

Engineering Together Sustainable Communities: Sustainability Engineering in Action

Dr. Noe Vargas Hernandez, Carnegie Mellon University

Noe Vargas Hernandez researches creativity and innovation in engineering design. He studies ideation methods, journaling, smartpens, and other methods and technology to aid designers improve their creativity levels. He also applies his research to the design of rehabilitation devices (in which he has various patents under process) and design for sustainability.

Dr. Heidi A. Taboada, University of Texas, El Paso

Dr. Heidi A. Taboada is an Associate Professor in the Department of Industrial, Manufacturing and Systems Engineering at The University of Texas at El Paso. She holds M.Sc. and Ph.D degrees in Industrial and Systems Engineering from Rutgers, The State University of New Jersey. Her research strengths involve the development of multiple objective optimization models and evolutionary game theory algorithms, design of new biologically inspired algorithms, and renewable energy systems optimization. As an active researcher, but also as a passionate educator, Dr. Taboada is interested in research related to engineering education. She is particularly interested in research related to increase the participation of minorities and women in engineering.

Dr. Jose F. Espiritu, University of Texas, El Paso

Jose F. Espiritu is an Associate Professor in the Industrial, Manufacturing and Systems Engineering Department at The University of Texas at El Paso. He received a BS in Biochemical Engineering from the Instituto Tecnológico de Zacatepec, a MS in Industrial Engineering from the Instituto Tecnológico de Celaya. He obtained his MS and PhD degrees in Industrial and Systems Engineering from Rutgers, The State University of New Jersey. His research interests are in the broad areas of risk and reliability analysis, energy systems optimization, sustainability engineering and engineering education. His work has been published in the IEEE Transactions on Reliability, Journal of Risk and Reliability, Electric Power Systems Research, American Society for Engineering Education and International Journal of Performability Engineering. He is a member of IIE, ASEE and INFORMS.

Dr. Connie Gomez, Galveston College

Dr. Gomez received her Ph.D. in mechanical engineering from Drexel University in Philadelphia, PA. She has worked in the areas of computer aided tissue engineering and sustainability at the University of Texas at El Paso. She is currently a member of Galveston College in Galveston, TX, where she is developing a new engineering program.

Dr. Isaac Andres Azuz, CETYS University

Full time professor/researcher at Enginnering School. CETYS University Mexico. Coordinator of the master program in Environment and Sustainability.

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Abstract

In the summer of 2015, a group of students and faculty from the University of Texas at El Paso and Carnegie Mellon University travelled to the city of Ensenada, Baja California, Mexico, to join a group of students and faculty from CETYS Universidad, a local prominent university in Mexico. The objective of the combined group was to learn about Sustainability Engineering and apply this knowledge to local community based projects. This paper is a recount of the experiences from this faculty-led study abroad exchange program funded by the 100,000 Strong in the Americas initiative. Furthermore, we present the lessons drawn from this experience with the hope that these help others with similar efforts. Some of these lessons include: key issues in planning effective community based projects, student teams' early work prior to travelling, connecting classroom theory to the local community, training students to consider non-technical issues in the community, importance of student full immersion in the community, understanding the local idiosyncrasies and policymaking, and making students aware of their power and responsibilities as engineers, among others. The bi-national, multidisciplinary student teams tackled a variety of real community-based challenges, ranging from energy and water conservation for processes at local wineries, to socio-cultural issues of the indigenous Kumiai tribe. This study abroad program provided a unique opportunity to engage in real, hands-on projects with local communities to design and implement sustainable engineering solutions; the objective of this transformative educational experience is to solve real problems, and in the process, train responsible leaders that are true agents of change. Preparing a program like this requires various steps in anticipation, sometimes with years in advance, for example: cultivating the relationships with the international counterparts, procuring funding to support the activities, establishing agreements with departments and colleges for course credit recognition, resolving institutional and federal travel risk issues, recruitment and selection of students, travel and housing logistics, local contacts involved in community projects, and follow up of the projects after program completion.

1. Introduction

Background

The objective of this paper is to provide useful recommendations for planning and executing faculty-led study abroad programs based on the authors' experience. In the summer of 2015, UTEP and CETYS conducted a study abroad program funded by the 100,000 Strong in the Americas Innovation Fund. The program was a real success, but the planning and execution presented continuous challenges that required quick thinking and adaptability from the organizers. These lessons are captured in this paper for the benefit of other institutions facing similar challenges.

UTEP is a Hispanic serving institution located in El Paso, Texas. Its location and history show a strong connection to Mexico and Latin America. This has been challenged by the surge in violence in Mexico in recent years. A group of faculty from the College of Engineering with strong ties to Mexico started a search for an opportunity to establish study abroad programs with Latin American countries. The group successfully established a faculty led study abroad program with Peru; this was funded by the Department of State under the Educational and Cultural Affairs (ECA) program. For 3 years (2013-2015), groups of UTEP engineering students traveled during the summer to Peru to join local students at the Universidad de Piura in the north of Peru. Students received credit for the Sustainability Engineering course at their respective institutions and worked together in community based projects addressing sustainability issues. The successes of this program were a motivation to explore study abroad opportunities in Mexico. As recently quoted in a New York Times article “More underrepresented and low-income students should study abroad in order to realize that we are more alike than we are different ^{1,2}.”

CETYS Universidad is a private university with presence in the state of Baja California, Mexico. Although CETYS is a relatively small institution with only 3 campuses (Mexicali, Tijuana and Ensenada), it has a great impact in the life of the region: educational, economic, political and social. The institution has a decades-long strong international tradition receiving international students and sending students for study abroad programs. CETYS is the only university in Mexico certified by the Western Association of Schools and Colleges (WASC). In recent years, CETYS has grown aggressively in quantity and quality of teaching and research, increasing the exchange of students and faculty with institutions abroad (43 universities in North America, 33 in Europe, 19 in Asia, 10 in Latin America and 2 in Australia).

The institutional relationship between UTEP and CETYS started in 2010; it was initiated by one of the faculty at UTEP and alumnus from CETYS. Initially, exploratory visits to El Paso and Ensenada looked at various options: research internships, faculty training, and student mobility, mostly in one direction (from CETYS to UTEP). As the group learned from each other, a clear opportunity emerged, the conditions were aligning for a truly bi-directional study abroad program between a US and a Mexican institution.

Motivation

The goal of engineering is often seen as the design and manufacturing of technical products that improve a process, a task, or just the quality of life. Many engineering students began studying the profession under this idea of driving improvement. And as the world becomes smaller, and the problems found all across the globe grow more pronounced, it becomes increasingly obvious that much of that drive to create change could be used to improve the quality of life in locations across the globe ^{3,4}.

But it is not just that drive to improve the quality of life of others across the world that should lead engineering students to spend time abroad. As students move towards working in an increasingly global economy, the call for globalized engineers also increases in importance. The ability to understand and work with others from all parts of the globe is becoming a more desirable trait for engineers to have, as they are often sent to company branches across the globe for work. Developing these skills early on, as students, will help these engineers to perform more successfully at their jobs ^{5,6}.

As Grandin and Hirleman ⁷ suggest, “*International experiences should be considered as fundamental as having a course in heat transfer for a mechanical engineer,*” since they allow students to learn a set of “soft skills” fundamentally essential to become a well-rounded engineer. In other words, an experience going abroad will grant students a fuller understanding of how to convey the knowledge learned in a classroom to others and to apply it to situations outside of their own comfort zone. And these sets of skills are ones that often cannot be taught in a classroom setting or at the student’s home university. Acquiring talents such as “*global mindset, collaboration, adaptability, flexibility, and learning and cultural agility*” gives the students a lifelong set of skills that will assist them in all aspects of life ⁸. These sets of skills are particularly crucial when considering how many of these students will go to work in engineering companies across the globe ^{9,10,11}, such as Siemens in India, Motorola and Intel in Malaysia, and Texas Instruments in Mexico.

In this day and age, it is rare that an engineer will collaborate only with other engineers in the workplace. More frequently than ever, they must interact with policymakers, lawyers, scientists, and engineers from other backgrounds, all for the success of one project. It is important for engineering students to understand how to effectively collaborate with others from different backgrounds and to gain some insight into these backgrounds, so as to improve their collaborations. Because most programs expect their engineering students to not only find an engineering solution to the problem at hand, but adapt that solution to the cultural values and expectations of their host country and work with local policymakers to design effective solutions, these students gain a deeper understanding of the different roles played in a collaborative team.

2. UTEP-CETYS Partnership

Preliminary Work

The UTEP faculty group had a strong interest in the topic of Sustainability Engineering. Previous funding from USDA allowed the creation of the first multidisciplinary Sustainability Engineering course at UTEP’s College of Engineering. This course was the precursor for the UTEP-Piura study abroad program. With this background, the UTEP group was able to identify faculty with strong sustainability and environmental interest at the CETYS Ensenada campus. With this common interest the joint group started giving form to a faculty-led study abroad student exchange program.

Proposal Preparation

The proposal “Engineering-Together Sustainable Communities” was written with a clear focus on preparing engineers with a bi-national understanding to tackle environmental issues; two valuable characteristics highly appreciated by both institutions. From the beginning, it was also clear that students should work on community-driven sustainable projects to provide lasting learning experiences. The objectives of the proposal were as follows:

1. Make USA and Mexican students more aware of their cultural differences and similarities and use this awareness to develop stronger relationships.
2. Develop professional skills such as team working, communication, leadership, etc.

3. Familiarize students with the technical jargon used in each nation in their respective language.
4. To build strong working relationships among UTEP and CETYS faculty participating in the program.
5. Learn about the challenges of sustainability in the modern world.
6. Use life cycle assessment as a technique to measure environmental impact of infrastructures, processes, or services.
7. Understand the principles of design for sustainability, with an emphasis on the built environment.
8. Be involved in community-driven development projects to implement sustainable engineering solutions.

Funding

The proposal was submitted to the 100,000 Strong in the Americas Innovation Fund; it was awarded and initiated during the fall of 2014 and implemented in the summer of 2015. The overall plan, as shown in Figure 1 below, starts in El Paso where CETYS and UTEP students congregate 4 days to kick-start the course. Tours to desalination plant and UTEP research labs are included. Then the course continues with virtual collaboration for one week with students back in Ensenada and El Paso. Finally, CETYS and UTEP students congregate in Ensenada for 10 days to work on community based projects and complete the course. This sequence changed in the actual project execution as explained in subsequent sections.

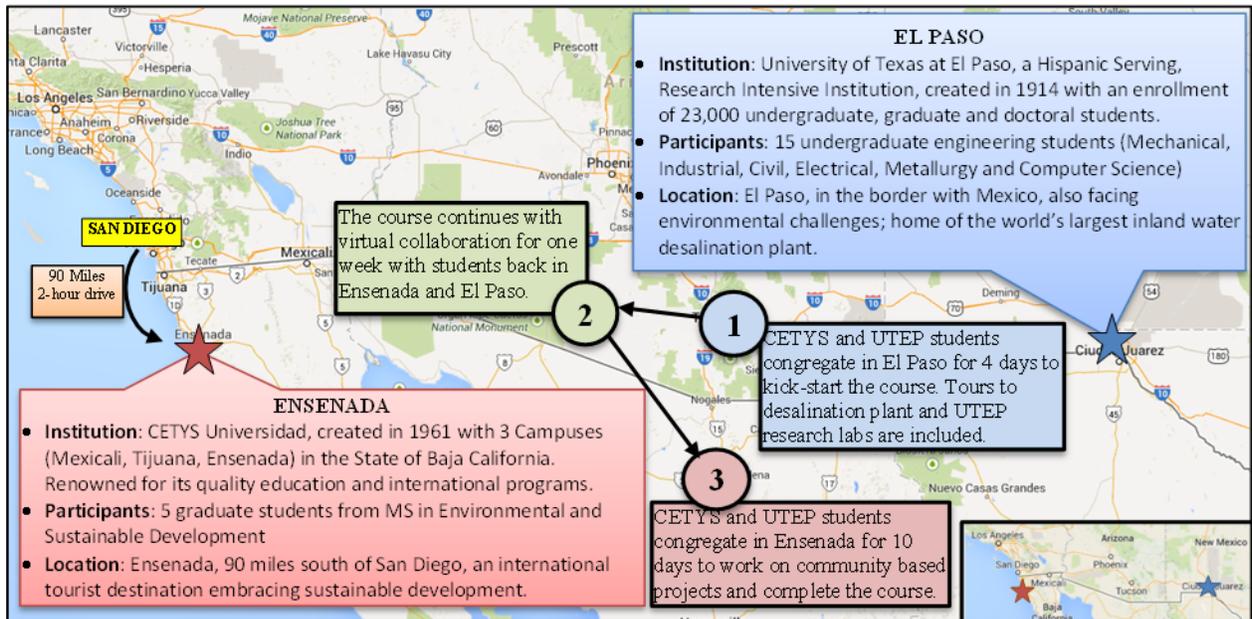


Figure 1 Overview of the UTEP-CETYS Building Together Sustainable Communities study abroad program

3. Project Implementation

Recruitment

The program was advertised to students at both institutions during the fall of 2014. The organizers at UTEP found that it is difficult to convey the richness and excitement of the program through traditional means (e.g. flyers, emails, etc.). The most effective method was word of mouth, especially from students that had previously participated (in this case in our UTEP-Piura project). Each student applicant had to include the following materials: transcript, letter of recommendation and a statement of interest; students were asked to have a minimum level of Spanish proficiency (mostly at a simple conversational level). All applicants were interviewed to gauge their interest. A total of 17 students from UTEP were selected for the program; 11 undergraduates and 6 graduate students from various engineering departments. A similar recruiting process was followed at CETYS where a total of 12 students were selected; 2 undergraduates from industrial and renewable energies engineering and 10 graduates from the master program in the environment and sustainable development.

Risk Mitigation

This project also faced challenges due to safety and security reasons. The violence in Mexico increased drastically in 2007, prompting the U.S. Department of State to issue travel warnings for specific regions, cities and states. In subsequent years violence in Mexico has continued, at points shifting to other regions and reducing or increasing its intensity. Based on this, the University of Texas System periodically issues travel advisories and limitations for official engagements. The faculty group at UTEP requested an exception based on a risk mitigation plan. The argument was based on multiple factors that make Ensenada a privileged location in the Mexican context:

- Ensenada is located in the state of Baja California, 90 miles south of San Diego across the Mexican border; the drive is quick, and the roads are well maintained.
- Ensenada has become a tourist destination, offering high quality cultural, gastronomic, artistic, and sport activities options. This port city caters to cruise ships arriving daily from San Diego and has a well -developed line of security to help maintain tourism.
- The weather is Mediterranean, with mild winters and summers.
- Ensenada is located within a 30 minute drive of the Valle de Guadalupe, which produces 90% of the wine sold in Mexico and includes dozens of wineries. This region has also attracted the development of hotels, restaurants, arts, sports, and ecotourism.
- Ensenada concentrates the highest number of scientists per capita in Mexico with various universities campuses and research centers.
- Ensenada is leading Mexico on Sustainability and Development; researchers focus on water conservation and oceanography. Ecotourism is a growing activity in Ensenada.

- Ensenada receives a high volume of tourists from North America, Europe and Asia, and has a sizable expatriate community. Besides the previously mentioned factors, the sense of security may be the biggest reason for this.

The proposed risk mitigation plan included continuous monitoring from the involved faculty while in Ensenada and a well-planned transportation and logistics plan were CETYS Universidad proved to have vast experience since it receives students and professors from other countries on a weekly basis.

Travel Logistics

The UTEP group of students and faculty travelled from Ciudad Juarez (across the border from El Paso) to Tijuana (across the border from San Diego) were CETYS transport vehicles drove them to Ensenada (around 2 hours' drive). All students (see Figure 2) stayed in a hotel just one block from the touristic and commercial area. In retrospective this had some advantages and disadvantages, having easy access to restaurants and entertainment was positive, but at times it also meant too much of a distraction. All logistics for transportation, field visits, and restaurants were efficiently provided by CETYS; their ample experience was a great advantage to adapt to last minute changes and find the best options for visits. UTEP faculty stayed at a hotel on the outskirts of the city, which in retrospective was advantageous and allowed us to focus on our work. UTEP students flew back from Tijuana to Ciudad Juarez while CETYS students drove back for one day (approx. 600 miles) to meet in El Paso to continue the program. UTEP was in charge of all the logistics while in El Paso including lodging, meals, field visits, campus tours, etc.



Figure 2 The group on their first day of classes at CETYS Universidad – Campus Ensenada

Community Based Projects

A key element of the program was the student involvement in community-based sustainability projects. The CETYS faculty in Ensenada had extensive experience working with the local community. Students worked in various projects relating to local wineries in the Guadalupe Valley (30 miles north of Ensenada). Sharing the same fate as California, Baja California also suffers a harsh drought. The projects addressed water conservation, energy conservation, use of renewable energies, assessment of the life cycle of products and process, and agricultural irrigation. One project in particular addressed the need of the native Indian community in the Guadalupe Valley; the Kumiai (Kumeyaay in English) are distributed in the north of Baja California and south of California. The Kumeyaay belong to the Yumans that includes other ethnic groups such as the Cocopah, Quechuan, Paipai and Kiliwa; the presence of these groups can be dated to at least 7,000 years ago. This project looked at various current issues such as water resources as well as handcrafts and tourism.

Classroom Activities

With a rich experience teaching Sustainability Engineering in Peru, the faculty group created a dynamic lecture plan that combined theory and practice. The first two weeks of lectures started in Ensenada (see Figure 3) and continued for one more week in El Paso. The topic of sustainability was covered in its wider sense including People, Profit and Planet, creating an understanding that any technical solution would be limited if other aspects are not considered. Expert researchers from Ensenada were invited to explain the complexities of land and water policies. In El Paso, the lectures turned more technical to take advantage of UTEP's research expertise on water desalination and other high tech topics.



Figure 3 First two weeks of classes at CETYS Universidad-Campus Ensenada

Field Visits

In Ensenada, students saw first-hand examples of community needs as well as success stories where sustainability was considered. The group visited 6 different wineries (see Figure 4) to learn about their processes, best practices and current issues with respect to sustainability. The production of wine in Ensenada dates back to the early 1900's when Russians from the Molokan group established in the Guadalupe Valley. The quantity and quality of the wines has increased dramatically in the last decades; this has brought an economic boom as it attracts tourism and detonates other activities such as arts, sports, gastronomy, culture, entertainment and education. This growth challenges the resource in the region, specifically water.



Figure 4 Field trips to the Valley of Guadalupe and Ensenada

Issues and Opportunities

As with any other worthy project, issues had to be addressed at every step. Some of these were easily solved, others threatened the project as a whole. For example, sudden US Department of State changes on travel policy, obtaining matching funds in a tight economy, etc. It became clear that the determination and creativity of the faculty group from UTEP, CMU and CETYS, and the support of the staff and administrators from each institution, were keys to tackling almost any issue encountered during this study abroad program.

4. Lessons Learned

Recruiting and Selecting Students

Nothing moves without motivation, and when recruiting for a study abroad program it is critical that mutual expectations are clearly defined. This is especially true when projects are involved in the area of sustainability; students must have a special interest on social innovation. How can organizers check for this? For the Ensenada program, it is necessary to strike a balance between advertising the fun side of the experience (cultural visits, making new friends, food, entertainment, etc.) and making sure that the students understood the work required (academic work, working with unprivileged communities, adjusting to life in other country, etc.). The faculty group found two decisive elements in the recruitment process: any proof of previous experience or interest on social innovation or sustainability projects, and a one on one interview where we could ask deeper questions to understand the motivations of the student. After a few years of experience, the authors agree that it is better to select students that are appreciative of the opportunity than students with high GPA or extraordinary technical skills that do not show a clear motivation to make an impact in the community or planet. In this sense, GPA becomes a secondary requirement.

Another step in the recruitment process was ensuring a level of proficiency in Spanish for US students. As the program stresses the importance of collaboration with other students and communications with the local community, it is imperative that students have a rudimentary understanding of Spanish, from which they can build upon their language skills. Furthermore, study abroad programs at Iowa State, Purdue University, and the Georgia Institute of Technology all stress a similar level of importance regarding language skills, as it creates a more comprehensive, immersive experience¹². That being said, UTEP and CETYS have unique advantages in that most students at both institutions are bilingual. UTEP is a Hispanic Serving Institution and most students know Spanish, although many students are only conversationally fluent in the language. CETYS, located next to the US-Mexico border has a very intensive English training program requiring high levels of proficiency for graduation from every student. Classes in Ensenada and El Paso were mostly conducted in Spanish, but reading assignments as well as reports were submitted in English. Furthermore, limitations in language were mitigated by creating project groups with students from both institutions, from multidisciplinary backgrounds, and from undergraduate and graduate students, where the groups could leverage the strengths of their respective group members.

Starting Early on Projects

Traditionally, studying abroad is seen as an option explored by students in the arts and humanities and oftentimes, studies abroad offices may not be prepared for programs that take engineering students abroad⁴. Therefore, it is imperative to start early on the project, so that any challenges faced due to the lack of engineering study abroad programs can be met on time. Furthermore, “engineering programs often do not have advisors who are knowledgeable about study abroad opportunities”⁷. Meaning that without starting early on the project, issues that arise with paperwork, recruitment of students, and more may not be addressed on time.

For the UTEP-CETYS program, the projects were procured well in advance; it could be said that this took years to prepare if we take into account the cumulative experience of the CETYS faculty, but the specific projects were arranged early during the Fall semester of 2014. These pre-existing connections allowed the program to have privileged access to various wineries and to the Kumiai community in the Guadalupe valley. It is crucial to have a partner on the ground that understands local culture and has established relationships with the local project “clients”. Building on these established relationships means that project groups can be made aware of sensitive issues, can avoid duplicated efforts, and build on the work of previous groups all within the allotted timeframe of the study abroad program. Two months before the actual traveling, the CETYS and UTEP groups participated in a skype teleconference and met each other. Teams were formed and the remote interaction started a month before traveling. The teams did their background information collection, preliminarily defined the problem and found solutions to similar problems in other places. A key element to enable this progress was that the CETYS students visited the project locations in advance to collect preliminary information.

How to find projects when the local partners do not have an existing relationship with the local community “clients”? The authors suggest contacting organizations such as Engineers Without Borders (EWB) or similar non-governmental organizations (NGOs) that have existing projects or previous experiences in the region. Governmental organizations are also a possibility, but one must be aware of possible implications, such as the transitional nature of governments, political preferences of communities, and other types of interests.

Understanding Students’ Expectations

Research conducted by the Georgia Learning Outcomes of Students Studying Abroad Research Initiative (GLOSSARI) have found that oftentimes, studying abroad can improve the grades and graduation rates of students who are on academic risk¹³. In another study in Indiana University, students were found to have higher grades than their peers after studying abroad². Other benefits of the UTEP-CETYS program include:

- 1) Work with a binational team,
- 2) Address an engineering problem in a developing country,
- 3) Work both in their country and outside their country, and
- 4) Be truly immersed with the cultural and societal needs of the community to create sustainable solutions that will be accepted by the community.

Often, when studying abroad, engineering students have a much more difficult time adapting to a new culture and environment due to their education’s lack of humanities course, such as history, art, politics, etc.⁷. Thus, it is important to note this fear and understand how to combat it, such as through crash courses about the culture, offered before the students leave to study abroad. Based on their Peru study abroad program, the UTEP faculty realized the transforming impact this experience could have on students, beyond the technical knowledge acquired. Students made valuable bonds with their host families and classmates and grew into true global citizens. For many of the UTEP students it was their first time traveling outside of the US and Mexico, and for some it was their first time taking a flight. For the UTEP-CETYS program, the most effective

method to convey what a life changing opportunity a study abroad program poses and to alleviate the fears that accompany embarking on this experience was using peer-to-peer communication. We invited students that participated in the Peru program to talk about their experiences; student recruits were able to understand their perspective and ask questions.

Summary: Checklist for Success

Programs from other universities, all with the same common intent of increasing the global competence of their engineering students have shared different tips for creating a successful, lasting study abroad program. Banks *et al.* suggest face-to-face meetings with the partnering university, pre-departure orientations that teach students of the culture and language, faculty presence, and student evaluations at the end of the program to gauge the program's success¹⁴. Here we provide a summary of items to help with the success of a study abroad program:

- Do not select students based only on GPA or technical mastery; a personal interview can reveal true interest in the program.
- Do not proceed with a study abroad program if the partner institution is not completely on board. There must be clear benefits for both institutions to buy-in.
- Establishing contacts for community-based projects can take years; if these are not readily available consider partnering with an NGO such as EWB.
- Whenever possible have the students stay with host families since it can be an enriching experience.
- Establish a buddy system, it is typical that someone may not be feeling well or encounter difficulties and the organizers need to know.
- Talk to each student privately during the program to know if there are any issues that may be sensitive and not disclosed in the group, for example, problems with adjusting to the host family food, not feeling safe when walking back home, etc.



Figure 5 Program closure ceremony at the Wine Museum in Ensenada's Guadalupe Valley

5. Student Feedback

After the UTEP-CETYS study abroad program was completed, a survey was applied to the UTEP participant students. Overall, students were satisfied with the program and found it to be relevant for their careers. Figure 6 presents results for questions relating to life experience, classmates and quality of instruction.

	Excellent	Very Good	Good	Poor	Very Poor	Total
Your student life experience in the program	46.15% 6	38.46% 5	15.38% 2	0.00% 0	0.00% 0	13
The relationship developed with your peers or classmates	84.62% 11	7.69% 1	7.69% 1	0.00% 0	0.00% 0	13
The quality of instruction you received	53.85% 7	38.46% 5	7.69% 1	0.00% 0	0.00% 0	13

Figure 6 Answers to questions relating to life experience, classmates relationships and quality of instruction

Figure 7 shows the students' comments to the question: Describe how your perspective of your field of study in engineering changed after this experience. The comments are very insightful and clearly show an important impact on their understanding of their engineering field.

Responses
I learned the importance of communication among different levels of abstraction with people from different backgrounds at an extraordinary speed, very fast, to solve different problems that can only be solved if we work together and do our job correctly.
I am inclined to practice more sustainable engineering
I always thought that as an engineer, one would simply finish the projects assigned and that's it, but this program showed me that the projects an engineer works in, affect people and they are for the people, and because people need something. We saw the worry and the hope in the people of Ensenada BC. It's not just about doing something you like and profiting from that, it's about changing people's life for the best, it's about helping. "We are no longer just designing a piping system, we are helping people get water without a long walk. we are helping them to survive."
My field of study was master's level social work. This program gave me another perspective on general treatment and modalities used within my field.
this gave me sense of feeling that no book or classroom can make you feel. I was constantly learning and applying my knowledge to a project and every day was a new thing I learned and an opportunity to expand my understanding towards the project. it showed me what real engineers do in the field because it was mostly hands on experience. now I can see things in the world and know how to manipulate my surroundings to make it better.
This experience allowed me to get a glimpse at a 'real world' type of environment.
I believe that if civil engineers were to incorporate sustainability practices during the design and construction of engineering projects, we would have the capacity and opportunity to maintain and improve quality of life without degrading the quantity, quality or availability of natural, economic, and social resources.
it was an excellent experience

Figure 7 Students' perspective of field of study changed with the study abroad experience.

Students were asked about their experience working in a binational and interdisciplinary team; comments are shown in Figure 8.

Responses
Extraordinary, a complete carnival of ideas and brain power that must be coordinated to successfully cooperate towards a common goal. Totally a mind opening experience. The numbers, the facts, the problems and solutions go beyond languages, beyond nationalities, a very real mind opening experience.
Frustrating at times but overall a good experience
Makes you an engineer without borders.
"It humbles you in the most amazing way" - Carlos Ferregut
Working in an interdisciplinary team was very rewarding as it was a little challenging. I really enjoyed every experience within the three weeks
It helped develop my interpersonal skills
I was surprised by how much we collaborated even if our fields were completely different, CETYS Mexicali could have put more effort into this program but the collaboration between UTEP and CETYS Ensenada was great!
It was great to work with people with different educational backgrounds, they offered a different piece of knowledge into the puzzle in their own different way because we all thought according to our discipline and that helped us create a bigger better project.
Working in a team with people from another country allows you to learn even more because you get to learn things in a different way
This experience made my knowledge about sustainable design more robust by taking and sharing methodologies between cultures. Professionally and personally, it gave me the opportunity to socialize with professionals and students who share similar interests as I do.
It was an excellent experience
Good

Figure 8 Students' comments about working in a binational and interdisciplinary team.

6. Conclusions

A study abroad program is an opportunity to have a positive impact in the life of a student. Nevertheless, creating such a program requires an enormous amount of effort and planning if it is to have a positive result for students, partner institutions, and the communities where these programs take place. Others embarking on a study abroad program should be aware of major challenges namely establishing a strong partnership with another institution, obtaining sufficient funding, planning logistics, using established relationships to secure meaningful projects and using additional criteria for student recruitment. Developing programs that give engineering undergraduate and graduate students the opportunity to complement their education with a global academic and practical experience within such constraints require creative solutions. At the end of this extraordinary experience we now have a group of young leaders that can make an impact in the sustainability of our world.

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