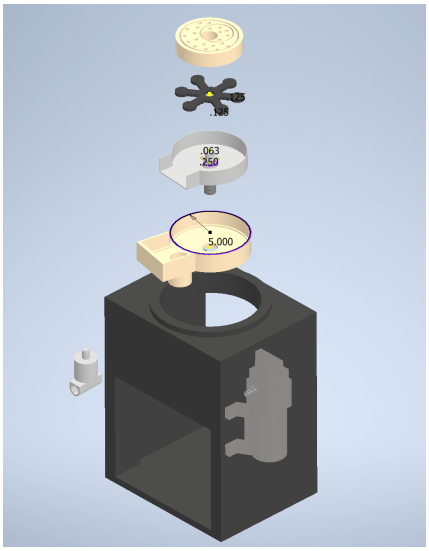


*Figure 1. Prototype schematic of a bottle cleaner for the trash management project done during the spring of 2023.*

**B. Course details**

"ACTIVA tu Speaking (AtuS)" is a project-based course in a Spanglish environment about a relevant scientific/engineering topic where engineering students enrolled in the University of Georgia collaborate with students from a Spanish-speaking country (i.e., Mexico). For students from the US, this course is a 3-credit course that is offered either as part of a junior/senior level technical elective or as a Spanish elective for students minoring in Spanish. The course requires skills in spoken Spanish and a basic understanding of the scientific method and/or engineering design process. For students from Mexico, this course is part of their elective class "Ser Global" (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 two sessions per week, where one of the sessions is dedicated to a virtual meeting (Zoom) with the international partner, and the second session was conducted intranational (i.e., US and Mexico meet separately) to discuss the progress of the project and topics that help teams stay accountable for the goals of the project. Some of the topics included leadership, teamwork, project management, decision-making, and developing engineering specifications, verification, and validation tests. The authors of this manuscript served as the primary instructors and mentors for the teams; however, graduate students were also engaged in the mentorship of the students, providing an environment to develop their mentorship and leadership skills.

The general topical outline established for the class during the spring semester was as follows:

1. Outline the project topic/challenge.
2. Research areas of interest.
3. Build a hypothesis.
4. Define the objectives (general and specifics).
5. Develop a methodology and schedule to achieve the goals (including facilities, personal, financial, and other resources).
6. Evaluate the findings/achievements of the project.

7. Present/publish findings/results to a broader audience.
8. Spread out the results among the scholar communities and the society.

In May 2023, students were able to present to a broad bilingual audience that included faculty members and professionals associated with the University of Georgia, the University of Guadalajara, the US consulate in Jalisco, and Clemson University. As an example of the artifacts developed in class, Figure 1 shows an exploded view of the CAD developed as part of the trash management project in the US. US students created a cleaning station to prevent cross-contamination in the recycling center, while the Mexican team developed a can crusher to save space and a bicycle and a picnic table with solar panels to charge electronic devices on campus. Exemplifying how the cultural environment draws different needs and solutions. Each team of students actively worked on their own solution while also providing guidance, support, and feedback to their counterparts on how to direct their own solution.

## III. DATA COLLECTION

This course was not originally planned as a research project; thus, the data available for analysis was limited to a promotional video created by students and end-of-semester, voluntary, written reflections about the course. The promotional video was transcribed using Otter AI software [6]. After transcription, we corrected the errors and removed contractions. On the last day of classes, the University of Georgia's students (8) were asked to voluntarily write a course reflection paragraph. The handwritten course reflection paragraphs were typewritten and stored as a text file for use in a word cloud package for its analysis. The study excluded Universidad de Guadalajara's students (8) because many of them were underage. After consultation with the institutional review board (IRB), it was rendered that this analysis does not require IRB approval for human research because of its haphazard research design.

## IV. DATA ANALYSIS

We analyzed the transcripts of the promotional video and the students' reflections using the open-source statistical program R [15], RStudio [16], and the word cloud package [17].

In the analysis, we removed common English words as defined by the word cloud package and other words that were common in the transcripts that did not add to our understanding of students' experiences. The list of words removed is shown in Table 2.

Table 2: Additional Common Words Removed

| |
|---|
| activa, uga, like, favorite, part, really, able, get, lot, well, say, definitely, also, just, can, major, majors, come, environmental, regular, getting, another, class, kind, something, tu, helped, wanted, will, take, open, course, setting, great, helps, ways, day, might, classes, today, college, minor, actually, miss, help, courses, couple, challenges, comes, year, maybe, behind, challenged, challenging, curriculum, always, little, going, even, everyone, many, first, now, way, quick, got, friend, friends |

## V. RESULTS

In the promotional video, the students were asked to describe their favorite part of the course. The most common word was “engineering” (Figure 1); suggesting that even though the main differentiator of the class was to have the Spanish language in a technical engineering elective class, the students still identified the engineering design process used in the class as the driven component of their experience. Secondly, the students talked about their experiences using Spanish in a technical environment and the development of professional skills as well as international awareness and developing confidence in working in an international environment.

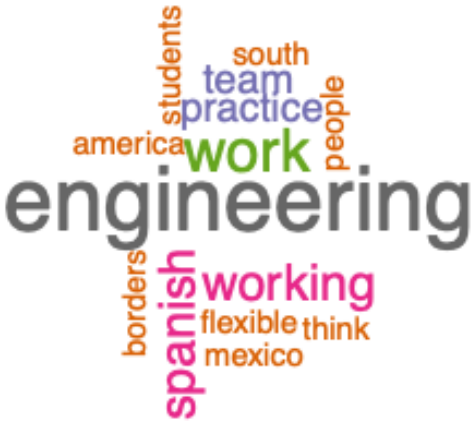


*Figure 2. What was your favorite part of this bilingual, international Engineering course?*

Thirdly, the students were asked to discuss how this course differed from other engineering courses they had completed. The most common word was “Spanish,” which is not a surprise since all other engineering courses at their institution are taught in English (Figure 2). Some students identified the usefulness of having a high command of English and Spanish as many US corporations have operations in Latin-America. These students also expressed their desire to join the workforce that connects such businesses. The students also expressed how they were learning engineering by dealing with real and relevant problems and the challenges of learning new technical vocabulary in another language. As with the first prompt, students mentioned developing the professional skill of working in a team.


*Figure 3. How did this bilingual, international engineering course differ from other engineering courses?*

The third prompt asked the students to discuss the challenges with the course. The most common word used was different (Figure 3). This is perhaps expected because the course has a different structure compared to traditional engineering courses. For most students, this was their first or second design-heavy course; thus, learning to define the problem and develop a design project was demanding. The concept of "People" was highlighted as an opportunity for students to enhance their work ethic by collaborating with a diverse international team. This challenge allowed individuals to adapt to different leadership styles and work dynamically with others.


*Figure 4. How were you challenged in this bilingual, international engineering course?*

The fourth prompt in the video was asking the students if they would recommend this course to other students (Figure 4). They all responded yes, with many saying “definitely yes”. Once again Spanish and engineering were prominent words.
Students appreciated the fact that the class count towards the graduation credits as a technical elective and having the option of using as Spanish credit for their minor.


*Figure 5. Would you recommend to others this bilingual, international engineering course?*

The students' end-of-course reflection paragraph commonly mentioned engineering and Spanish. There is preliminary evidence of the students developing a professional identity as engineers (technical, research, projects, professional, work), engineering academics (learning, knowledge, vocabulary), developing professional skills (team, speaker, confidence, comfortable), and international awareness (world, international, locations).


*Figure 6. Student's reflections on this bilingual, international engineering course.*

When all responses, including the promotional video and the written reflections, were analyzed, 31 words occurred five or more times as reported in Table 3. The word cloud for all responses is shown in figure 6. We grouped the most frequent words into four groups: Professional Identity (engineering, work, real, future, project, technical, engineer, problems, and professional), Engineering Academics (different, learning, think, know, experience, skills, and learn), Professional Skills (team, people, time, students), and International Culture (Spanish, language, country, and international). There were a few words that did not fall in any category (good (6), recommend (6), feel (5)). These terms are primarily related to how students felt about the course. The students in this class expressed their professional identity (86) and engineering academics (96) strongly through their word usage, which was surpass by the international culture (58) followed by professional skills (27).

Table 3: Total Word Frequency

| Word | Freq. | | Word | Freq. |
|---|---|---|---|---|
| Professional Identity | | | Professional Skills | |
| Engineering | 22 | | Team | 7 |
| Work | 16 | | People | 7 |
| Real | 9 | | Time | 7 |
| Future | 8 | | Students | 6 |
| Project | 7 | | International Culture | |
| Technical | 7 | | Spanish | 36 |
| Engineer | 6 | | Language | 6 |
| Problem | 6 | | Country | 5 |
| Professional | 5 | | International | 5 |
| Engineering Academics | | | World | 6 |
| Different | 27 | | | |
| Learning | 16 | | TOTALS | |
| Think | 16 | | Prof. identity | 86 |
| Know | 12 | | Eng. Academics | 96 |
| Experience | 10 | | Prof. Skills | 27 |
| Skills | 9 | | International C. | 58 |
| Learn | 6 | | | |

## VI. CONCLUSIONS, IMPACTS ON ENGINEERING EDUCATION, AND FUTURE WORK

The course was successful in having students from the University of Georgia and the Universidad de Guadalajara work together in a bilingual, international environment. Our analysis suggests that the course helped University of Georgia students build their engineering identities; however, a future study with a stronger framework is needed to confirm the dependency. The students also reported interest and increased confidence in their ability to work in a bilingual, international environment. Additionally, both heritage Spanish-speaking students and students who learned Spanish in the classroom reported increased confidence in using technical vocabulary in Spanish and expressing engineering concepts in Spanish. The University of Georgia students report that the course helped in developing their identity as engineers and developing engineering academic skills. The students also showed development in professional skills and international awareness.

Some lessons learned included the coordination of different time zones and school schedules. During the spring semester, a shift in daylight savings time occurred, and that placed the meeting times in an off-regular schedule. Moreover, the spring semester calendar is different in both institutions; in particular, the University of Guadalajara had five extra weeks to work on the project during the months of May and June. For the next cycle, the class will be offered as undergraduate and graduate to allow graduate students to develop their leadership and mentorship skills.

More importantly, the students discovered that while they were working on the same project, the specific needs of each community led to unique requirements and priorities. As an example, in Athens Georgia US, the recycling center relies on having aluminum cans intact for the

purpose of sorting while in Guadalajara Mexico compacted cans were desirable to reduce the space while stored.

Given the success of increasing students' competence and confidence in their engineering skills in this initial class, research questions have been identified for future work, such as: 1) How is this type of international experience compared with other local corporate project-based classes, such as in the Capstone program of the University of USGeorgia? 2) How close is this experience to a study abroad experience in terms of academic experience and teamwork? 3) How do the course perceptions of students from Mexico Guadalajara differ from those of U.S. students?

For future work, we will assess the effect of the experience on students' engineering identity and cultural awareness in greater detail, and work to include the perspective of Mexican students in addition to U.S. students. Furthermore, we are currently developing agreements with other Universities located in Spanish-speaking countries (i.e., Mexico, Spain, Chile) to consider a diverse cultural environment.

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