# AC 2012-3801: ENGINEERING SERVICE LEARNING: CASE STUDY ON PREPARING STUDENTS FOR THE GLOBAL COMMUNITY

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# Engineering Service Learning– Case study on preparing students for the global community

Today's engineering students need to be proficient not only in engineering and science principles but also be aware of the interplay among science, technology, and society. The mission of Santa Clara University's School of Engineering is to prepare our students for professional excellence, responsible citizenship, and service to society. To meet this mission, we provide students with opportunities to work on community projects both locally and globally and have formalized their service learning through a course "Engineering Projects for the Community". This course includes service and civic learning experiences for each of the engineering disciplines; provides interdisciplinary projects of the students' choice; and includes structured reflection as a key course component.

This paper presents a case study on a global project where the students gained experience working for real world clients on problems with real world constraints and insight on how engineers impact and influence the world around them. The project was developed by the Engineers Without Borders (EWB) Student Chapter. The EWB students involved in this project enrolled in the course to prepare for the non-technical components of the task including ethics, communication, and leadership. The course also addresses the engineering design process to assist students in applying their technical skills on the project.

Through the use of study surveys and student reflections, this paper attempts to identify the effect of community projects on student learning and student perception of their chosen career path. As one student reflected, "The engineer must be able to understand much more than the 'engineering'; there is a huge ethical and communal side to engineering." Another noted, "This experience has a large impact on the team members' concept of what it means to be an engineer".

## Introduction

In 1997 a major change in engineering education in the United States began with the introduction of ABET's EC 2000. This new criteria not only focused on what is learned as opposed to what is taught, but it emphasized "soft" skills along with traditional technical abilities.[1] These soft skills introduced teamwork, communication, professionalism, ethics, global awareness, leadership, and life-long learning to engineering curriculums across the country. In 2004, the National Academy of Engineering's "The Engineer of 2020", reinforced the criteria when they reported the engineer of 2020 will need strong analytical skills combined with interdisciplinary competence; the ability to synthesize information from a broad range of disciplines and contextual competence; the ability to understand the constraints and impacts of engineering solutions on social, cultural, political and environmental contexts. [2, 3]

At the same time ABET introduced EC 2000, Purdue's School of Electrical and Computer Engineering published the first results of their EPICS, Engineering Projects in Community Service, program.[4] Student evaluations from the first three semesters of EPICS showed significant promise in service learning as a vehicle to address the soft skills of engineering.

Students were asked the impact the EPICS program had on their communication skills, ability to work on a team, awareness of ethical issues, organizational techniques, and awareness of community. The percent of students rating the impact of these areas with an A or B grade ranged from 84% - 93%, with the exception of ethical issues which only received 73% A's or B's. In a 2005 paper on the continued success of the EPICS program, the reported results of fifteen semesters and 2835 students surveyed show a slight decrease in the percent of students rating the experience an A or B. However, with the exception of ethics, which received 68% A or B, the percentages of students rating their experiences in the topic areas listed above ranged from 73% to 88%.[5]

Historically, service learning has been a valuable tool in the humanities and social science curriculums. A study by the Higher Education Research Institute of 22,236 college undergraduates attending a sample of national baccalaureate granting colleges and universities compared several outcome measures, which were all positively affected by a service learning experience.[6]

The Higher Education Research Institute study highlighted two key elements to any successful service learning experience. First, the student's interest in the subject matter is directly related to their perception of the service learning experience enhancing their understanding of course material and whether the course was viewed as a learning experience. As such, service learning experiences should be included in a student's field of study. Second, opportunities for reflection provide the means for students to connect the service experience to the course material. The report noted the primary forms of reflection were discussions among students, discussions with professors and written reflections in the form of papers or journals.[6]

Santa Clara University's (SCU) curriculum is centered on the three C's of Competence, Conscience, and Compassion. In the past few years we have adopted a new core education that aims to instill the knowledge, habits of thought and action, and orientation to society that we believe will best prepare our students for life.

**Interdisciplinary Course Description**

In order to meet these university core requirements as well as promote the integration of engineering concepts into service learning projects we developed a course "Engineering projects for the community" (ENGR 110). The course aims to create a learning experience for engineering undergraduates that fosters the development of scientific principles, technical knowledge in STEM disciplines, and workforce skills through serving the community in real-world projects. This course also allows students the opportunity to relate the various components of their education and to reflect on their choice of vocation and possible impact on the world.
The course objectives are detailed below.

- Gain practical engineering experience working on a project in the community.
- Design a service or product using the engineering design process.
- Develop project management, organizational, and leadership skills
- Develop effective listening and collaboration skills while working with customers

- Recognize and summarize ethical responsibilities of engineers.

In ENGR 110, community-based projects are distinguished through an interaction, motivation, and/or impact that involve a community beyond the university. During the course, students visit several community partners at their sites to understand the operation and needs of each agency. The interdisciplinary undergraduate student teams design, test, and deploy functional systems to solve engineering-based problems for the benefit of the communities and agencies that serve them. The community interactions are in fields such as environmental engineering, health and medical technologies, assistive and rehabilitative technology, web-based services for non-profits, infrastructure development for social programs and educational models. The students communicate regularly with their community customer to elicit specifications for the need, feedback on design choices, and coordination for final deployment of the end-product. The students hold regular design reviews to ensure that the quality of the end product meets the standards of the school of engineering and satisfaction of the community partner. By the end of the class, each team completes a comprehensive conceptual design based on creative problem solving and preliminary impact analysis with the deliverables being complete design details, a significant portion of the hardware/software for the project, and a demonstration of the design along with a design report.

The two-unit course includes weekly meetings that provide training in all phases of the engineering design process from needs assessment through viability and social impact. The course provides sessions on topics that help students go beyond just the engineering tasks and help them prepare for working in a global setting. Some topics include:

- Working in Teams/Dealing with Conflict;
- Science, Technology and Society;
- Effective/Professional Communication- technical writing and oral presentations;
- Entrepreneurial Thinking- innovation and product development;
- Reflection on Personal Goals, Lifelong Learning, and Vocation.

This course also works well for the long term projects as it may be taken multiple times for credit and work on projects span all phases of the engineering design process. In order to complete their service project, students self-select into teams that are typically interdisciplinary. The teams are encouraged to be vertically integrated including members at various levels in the program. As some projects extend into several quarters, students with prior experience in the course and upper division students assume leadership roles while new students in the course or program learn from the team.

Critical thinking and reflection are important components of the course and the students write narratives that describe their thinking, their observations and experiences, and the connections they make to what they've learned in this course and in prior courses. We ask that their reflection describe their thought process, the factors that were considered, their reasoning, and how they arrived at decisions. In Engr110, they write three narrative reflections. In the first reflection, they report back on the community partner and their mission. In the second narrative, they reflect on the project's impact with respect to factors related to science, technology, and society. The third and final reflection asks them to comment on their learning gains from the course and project work done.

**EWB Alliance:**

With our emphasis on values-based education, SCU's EWB student chapter has taken on projects to serve in global communities to help them sustainably meet basic human needs. While the EWB program provides innovative professional educational opportunities and helps members gain enriched global perspectives we need to make sure our students are prepared to help meet the developing world's needs and work effectively with a community partner. To satisfy this requirement, a unique partnership has been developed between the SCU EWB student chapter and the community projects course. Students involved in EWB also enroll in ENGR 110, which provides them the opportunity to develop their non-technical skills and requires them to have a structured reflection on their experiences.

Students involved with the EWB group developed a relationship with Un Mundo, a non profit working in Honduras. The EWB students identified pressing service projects through meetings with Un Mundo for the community in El Pital, a small village of approximately 85 households and 450 people in Northeast Honduras. 31% of El Pital residents are illiterate, 18% have no formal education and only 42% have schooling beyond the 6$^{th}$ grade level.[7] The village sits on the banks of the Cangrejal River which is approximately 265 feet across and residents must navigate waist deep water and gravel bars during the dry season to access crops on the hills across the river. During the rainy season, water levels raise by an average of sixteen feet according to local history and water marks, which prevents access to the far shore. The community currently has an inadequate water distribution system that delivers water from a small tributary located on the far side of the river. The Cangrejal River does not provide potable water as it is contaminated by agricultural and human waste from communities up river.

During EWB's 2010 assessment trip to El Pital, the community's needs were discussed and reliable access to potable water was identified by the community as the most pressing. The community also identified the challenge of maintaining the water system components on the far side of the river during the rainy season. They also indicated Un Mundo had both a cable and a metal basket to build a canasta (a ropeway across the river for moving people) but lacked the knowledge and experience to build the canasta safely.

EWB returned to the community for ten days during the summer of 2011 with two goals: to strengthen community relations and to gather necessary data to: determine the feasibility of retrofitting and purifying the water in the current system, the viability of alternative water sources, and the need and preferred option for access across the river during rainy months. With the assistance of Un Mundo, the EWB team was able to work closely with the community's recently formed Junta de Agua, or Water Board. Un Mundo also organized a town meeting with EWB so all residents could voice their opinion regarding the need for a new water system. Finally, the EWB participants interviewed locals, including the health clinic director, to gain individual opinions on the need for the water system, the current health of the community, and their thoughts on the relationship between the current water and health problems.

During their investigations, the EWB team identified viable alternatives for providing potable water to the community, which all required access across the river for construction and regular maintenance. The EWB team revisited the idea of the canasta with the Junta de Agua and also proposed a pedestrian bridge as an alternative. They asked the committee to discuss what the community's long term needs were and if the convenience of a pedestrian bridge outweighed its significantly higher expense and longer completion time as compared to the canasta. At the time of writing, the Junta de Agua were favoring the canasta but waiting for cost and time estimates for a pedestrian bridge to make the final decision. These estimates are currently being developed by EWB members in the ENGR 110 course.

While in Honduras, the EWB team collected required information to create a preliminary design for the water distribution system and the canasta. For example, elevations of the water sources and potential peaking tank sites were established. To facilitate the design of the canasta, the EWB team took an inventory of the existing canasta parts in Un Mundo's possession. Soil samples were taken at the canasta's potential foundation sites on each shore and the horizontal and vertical distances were determined between these sites. Local builders where questioned on concrete mixing techniques and concrete samples were taken during a local pour to cure and test for compressive strength.

**Student Reflections:**

The following section details reflections done by EWB students who went on the trip to Honduras. Students were asked to reflect on Community Partnerships, Societal Impact, Learning Gains and Ethics. To facilitate the reflection process, reflections were written while students where in Honduras, within a month of their return, and during the following quarter in the ENGR 110 class. A short description was provided on what reflections should contain and what the focus should be. The students showed incredible insight as was evident in one line stated by a student at the start of her essay:

> *On many levels, the entire time I was in Honduras I saw through new eyes.*

<u>Reflection 1: Community Partnership</u>

The student reflections showed recognition of the reciprocal nature of a successful community relationship; and that they listened and developed an understanding of the community, their needs and their role in the partnership. They also realized that community consensus requires prolonged discussions.

> *Our presence proved very important—we were active participants in the meetings, often used to help explain activity instructions, engineering, our roles, their roles, the situation, anything and everything, and our every word was highly valued. I think we were a motivational factor—the community wanted to impress us, and I think this was reflected in the eagerness to step up and progress in meetings as well.*
>
> *Overall, the pace of life in El Pital is much slower than the level of efficiency we are used to in the American work-work-work rush. By the end of lengthy meetings, the water board, EWB, and Un Mundo finally concluded, officially, that the community's greatest concerns are the canasta …. and 'better' water.*

*The project is underway—we are a step in the right direction now after a week of almost daily meetings. The water board has a much better understanding of their role, our role, and Un Mundo's role in the project. They understand what an engineer does, and our limitations as students a long distance from the community.*

Students also commented on how the community partner contributed to their attitudes and knowledge. Many recognized how evenly distributed the partnership was in that the students' academic knowledge did not outweigh the community members' wisdom.

*The community is so rich with knowledge; they simply just need some organization and a voice. The community mostly taught me that life couldn't be a one-man show; there is more to it than personal well-being and even the well-being of your own family, there is the support you give and receive from those around you.*
*Community members might not have a formal scientific education, but they have extensive common sense and knowledge of their environment, which is foreign to us.*

*Additionally, it is extremely important that while working as an engineer on these projects, we act like an equal and not as a group that is above any one person in the community of El Pital.*

Reflections also identified the students' awareness that this project did affect the community as a whole. For it to be successful, the entire community need to be on board and educated.

*They lack the education to know what 'better' water is, but it is our job to help them understand contamination and sanitation, and build a healthy system and healthy habits. Without understanding across the entire community, a water project would start and stop; our involvement is necessary in order for it to last.*

Finally, we found that the experience required the students to look outside of themselves. In the classroom, their efforts are self-centred, focusing on their own knowledge and their own grade. Working with a community to solve a social problem provided the students with a motivation outside of themselves.

*The community's inherent concern in the water project, largely due to their marginalized living conditions, was very beneficial in making the travel team work very hard for the duration of the trip and make team members realize they were working outside academia.*

<u>Reflection 2: Societal Impact</u>
Student reflections on societal impact varied from the practical aspect of having clean water to the more intangible effects of giving versus teaching. This project caused them to reflect deeper to recognize, analyze, and understand social reality and injustices in contemporary society.

*In the process of doing this project, we will have the opportunity to educate the community in project management and the design process hopefully empowering them to take on projects of this magnitude in the future without our help.*

*The engineer must be able to understand much more than the "engineering" there is a huge ethical and communal side to engineering. You can't just come in and give a community a project and then walk out. .... Globally we need to understand that we are only as strong as a weakest link and that developing countries can't just be driven by the developed.*

*With clean water, hopefully there will be a positive physiological impact on the community. This could range from improved health to confidence and dignity gained by working together as a community to make their community a better place as well as improve their lives.*

A few students also considered the potential negative impacts on the community that could result from progress.

*This project will have a huge impact on the community, both positive and negative ways. The positive is somewhat obvious: reliable access to clean water.... A huge issue I see is the issue of wastewater treatment. One of the major reasons the community is unhealthy is due to their living situation and lack of waste management. What will happen when we give them more water, and in turn greater amounts of waste?*

*We also do not want to introduce a system that will change the community in unforeseen ways such as with building a bridge over the Cangrejal River, it is uncertain how the community will use the bridge; access to the other side of the river can lead to increased farming and development which could result in environmental degradation and decreased water quality.*

<u>Reflection 3: Learning gains</u>
These students' comments show how they benefited (personally, academically, or otherwise) and how this overall experience improved their engineering skills. Further, the students' comments demonstrate an increased confidence that they can use their knowledge in ways that are relevant and meaningful to them.

*The biggest thing I learned within the course was how to communicate and coordinate with a customer. This ranged from figuring out what the problem is, listing different solutions, emailing to get facts, to setting up meeting times.*

*Working with students younger than me reminded me how important detailed instructions and timelines are for keeping a project on track. My leadership skills could have been better during this project but they have improved for when I do another project.*

*I learned ... that engineering is so much more than crunching numbers and designing. Engineering is more of a process, especially in this situation. There are ethical issues with every engineering project, and many aspects of community building that I overlooked until now.*

*Personally I benefited from simply beginning to understand this culture.*

*Student members benefit from working on this project by being exposed to new engineering fields, being able to work with other engineering students and mentors, and being able to able to apply engineering theory from courses to the tangible. Students improve engineering skills through seeing how theory plays out in real projects and how the full design process works. Early exposure to the design process makes senior design easier.*

Unlike a specific homework assignment or engineering exam, the travellers realized that real engineering problems will not come with a set solution:

*When entering into another culture, community and country, one encounters a range of tricky questions. As I was reminded during our short ten days in Honduras, many of these questions, engineering, social and ethical don't have one right answer, if an answer at all.*

Reflection comments also included learning gains for the community as observed by the EWB students.

*By the end of the last meeting, a few of the most involved water board members seemed to begin to understand the links between health and other issues and the 'dirty' water, cause and effect relationships visible and invisible in the community, and the importance of getting to the root of the problems to achieve the ultimate goal of happy children.*

*The biggest lesson that this community can learn is growing socially through the project. A water project is a communal system in which the entire community benefits from it. The support of the entire community is needed to help run and maintain it. This paves the way for other projects that may be realized in the coming years.*

Reflection 4: Ethics

Merriam-Webster defines ethics as "a set of moral principles".[8] The Markkula Center for Applied Ethics at Santa Clara University offers the definition in a paper by Velasquez et al. as "ethics refers to well-founded standards of right and wrong that prescribe what humans ought to do." [9] The student reflections range from the moral question of what is the right thing to do to professional ethics.

*We have to make sure the water everyone gets is water we would drink, because otherwise teaming up on this project is not "helping."*

*Ethical challenges for this project include the questions: how will a new system change the dynamics of the community, how do U.S. standards align with Honduran standards and which standard governs the final design. As engineers it is our duty to ensure that what we design does not create a financial burden on the community that it cannot pay.*

*I don't believe that is an obligation to help anyone if you don't want to. Even if everyone saw how difficult one's life was, there really is no need for anyone to help them. I choose to help El Pital because I want to. I personally can't live knowing that while I type away on my computer in a clean room with access to clean water, there are millions of other people who thirst for clean water. Why do I get the life I do? Why am I privileged? I don't know. However, I have the resources to help communities like El Pital and I have decided that I want to make a difference. I feel that with everything I've been given, I need to give back to my community. Yes, El Pital is my community.*

**Student perceptions of the effect of the service learning experience.**
Student reflections provide a valuable insight on the impact of community projects on student learning and student perception of their chosen career path. Below are highlights from student comments.

<u>The effect on student learning:</u>
As with any real world project, the EWB project provided the students with a chance to apply their new skills. As one student noted:

*There are many benefits for the travel team from this experience. As students, we get to see real world applications for the concepts we are studying in school, ranging from engineering topics to social studies and ethical dilemmas.*

*I gained more in my education through this single trip that I would have in over a month of education. In a way we were thrown into the water to see if we could swim. I love this type of education, and education through experience.*

But the EWB student team was quick to learn that engineering is not just about numbers. When providing a technical solution to a social problem its success rests on educating the public, meeting the community's needs and insuring the solution is ethical.

*The sustainability of our work and education of the community arose in every community meeting that we had. I, as well as the travel team as a whole, was reminded that crunching numbers is only one facet of a project such as designing a community water system.*

Any real world experience has the potential to improve student learning by providing them a chance to apply their skills. The students developed compassion for their "customer" and a deeper understanding of what it means to live without the basic necessities we take for granted. The student reflections were rich with thoughts on social justice and social awareness. Further, they began to grasp their roles as partners to the community rather than rescuers. The following are examples of these reflections:

*The actual construction might not take very long, but in order to create a lasting and successful project, a lot of time must go into the "social engineering." Social engineering might be a loaded term. We are not interested in changing the culture of El Pital. We want to empower the community to take control and change their lives for the* *better. To empower them, education becomes a central theme. Through doing this project to provide clean drinking water to the community, we have a great opportunity to help educate as well as learn ourselves.*

*Apart from this personal growth due to understanding other's realities, the travel team has an opportunity to create a lasting positive impact on the community members through education, confronting engineering challenges and interpersonal connections. This project gives an opportunity to help the travel team improve their worldview just as much as it is an opportunity to help a marginalized community*

<u>The effect on their chosen career path:</u>
Student reflections regarding their travel experience and homestays in Honduras showed the students felt empowered by their career choice and saw the potential for engineering solutions to improve another's quality of life. A mechanical engineering junior noted:

*As engineers, we discovered that we could apply the critical thinking and problem solving skills that we learn in school to address social problems that can only be practically solved with engineering solutions.*

But with solutions comes great responsibility. A bioengineering sophomore identified the obligation she felt to share her skills and the intricacies of using her skills to provide a social solution.

*Article 25 of the Universal Declaration of Human Rights says all humans have the right to "a standard of living adequate for the health and well-being of himself and of his family," and Article 27 says all humans have the right to "share in scientific advancement and its benefits." Engineers tackling projects addressing these issues must be inclusive, empathic, good listeners, open, driven, patient, reliable, responsible, understanding, brave, tactful, good at explaining in 'small' words, personable, ready to learn and take risks, and self-confident and friendly.*

The experience also highlighted the broad scope and impact of engineering projects:

*This experience had a large impact on the team member's concept of what it means to be an engineer. It became apparent that a large part of the project is not crunching numbers and taking measurements, but instead communicating with the customer (the community). This communications is key because the goal is to design a project that works for them. In order for it to "work," the project must meet several criteria. It must be user friendly, easy to maintain, feasible to construct, and affordable.*

*These projects we do for the good of our earth. It is a way of making the world a bit more level. When I say this I am talking about the fact that we, as gifted Americans, have almost an unfair advantage at life. We didn't grow up in slums and from day one we plan on going to college. We are within the top half of one percent of the world purely because we are lucky. This project is the first of many projects I plan to be a part of simply* *because I would like to be remembered as someone that changed the world, and if not that someone who tried*.

**Analysis of Course Enrollment**

Enrollment statistics for the course have been tracked over the past three years. Figure 1 provides enrollment numbers by discipline and term, with spring enrollments regularly outpacing other quarters. Although initial enrollment numbers are low, a steady growth in numbers is evident. With the exception of Spring 2009, the initial offerings of the course were predominately taken by computer engineering, bioengineering and electrical engineering students. The diversity of disciplines has been increasing since Winter 2011. The alliance with the EWB chapter resulted in a steady increase in enrollment by civil engineering majors.

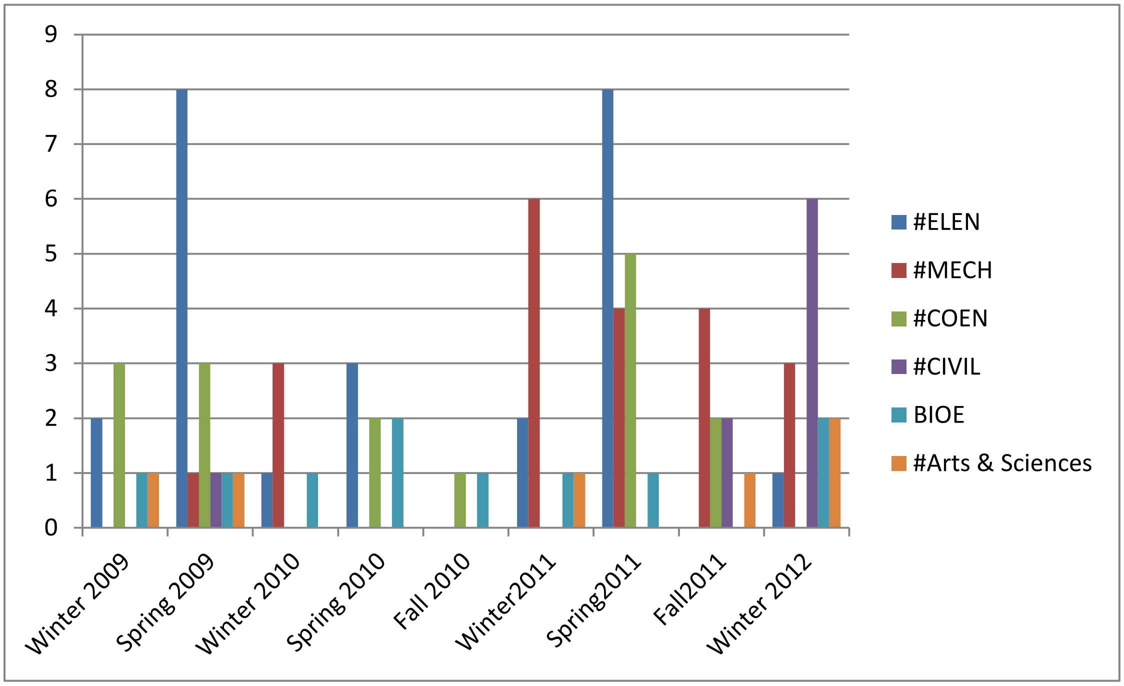


Figure 1: Student enrollment by discipline in ENGR110.

Tracking the diversity of students involved in the projects provides a measure of the extent to which this approach helps attract and retain a diverse student body in engineering. Over the course of three years, 41 percent of the students who elected to participate in the course were women; even though engineering enrollments at our university consist of only 23 percent female. The variety of majors and the grade level of the students enrolled in the course offerings, as shown in Figure 2, highlights the interdisciplinary nature of the teams and whether vertical integration is occurring. This is especially important in community projects that come from a wide range of fields and when student self-select into teams based on interest. The multiple grade levels helps younger students learn the fundamentals of the engineering design process while juniors and seniors can apply their classroom engineering knowledge to real-world problems. Figure 2 indicates the course is taken predominantly by juniors; whose reflections suggest their primary motivation for taking the course is to gain experience and develop ideas for their senior capstone project. Interestingly, since the alliance between ENGR 110 and the EWB student chapter, there has been an increase in enrollment of first-year students as can be seen in Figure 3 The data also shows that efforts to make the course attractive to younger students and non-engineering students appear to be effective.

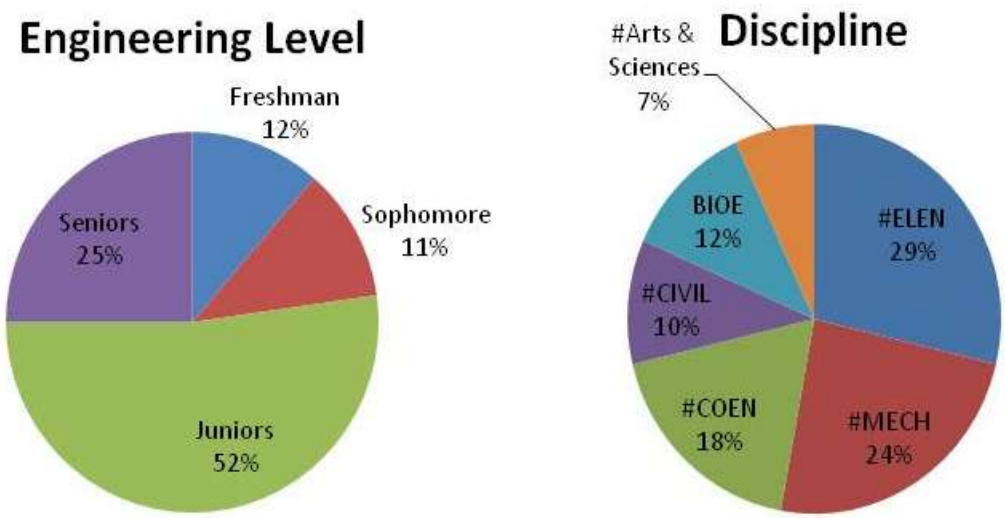


Figure 2: Student statistics in ENGR 110.

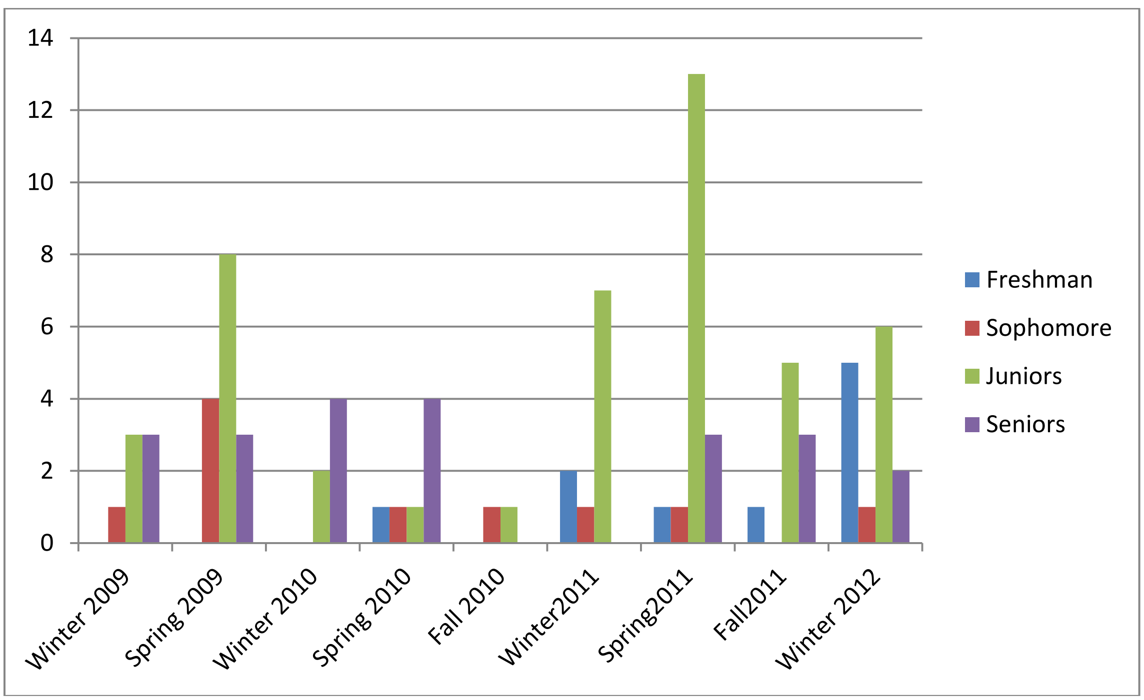


Figure 3: Student enrollment by grade level in ENGR110.

**Results from Surveys**

In ENGR 110, students complete surveys at the beginning and the end of the course. The introductory survey asks about their background, interests, and learning goals desired from the project experience. The exit survey determines their level of satisfaction with the course, and in their achievement of project goals, and will gauge how attitudes have changed on certain factors. This data collection is ongoing, with preliminary data from the initial course offerings included here. Table 1 presents student's self-ratings of their abilities before and after the course in the areas listed. The scale was: 1=not developed; 2=under developed; 3=developed; 4=strongly develop.

Table 1. ENGR 110 Student Survey (n=28 for INTRO and n=22 for EXIT))

| *Question: Please rate your skills and abilities in the following areas* | **INTRO** | **EXIT** |
|---|---|---|
| Solving engineering homework problems. | **2.62** | **2.91** |
| Finding solutions to open-ended engineering problems. | **2.62** | **2.95** |
| Learning in engineering classrooms about the engineering design process. | **2.86** | **3.14** |
| Developing an engineering plan that will lead to a solution to an engineering problem. | **2.52** | **3.00** |
| Conceptualizing a unique design to solve an engineering problem. | **2.38** | **3.05** |
| Working well with a team on an engineering project. | **3.00** | **3.32** |
| Taking a leadership role when working with others on an engineering project. | **2.81** | **3.05** |
| Orally communicating engineering ideas to practicing engineers. | **2.38** | **2.91** |
| Communicating engineering ideas in written form to practicing engineers. | **2.19** | **2.59** |
| Producing a device or prototype that will have an impact on your field of engineering. | **1.90** | **2.36** |
| Working with members in the community to define project requirements. | **2.33** | **3.18** |
| Developing an innovative or unique concept. | **2.52** | **2.91** |
| Working with cutting edge technology. | **2.00** | **2.50** |
| Orally communicating engineering ideas to non-engineers. | **2.67** | **2.95** |
| Communicating engineering ideas in written form to non-engineers. | **2.38** | **2.73** |

The survey also required students to evaluate their non-technical skills. The survey questions were purposely aligned with those used by the EPICS program. [5] Topics included communication skills, ability to work on a team, awareness of ethical issues, organizational techniques, and awareness of community. Similar to the results in the EPICS research mentioned earlier, our students gave the course high marks for developing the soft skills of engineering with the exception of an awareness of the ethical implications of their work. This leads us to believe that there is a need for strong ethical component in the course.

**Developing the Ethical Component**

Initial projects completed in the ENGR 110 course have been in local communities, but the alliance with the EWB travelling teams provide an opportunity to present scenarios of engineering projects in rural and global communities. This will allow students the opportunity to analyze the effect they can have on life in that community. To further develop the ethical component of the course, we have partnered with the Markkula Center for Applied Ethics at Santa Clara University to develop improved exercises in ethical reflections. The Center's recommendations include three areas of focus for the reflections.

**Ethics Area 1: Why do these projects at all?**

To complete this reflection students are referred to the ethics section of our school's Engineering Handbook. [10] Students are asked to reflect if equality/justice comes into play during their projects. They are also asked to consider that while there may be a practical rationale for the projects, there should be some moral reasoning that also should be considered.

**Ethics Area 2: What are the internal ethical challenges to the projects themselves?**

Most professional disciplines have their own code of ethics. Students are instructed to research any established code of ethics that would apply to the disciplines involved in the project. As an example, students on the EWB project are directed to the Code of Ethics of the American Society of Civil Engineers. [11]

**Ethics Area 3: What are the character traits of an engineer most important to doing the work on these projects?**

This reflection question is not assigned to imply there is a correct answer, but rather to allow students to look at their own beliefs and convictions. No matter if the student is working on a urban project in a first-world country or a rural, third-world project, they are still asked to consider this question. Through this reflection students can see how their own ethical convictions align with standard codes of ethics for their own disciplines.

**Conclusions:**

This was our first attempt at linking a global design project with the community based project course. For others considering projects in other countries, the EWB members' insight on adapting your expectations to another culture are priceless. One student summarized it succinctly as:

> *Waiting is a part of the normal work day in Latin America… It is a part of the culture that cannot be escaped. If you are in a rush, you need to buy a hammock and learn to watch the world go by.*

As compared to past projects that focused on local community projects, the instructor noticed the significant difference (impact) on ethical decisions, communication, and design challenges that developed while working on a project within a foreign community. Anecdotal evidence between student experiences that worked on both global and local projects suggests that the global projects offered improved opportunities for student growth, which has motivated change in the course. As an example, the low literacy rate in El Pital created its own unique challenges during community meetings. All EWB travelers commented on the unusual techniques incorporated by Un Mundo to allow everyone a chance to communicate and explain their point of view. Further, canasta designs must be based on a frugal approach. Engineering that requires shop fabrication and welding is not a feasible option. Engineering design for regions without the advanced fabrication techniques we take for granted provides greater opportunities for innovative thinking. The course will now address these unique issues that one can encounter while traveling to global communities.

From the perspective of the course, more activities that increase student awareness of the impact of technology on society will be included. Due to the present small course enrollments, team self-selection results in interdisciplinary teams with integrated grade levels. As enrollments increase, team assignments may become necessary. From the perspective of the EWB chapter, improved training before the students travel to the project site is essential to a successful outcome.

As a student perfectly put it:

> *I am excited that many of the things I learned can be applied to the water project in Honduras and this class in general is great for EWB.*

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