Development of the Whole Student through an Engineering Abroad Service Learning Program: Rainwater Catchment/Filtration System in Guatemala

Abstract

The first engineering service learning abroad program was offered during the 2013-14 academic year which consisted of an application process; weekly preparatory meetings; the two-week January 2014 community engagement service project in Guatemala; and weekly culmination meetings. From the application process, eleven engineering student delegates and three alternates were selected. The student delegates represented varying fields of engineering, and had range of construction experience and Spanish language skills. During the Fall 2013 semester preparatory meetings, the two faculty leaders and the fourteen students met to explore Guatemala's culture; learn about health and safety of traveling abroad; and perform preliminary design of a rainwater catchment system in order to provide the village of Vuelta Grande with potable water. The two-week abroad experience in Guatemala, between the fall and spring semesters, consisted of working with the adult leaders of the village to design, procure material, build, and test the rainwater catchment-filter system. During the Spring 2014 semester following the experience weekly culmination meetings allowed the students to reflect and document their experience in a series of presentations to the college and the local professional community. The student delegates conducted a self-assessment survey in which they rated their growth before and after the abroad experience in six relevant constructs related to their professional and personal growth. The instrument was based using practices by Purdue University's EPICS Program. The instrument had 26 statements from which students gave themselves a rank using a scale of 1 (low) to 10 (high). The areas of growth included industry skills, the value of civic engagement, awareness of engineering as a global profession, global and cultural skills. The results from the students' self-assessments showed an average increase of 32% or 2 mean points before vs. after the Engineering Abroad program. Students experienced change and noticed their skills and abilities were enhanced after the abroad experience.

Cabrillo College

Cabrillo College was established in 1958 and is an accredited community college located on the California central coast serving all of Santa Cruz County, the northern part of Monterey County, and the western portion of San Benito County. To the south is the city of Watsonville, which is home to thousands of farm workers who for decades have harvested the fruits and vegetables of the fertile Pajaro Valley. This agricultural region, while rich in culture and ethnic diversity, is characterized by lower socio-economic status with low levels of educational attainment, high seasonal unemployment, and low per capita income with one in four families living in poverty. Just north of Cabrillo College is the Silicon Valley with high tech industry and multiple four-year universities offering baccalaureate degrees in engineering. One important objective of the engineering program at Cabrillo is to prepare underprivileged students from areas such as Watsonville for success in upper division engineering programs.

Cabrillo College has over 5,400 full-time equivalent students (FTES) and a total student enrollment of approximately 14,000 students per semester. The college serves a large diverse population and is federally designated through the US Dept. of Education's Title V program as a Hispanic-Serving Institution (HSI).
Student demographics are as follows:

- 32% of students are Latino (Hispanic)
- 81% of students attending Cabrillo's Watsonville Center are Latino
- 32% of students are full-time
- 82% are first generation in family to attend college
- Median age is 24 yrs.
- 91% are US Citizens
- 43% receive financial aid
- 84% of incoming high school students assess below college-level math
- 18% of STEM majors are Latino

[Data is from Cabrillo College Fact Book and Cabrillo College (2013), Preliminary STEM Pipeline Study, (2009).]

Cabrillo College transfers more students to University of California at Santa Cruz than any other California Community College. In 2013-2014 Cabrillo transferred 338 students to four-year universities. However, more important is how well students from Cabrillo perform at four-year institutions. One example of the quality of instruction at Cabrillo and how well Cabrillo students perform after transfer is the results of a writing skills test given at San Jose State University to students prior to taking upper division general education. Out of eight community colleges in the greater Silicon Valley region, Cabrillo College had the highest pass rate on this writing test over a period of five years. It is not unusual for Cabrillo STEM faculty to hear that their former students are performing as well as if not better than the native students at the four-year institutions. Although much of this feedback is anecdotal it is not surprising given the intense usage and culture of work that is apparent in the campus's STEM Center.

Engineering Department

The engineering department at Cabrillo College offers a complete lower division engineering program preparing students to transfer with full junior standing to public and private universities in California and throughout the US. The engineering department has grown steadily over the last five years with approximately 350 students now declaring engineering as a major. When comparing numbers of declared majors, engineering is the second largest STEM major and the fifth largest major campus wide.

Many of the engineering students at Cabrillo are Latino and the first in their family to attend college. These students are diligent but often struggle due to lack of high school preparation in the STEM areas. One objective of the engineering department at Cabrillo College is to prepare underprivileged students for success in an upper division engineering program. One way this objective is addressed is by promoting a student community and a culture of respect and support. Through an engineering abroad program with service learning projects in Spanish speaking countries, non-traditional engineering students are able to capitalize on skills they already have,

such as language skills or hands-on work experience, and apply those abilities to an engineering group project. It is in this setting that many of these non-traditional students are able to "shine" and be a critical teammate in a real world engineering project.

Engineering Abroad Program

The Engineering Department established Cabrillo's Engineering Abroad Program to provide a greater depth of engineering opportunities to students in a vastly different cultural setting.

According to the Institute of International Education (IIE) [1], "*If the next generation of students fails to experience and understand foreign cultures and languages, the complexities of U.S. relationships with other nations, and the leadership qualities that are required in cross-cultural contexts, this failure may extend to crucial aspects of America's national security, economic competitiveness, and global leadership. Abroad helps meet these challenges. The experience of living and learning abroad provides U.S. undergraduate students with the opportunity to develop cross-cultural competency and international expertise. It also fosters self-confidence, independence, and leadership qualities."*

By providing opportunities for all engineering students to have cultural experiences in other countries, they learn that engineering success is not just about solving a technical problem but also about meeting a human need and realizing that to meet the need requires an understanding of the culture and physical constraints of the environment. The objective of this program is to show students that engineering is much more a team sport and that problems are "messy" and design occurs under constraint. By providing a real-world engineering problem in a setting where students encounter unplanned obstacles, students "lose" themselves in the problem and focus on issues and people other than themselves. According to the RP Group[2], "*Persistence and success appears to be greater among students who are involved in the abroad project.*"

The Engineering Abroad Program focused projects in Spanish speaking countries as a means of capitalizing on the language and cultural knowledge that most Latino students possess since more than 25% of the student population at Cabrillo College is Latino. The student delegation is selected for diversity in terms of the knowledge, background, and skills students bring to the team.

Dream Volunteers (DV) [3] of Redwood City, CA was the chosen nongovernmental organization (NGO). DV had experience running various service trips to Guatemala and this experience was needed to ensure that there would be a good match between Cabrillo and the service project. DV worked through La Union, A Spanish-language school in Antigua, Guatemala who arranged the guide, transportation, home stays, and cultural visits. Specifically, DV had worked with the village of Vuelta Grande (VG), a 120-family hillside town outside of Antigua, for the past eight years. In anticipation of our service trip, Brian Buntz (Founder and Executive Director of DV) spoke to the villagers of VG to determine their greatest need; that need was a potable water system.

This first abroad cohort was comprised of eleven Cabrillo College engineering students from various engineering disciplines and with differing skill levels, and two engineering faculty

members, JoAnn Panzardi with an MS in Civil Engineering and a PE license, and Karl Ewald with a PhD in Materials Science and over 15 years of industry engineering experience. The program consisted of a Spring 2013 application process; Fall 2013 preparatory meetings; two-week abroad experience in Guatemala in January 2014; and Spring 2014 culmination meetings.

Application Process

Since so many engineering students at Cabrillo were interested in the program, there was an application process with interviews in spring 2013. Students were evaluated based on the following criteria:

- Engineering major
- Completed ENGR 5 Engineering as a Profession and ENGR 25 Graphics and Design
- Full-time student for the semester following the abroad trip
- Completed at least 30 units of major coursework (math, physics, chemistry, computer science, and/or engineering)
- Minimum GPA of 2.50
- Leadership experience
- Interest in sustainability
- Hands-on building experience
- Spanish language skills desirable
- Limited travel experiences or never traveled outside the US to be given special consideration
- Participants must commit to attend mandatory Fall 2013 preparatory meeting and Spring 2014 culmination meetings on Fridays; 1:00 - 3:00 pm

Approximately 25 students applied for the January 2014 experience. Ten students, one peer leader, and three alternates were selected. Since this was the first year of the abroad program, the student group was limited to eleven students. Of the eleven students, four had construction experience, four were women, four spoke Spanish, and three were Latino. The 27% Latino mirrored the percentage of Latinos at Cabrillo College. In addition the two faculty members each took responsibility for different aspects of the program: Jo-Ann Panzardi coordinated the logistics of the program and Karl Ewald oversaw the engineering project.

Preparatory Meetings

The two faculty and eleven students met for two hours every Friday during the Fall 2013 semester to prepare for the abroad experience. Preparation included team building activities, understanding health and safety in Guatemala, researching Guatemala's history, culture, political, economic and social systems, and preliminary engineering project design.

In regards to the project, Brandon (student) wrote…

> *"From a project and planning perspective there were a lot of unknowns. What was the site actually like? What were the dimensions? What materials were going to be available? Are parts in metric or in standard? How were materials transported and delivered? In order to work with these variables we had to go in with a goal, and a*

flexible template that we could later input definitive plans and measurements once we were able to thoroughly assess the site. To remain flexible we broke the main project into different levels of completion. Achieving any level, though, would have been a success!

With the help of Google Earth and pictures that Karl had taken during his site visit, we were able to draw up rough sketches and get some loose plans drawn up. From that, vision and understanding sprouted, which gave us the foundation and confidence to achieve our goals. Soon to follow were a tools and theoretical materials list."

Budget and Fundraising

During the Fall 2014 semester, in addition to the preparatory meeting, the students formed the Engineering Abroad Club (EAC) selecting engineering student, Sarah Kalman, as its president. The club's slogan is "Trabajando Junto Para un Mundo Mejor". The EAC set a fundraising goal such that all selected students could participate regardless of their financial situation.

The cost of the two-week experience was projected to be approximately $2,300 per person, totaling $30,000 for 13 people. This cost includes airfare, land transportation, homestay lodging, meals, project materials, and unanticipated miscellaneous travel expenses. The students were only responsible for paying for their own flight valued at ~$700 and the excursion to visit the ruins of Tikal, a UNESCO World Heritage Site, valued at $450 per person.

There were two fundraising arms, one being student-driven and the other being faculty-driven. The students raised money through local businesses; selling snacks in the STEM Center; and through a donation from the Student Senate, which covered the Tikal excursion and half their airfare. The faculty raised money through local engineering professional organizations, engineering firms, two rotary clubs, and Cabrillo engineering alums, which covered the remaining cost with the exception of $3,000.

Even though fundraising efforts were somewhat successful, the engineering faculty and the EAC learned that fundraising is one of the most challenging aspects of the project.

Guatemala Community

Vuelta Grande is a small, but growing, rural village of 120 families set high in the mountains just outside the city of Antigua. This farming community is a representation of what daily life is like in rural Guatemala. The indigenous people harvest their crops on steep mountain slopes at an elevation of 1,500 feet. Boys as young as eight begin to work in the fields alongside their fathers while girls work with their mothers tending to younger siblings and performing household chores.

Vuelta Grande, Guatemala was chosen to be the project site for the 2014 Cabrillo College Engineering Abroad Program. This ethnically Mayan population speaks both Spanish and Kaqchikel, making good communication feasible. Due to poor socio-economic conditions and wealth disparity in Guatemala, infrastructure like municipal utilities, adequate wells, and water

distribution systems are not being implemented. VG had water needs that DV felt could be adequately addressed by the Cabrillo abroad group.

Guatemala faces numerous challenges in terms of water resources and sanitation. An estimated 98% of water resources in Guatemala are moderately contaminated with fecal matter and harmful chemicals. VG's water needs are met by a well that runs dry seasonally, and during these dry months the town's families must pay to have water delivered to communal tanks. The challenges that the community of Vuelta Grande faces in terms of poverty, clean water, and education, are common throughout the country.

Engineering Service Project

To begin to address the water resource issue in Vuelta Grande, the engineering abroad group decided to design and construct a rainwater catchment system. Rainwater is relatively free of contaminants; therefore it requires minimal treatment to achieve potable quality. Other sources of water, other than deep confined aquifers, are likely to harbor significantly higher levels of harmful contaminants. Moreover data showed that much of the town's rainwater was being lost to run-off.

There were three components to the rainwater catchment system: rainwater collection, storage, and a purification system. The group worked to collect water from the roof of the elementary school and transport it to a storage location tucked behind another building. Work was done to remove and reinstall the existing gutters so they would direct water from the roof to the collection point. One challenge was to devise a simple "first-flush" system that would divert the first 200-300 gallons of water from the roof into the existing drain. This is done to flush any debris (animal droppings, leaves, etc.) and toxics (road grime and dust) off the roof before water is diverted to tanks. Once the "first-flush" has had a chance to divert the dirtiest water from the roof, the water then starts to flow into a 40-gallon barrel that includes a sump pump and float switch. When the level of water reaches a pre-determined level, the pump engages and pumps the excess water to two 650 gallon storage tanks. There are float switches in the storage tanks used to prevent pumping to full tanks. Finally, the water in the tanks was treated with chlorine to kill most organisms to make it potable.

To tackle the project, the group formed seven teams to focus on each sub-component. Those teams focused on: gutters; the "first-flush" system; electrical controls; conduit for the electrical wires; the plumbing system; storage tanks; and the filtration system. Each team was assigned a leader who had the most experience in the area. Having separate modules broke the entirety of the project into smaller bite-size pieces. And, each team had a "floater" to move from team to team to convey information. In addition, during the whole construction, the young adult leaders of the community were part of the process every step of the way.

Each of these seven components had their own tasks, goals, schedule, and challenges all while working towards the common goal of the completed project. Once assessing the site, they were able to inspect the existing infrastructure, take measurements, figure distances and elevations, calculate amount of material needed, and finally solidify our plan.

The gutter teams' major focus was to make sure the gutters were functional and feeding our system effectively. In order to do so, the team had to dissemble the gutters, clean them, re-set the existing brackets, and seal the seams. The team's biggest challenge was in having to re-use the existing gutters and brackets. They did not anticipate the gutters being in such poor condition. Stronger brackets should have been fabricated and new gutters could have been purchased, yet they were resourceful and worked with what they had.

The "first flush" team had one of the more technical and customized parts of the project. The challenge with a rainwater catchment system is in addressing water washing off dirty roof tops and contaminating the system. Before leaving the US, the team developed a way to divert 200-300 gallons of dirty water from the roof before it entered the system. They built a small chamber underneath the down spout of the gutter that would collect a small portion of the water while the rest of the water flows out a drain. Inside the chamber is a float the rises as the chamber fills. Once the chamber is filled, the float seats, and shuts off the drain, forcing water to then enter our system and into our tank with sump pump. Thankfully they had built a prototype and tested it at home to work out any issues ahead of time. A strainer was also fabricated to prevent large particles from entering the system, and access ports were placed at crucial points in the first flush system for easy cleaning and maintenance.

There was a team in charge of prepping and placing the tanks in our system. They needed a small tank to hold our sump pump and larger capacity tanks for storage. They were able to acquire two 650 gallon tanks for storage, and a 30 gallon blue barrel with locking, sealed lid for the sump pump. Once the site of all the tanks was agreed upon, the team then cleared brush and leveled the pads. There was already an existing concrete pad buried under brush and a few inches of dirt where the storage tanks needed to be, so they were fortunate there. The small tank for the sump pump would need to be right next to the down spout and first flush which would place it against a building on a concrete slab. The tanks all needed holes to be drilled into them. The sump pump tank had rainwater flowing in, water being pumped out, excess water flowing out a drain, and electrical wiring to supply power to the sump pump and float switch. The large storage tanks needed to be bridged to act as a single tank, along with needing an inlet from the sump pump, an outlet that feeds a spigot, an overflow, and a site tube to allow for easy viewing of the water level inside the tanks.

Connecting all pipes and plumbing of the components was the task of our plumbing team. Once the placement of the first flush and tanks were decided, the plumbing team laid out and dug the trench to connect them and cut, glued, and threaded all of the piping needed to connect our system. Help from the community made an easy task of digging. Challenges varied from having to dig underneath a slab of concrete to get to the sump pump, breaking existing pipes, and having to fabricate a dobber for the PVC glue after realizing our bottle didn't come with one.

Another team in charge of connecting our components together was the conduit team. This team's task was to plumb all of the piping that the electrical wires would be run through. The conduit used in Guatemala was not like what is used in the US. The conduit there is a continuous poly tube much like what is used here for drip irrigation systems. It was difficult to work with the long roll of conduit, mounting it to walls, fishing it through rafters and burying it

underground. Mounting the electrical boxes was also the responsibility of this team, but was done in collaboration with the electrical team.

The team with one of the most challenging tasks was the electrical team. The reason for the challenge was that fact that this was the only major aspect of our component that had to be tied into their existing infrastructure. For the most part, the rest of our system was self-contained. After our first assessment they realized that the school was not properly grounded and clearly didn't follow the same set of codes and regulations that they require here in the US. They purchased and installed a grounding rod, chose the most effective electrical box to tie into and fished wire through the conduit that was put in place. They needed power to feed our sump pump, a normal-open switch at the sump pump, a normal-closed switch in the storage tanks, and a 110VAC receptacle installed at the tank in preparation for a future UV filter.

The filter team, this year, was responsible for showing a local student leader how to properly chlorinate the water in the tank, along with how to maintain, and clean the system.

In regards to the design, Karl (faculty) wrote…

> *The system was designed and built as a prototype that could be replicated in other parts of the village. We don't know exactly how the community will use the water… While I'm sure the water will be used at the school, our thinking was that community members would feel welcome to visit the school to fill containers as needed, but we don't know exactly how things will actually shape up. I know the long term hope is to connect the isolated system we built to the municipal water supply.*

There were multiple challenges to the project ranging from a technical nature, to time pressures, to language barriers.

The Latino students who participated in the program reported feeling special and integral to the process because they were needed to interpret for the non-native speakers. In regards to his language skills, Jose (student) wrote…

> *"When we bought the materials in Antiqua and four of us who spoke Spanish had to translate for more than four hour, I learned that being fluent in two languages is a great asset. I can use this to help better Watsonville, the community where I live, and where most people speak Spanish and where I want to do projects as an engineer in the future*"

Guatemala Cultural Experience

The Guatemala experience was a total of 14 days, with eight days working on the service project. During the six remaining days, students experienced the culture of Guatemala by exploring Antigua, Tikal, Lake Atitlan, and Chichicastenanga. Visiting Tikal and Lake Atitlan caused students to reflect on engineering at these two sites.

Patrick (student) wrote…

> *"Lake Atitlan is situated in the central Guatemalan highlands at an elevation of 5,100 ft. This is an indispensable natural resource for a community of 400,000 people living in the Lake Atitlan watershed for which the lake is a source of water used for agriculture, drinking, sanitation, and fisheries. In recent years the lake has seen a surge of harmful-algae and toxic cyanobacteria blooms in the lake. This is due to increasing levels of pollution from lack of wastewater treatment facilities in the communities surrounding the lake and agricultural fertilizers in surface run off in the lake's watershed. Erosion, exacerbated by deforestation, during heavy rain events has also adversely affected many Lake Atitlan communities. This knowledge led to conversations on the bus about engineering solutions to these problems such as a native wetland restoration to deal with contamination and a sustainable agriculture and reforestation program to reduce soil erosion on the steep watershed.*

Jill (student) wrote…

> *Tikal National Park is a UNESCO cultural heritage site as well as a UNESCO environmental heritage site. Tikal hosts nineteen different ecosystems within the park as well as ancient Mayan. It was wonderful to learn from local experts about the rainwater collections cisterns and the pyramids designed thousands of years ago by Mayan architects and engineers.*

Culmination Meetings

The two faculty and eleven students met for two hours every Friday during the Spring 2014 semester to reflect on the experience and prepare presentations to dissemination to the Cabrillo and Santa Cruz community.
Each student wrote a 500-page reflection on how the abroad experience impacted her/him as a person and as a future engineer. In addition, each student prepared a 15-minute photo journal and presented it to the Cabrillo community. Finally, the group captured their experience in a 20-minute presentation that they shared with donors and local engineering organizations.

There were two unexpected outcomes from the abroad experience. One, four of the students were given internships from their interaction with local engineers. Two, a few of the students set up a Limited Liability Corporation (LLC) to work locally on real-world engineering projects. There were four student objectives to this LLC:

- To engage in service learning projects locally.
- To acquire the skills needed to be successful in an abroad project.
- To find ways for students to monetized their engineering skills prior to earning a degree.
- To learn how to seek out meaningful work by serving the needs of the community.

During the spring 2014 semester, students in the LLC visited three potential projects, all involving water management. As of the writing of this paper, one grey-water system project was completed.

Testimonials

The first-year abroad experience had a dramatic impact on students' feelings of empowerment, as can be inferred from student testimonials below:

> *"Physically working on a project we had planned for 3-4 months and seeing everything come together was incredibly gratifying."* Tom

> *"In Guatemala I was able to experience engineering in the field first hand and I feel the knowledge learned from first hand experience has extreme value, and it's not everyone who gets this at an educational institution."* Gracie

> *"Even with our different degrees of skills among the group, we worked together and built a functioning rainwater catchment system that will greatly benefit a community. This reaffirmed my goal to be an engineer!"* Jill

> *"I now see this as a valuable experience that has helped introduce me to the interpersonal and work skills necessary to being a working professional and a good engineer.* Patrick

> *"This project was invaluable in renewing the reason why it is that I struggle through these difficult courses as this is exactly the kind of work that I want to be doing."* Hayley

> *"The experience in Guatemala greatly helped me to define who I am and that I want to become a mechanical engineer and work on projects with an emphasis on ecological principles."* Santiago

And, the abroad experience had a dramatic impact on the community of Vuelta Grande:

> *"Thank you for fulfilling our 8-year wish of providing us with clean water."* Irbin, Vuelta Grande leader

Assessment and Evaluation of the Engineering Abroad Experience

The Cabrillo Abroad Program used both qualitative and quantitative evaluations methods.

The qualitative evaluations included the reflections (discussed above) and two assessments completed just after the two-week experience in Guatemala. The first assessment asked the students to comment on how well prepared they were for the time in Guatemala in terms of health and safety, understanding Guatemalan culture, and the engineering service learning project. The second assessment asked students to comment on the details of the time in Guatemala in terms of their living and working experience. The results of these are presented throughout this paper in the form of quotes from students.

The quantitative evaluation focused on the perceived level of change that the student had before and after the engineering abroad experience. The student completed a self-assessment to rate

themselves on the skills below in Table 1. This assessment was adapted from Purdue University's EPICS program. Students were asked to rate themselves from 1 (lowest) to 10 (highest) on the skills prior to the preparatory meetings and abroad experience and at the end of the culmination meetings.

Industry Skills	1. Team Work 2. Project Management 3. Presentation Skills 4. Comfortable Interacting with Engineers 5. How Businesses are Run
Civic Engagement	1. Engineering is a helping Profession 2. Knowledge of Social Issues 3. Desire to be involved in Community 4. The Importance of Community Service 5. Awareness of Community Needs
Global/Cultural Skills	1. Comfortable interacting with people from different cultural backgrounds. 2. Connection to a "World Community" 3. Knowledge that Engineering is global 4. Work Effectively in a diverse environment
Personal Growth	1. Personal Satisfaction and Growth 2. Connection with other students 3. Confidence in facing challenges 4. Development of empathy 5. Build confidence in ability to make a difference 6. Motivation to complete your engineering education 7. Enthusiasm for the Engineering Profession 8. Solidify classroom concepts
Engineering Skills	1. Knowledge of Sustainable Design 2. Real-life applications of Engineering Principles

Table 1. Student Self-Assessment Skills

The assessment results are shown in Chart 1 which displays average growth of the students' self-assessment before (pre) and after (post) the abroad experience. The results showed an average increase of 20% for each of the five areas overall. This data suggests that each student increased their understanding of social issues, desire to do community service around the world (and understanding its importance), ability to share research and influence others to be involved in service work and sustainable engineering and having an overall better platform to stand on for pursuing a career as an engineer; all of which was direct result from being involved in the Engineering Abroad Program. It is important to note that the rates were done at the end of the experience. Using the Non-Parametric Test technique, the change on each statement was evaluated. It was determined that 13 of the 25 had significant differences to ($p < 0.05$) as shown in Chart 2.

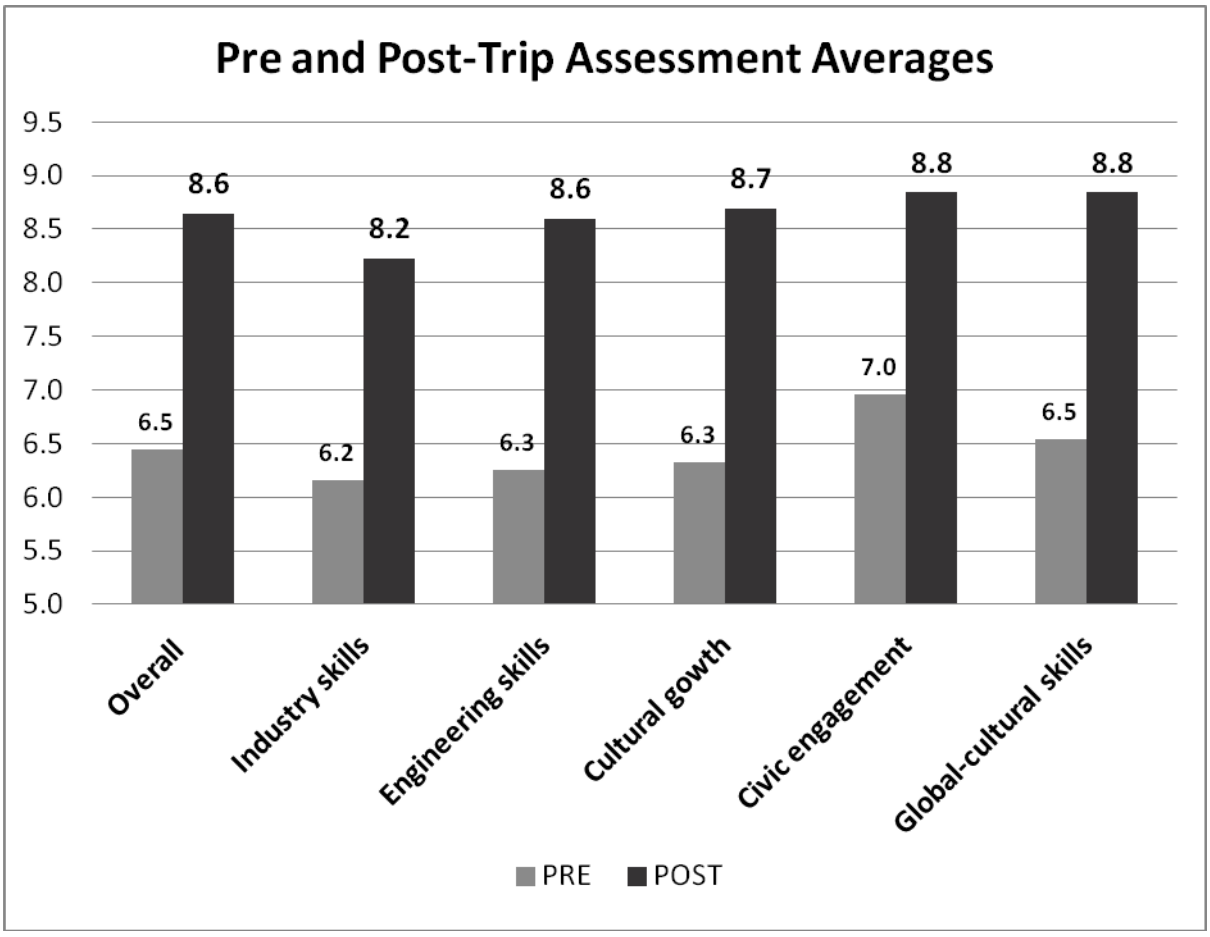

Chart 1. Student Self-Assessment Skill Ratings

[1 to 10 scale, 10 being the highest rank]	PRE		POST			Mean Change
n=10	Mean	SD**	Mean	SD**		
Overall	6.5	1.6	8.6	1.3	(*)	2.2
How businesses are run	5.8	2.1	7.6	1.4		1.8
Project management/leadership skills	6.0	1.3	7.7	1.4	(*)	1.7
Team work skills	6.9	1.6	8.4	1.1		1.5
Overall presentation skills	5.9	1.5	8.7	1.3	(*)	2.8
Comfortable interacting with engineers	6.2	2.1	8.7	1.6	(*)	2.5
Overall Industry Skills	**6.2**	**1.5**	**8.2**	**1.2**	(*)	2.1
Knowledge about social issues	7.3	1.6	8.6	1.4		1.3
Desire to be involved in your community	6.9	2.2	8.8	1.3		1.9
How important is community service	7.1	2.5	8.8	1.7		1.7
Awareness of needs in a community	6.6	1.9	8.9	1.4	(*)	2.3
Engineering is a helping profession	6.9	2.1	9.1	1.7		2.2
Overall Civic Engagement	**7.0**	**1.8**	**8.8**	**1.4**	(*)	1.9
Understanding community needs	6.1	1.4	8.3	1.1	(*)	2.2
Connection to the "world community"	5.8	2.7	8.4	2.0	(*)	2.6
Work effectively in a diverse environment	6.9	2.1	9.0	1.6		2.1
Comfortable interacting with people different cultural	7.1	2.0	9.2	1.3	(*)	2.1
Knowledge that engineering is global	6.8	2.1	9.3	.8	(*)	2.5
Overall Global-Cultural Skills	**6.5**	**1.8**	**8.8**	**1.2**	(*)	2.3
Solidify classroom concepts	5.1	1.9	8.1	1.6	(*)	3.0
Personal satisfaction	6.8	1.8	8.3	1.7		1.5
Connection with other students	5.5	1.6	8.6	1.6	(*)	3.1
Confidence in facing challenges	6.2	2.0	8.6	1.6		2.4
Development of empathy	7.3	2.8	8.6	1.7		1.3
Personal growth	6.5	2.1	8.7	1.8		2.2
Build confidence in ability to make a difference	6.0	2.1	8.9	1.4	(*)	2.9
Enthusiasm for the engineering profession	6.3	2.0	9.1	1.3	(*)	2.8
Motivation to complete your engr education	7.2	1.7	9.3	1.3	(*)	2.1
Overall Cultural Growth	**6.3**	**1.7**	**8.7**	**1.4**	(*)	2.4
Knowledge of sustainable design	6.7	2.3	8.5	1.8		1.8
Real life applications of engineering principles	5.8	2.6	8.7	1.4		2.9
Overall Engineering skills	**6.3**	**2.3**	**8.6**	**1.6**	(*)	2.4

*Colored cells are present on statements in which the difference between means is significant at the 0.05 level. Blue cells have highest ranking. Pink cells have lowest ranking.

**SD= Standard deviation

Chart 2. Student Self-Assessment with Parametric Analysis

Proposed Future Abroad Program Assessment

The initial success of the program was the catalyst in applying for an NSF EAGER grant for two future engineering abroad programs to Guatemala, which was funded. The assessment for these future programs will be more thorough and will include the following:

- The qualitative evaluation component will include a survey and focus groups four (4) times during the program: a) prior to the preparatory meetings; b) following the preparatory meetings; c) following the Guatemala experience; and d) following the culmination meetings. The survey will ask students to assess themselves relative to indicators in Table 1. Having these four assessments will allow us to determine which parts of the abroad experience led to which skills. The focus groups will provide additional opportunities to explore in depth how the abroad experience may have contributed to change students' confidence, plans for the future, perception of themselves as leaders, and commitment to the field of engineering. Particular attention will be paid in both the surveys and focus groups to capture differences in how the experience affects Latino and non-Latino students. This part of the research, while only exploratory in nature, will build on observations the Principal Investigator made after the first trip abroad where Latino students who spoke Spanish fluently enjoyed unique opportunities to assume leadership positions on site. The Principal Investigator noted that she believed this experience may have contributed to augment these students' sense of their own opportunity to serve as leaders while also strengthening their commitment to the a career in engineering. Chart 3 Illustrate the plan.

- The quantitative evaluation will include assessing academic performance and degree progress of students participating in the engineering abroad experience compared to corresponding outcomes achieved by students in a comparison group. The comparison group, potentially several times larger than the engineering abroad group, will be selected from among current students and earlier students, using the standard technique of propensity score matching (PSM). PSM is intended to produce comparison students whose only difference, probabilistically as a group, is non-participation in the abroad program. The students will match in all other academic and demographic variables. Students will be tracked on success, completion, major declaration, unit load and transfer rate. The differences in outcomes between the two groups will be measured statistically at the end of the program. Since many student characteristics as available in the data, PSM will be used to minimize the differences between program and comparison students that relate to self-selection into the program.

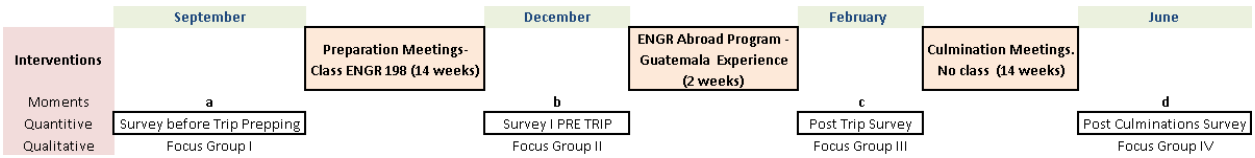

Chart 3. Student Self-Assessment with Parametric Analysis

Summary

Cabrillo College's Engineering Abroad Service Learning Program has proven to be a valuable enrichment opportunity for engineering students. Early assessment of student participants indicates multi-faceted growth ranging from areas of technical skills and knowledge to sensitivity and awareness around the reasons for why certain cultures struggle to acquire basic technological systems. Moreover by exposing students to both current culture as well as the history of the region, students witness that technological prowess is not something you are born with but something that is cultivated over time and maintained through education, economy, and a political system that rewards innovation.

In summary, Patrick (student) writes…

All of us left with a distinct sense that the skills we were learning in our engineering education have the potential to improve quality of life and protect our natural resources. Although solutions to issues we witnessed at home or abroad in Guatemala are not solely technical and in the domain of engineering, we learned how our future roles as engineers fits into a multi-disciplinary effort to make the world a better place.

Bibliography

1. Institute of International Education*, "Meeting America's Global Education Challenge: Expanding Education Abroad at U.S. Community Colleges*," *Issue Number 3*, Institute of International Education, n.d., Web (May 30, 2014). http://www.iie.org/en/Research-and-Publications/Publications-and-Reports/IIE-Bookstore/Expanding-Education-Abroad-at-US-Community-Colleges

2. Willet, T., Pellegrin, N., Copper, D., *"Study Abroad Impact Technical Report,"* The Research and Planning Group for California Community Colleges, (Dec. 21, 2013)

3. *Dreamvolunteers.org*. N.p., n.d. Web.

4. Jesiek, B., A. Dare, J. Thompson, and T. Forin, "Global Engineering Design Symposium: Engaging the Sociocultural Dimensions of Engineering Problem Solving," *Proceedings of the 120th ASEE Annual Conference & Exposition*, (2013).

5. Engineering Abroad Program, http://www.cabrillo.edu/academics/engineering/engrabroad/index.html Cabrillo College Engineering Abroad Program, n.d., Web (May 1, 2014).

6. Guzman, K., "*Cabrillo College Engineering Program to leave for Guatemala on Monday,*" Santa Cruz Sentinel, (Dec. 26, 2013)

7. Guzman, K., "*Cabrillo College students build water system in Guatemala,*" Santa Crux Sentinel, (Jan. 22, 2014)

8. Cummings, A., J. Huff, W.C. Oakes, and C. Zoltowski, "An Assessment Approach to Project-Based Service Learning," *Proceedings of the 120th ASEE Annual Conference & Exposition*, (2013).

9. DiBiasio, D., Mello, N.A., "Multi-Level Assessment of Program Outcomes: Assessing a Nontraditional Study Abroad Program in the Engineering Disciplines," *The interdisciplinary Journal of Study Abroad.*

10. Thomas, B., "A Wind Powered, White LED Lighting System for the Kibera Slum of Nairobi," *International Journal for Service Learning in Engineering, Vol.2, No.1*, 2007, pp 16-31.

11. Wittig, A., "Implementing Problem Based Learning through Engineers Without Borders Student Projects," *Advances in Engineering Education,* New York, NY, (2013).

12. American Society for Engineering Education, "Knowledge, Skills, and Attitudes Acquired through Engineering Student Experience Abroad," *Proceedings of 120th ASEE Annual Conference & Exposition*, (Jun. 23-26, 2013)