

## **Design for Community: Perspectives from Professors, Students, and Community Partners**

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# **Design for Community using Problem-Based Learning: Perspectives from Professors, Students and Community Partners**

## **Abstract**

Santa Clara University has a commitment to educating students of competence, conscience, and compassion. To support this goal of producing technically-proficient, empathetic graduates, engineering education has a need for more real world, hands-on, and team-based problem solving. This paper aims to showcase a collaboration between an engineering course, Community-Based Engineering Design (CBED), and Bronco Urban Gardens (BUG), a Food Justice Outreach Program, which has successfully incorporated student learning and social justice through project-based learning.

As part of this paper, we will discuss three different perspectives of participants involved with this collaboration, specifically detailing participation goals, success definitions, and challenges from each point of view. Some specific student-produced design solutions will be given as examples of this effort. Overall, this partnership has been successful, delivering student projects which have added educational dimensions to the school gardens and created a positive visual impact to the spaces. Both students and community stakeholders are mutually benefiting from the relationship formed through engagement, clearly indicating how partnerships can support the creation of projects which offer inclusive learning opportunities for all participants. While challenges exist, the class will continue to evolve and hopefully the partnerships will continue to be meaningful to all involved.

## **I. Introduction**

One primary purpose of higher education in engineering is to prepare engineering students for their future world of engineering practice. Recently, this purpose has required engineering educators to shift our thinking towards preparing students specifically as engineers who emerge from college ready to participate as active and effective members of a global society [1], [2]. Haag, et al. [3] observe that the “current work environment requires engineers to be global citizens, as well as aspirational, ethical leaders” and mimics other calls for a cultural shift in engineering education to “recapture the societal relevance” of the undergraduate engineering curriculum and the engineering profession itself [6].

This shift is fueled by the need for future engineers to deal with uncertainty and solve complex problems, use higher order thinking, and also demonstrate more interpersonal aspects of a career such as communication, social, and teamwork skills [1], [5], [6]. Unfortunately, a gap between the active engineering field and the passive classroom experience remains one of the problems within engineering education [7]. Educational practices that over-emphasize theory are outdated; it is important for students not only gain knowledge about engineering, but also to learn how to be an engineer. Students must be exposed to a number of projects that offer real-world problems, along with the complexity and uncertainty of factors that influence such problems [2]. Students should learn how to frame a problem, identify stakeholders and their requirements, design and select concepts, test them, etc. Currently, many of today’s engineering graduates often lack these

skills and have difficulty applying their fundamental knowledge to problems of practice [5], [6], [8], [9].

One solution to this need is the use of Problem Based Learning (PBL) in engineering education. In the literature, there are many definitions of PBL, although Wilson [10] offers a succinct summary which states “At its most fundamental level, PBL is characterised by the use of real world problems as a context for students to learn critical thinking skills and problem solving skills and to acquire knowledge of the essential concepts of the course.” In fact, it has been shown that learning to apply theoretical principles is much better done when given real problems and hands-on activities in projects [2].

Overall, PBL has been described as ‘reflecting the way people learn in real life’ [11] and lends itself as a teaching strategy that leads students to ‘learn to learn’ and encourages students to develop critical thinking and problem solving skills that they can carry for life [12]. The goals of PBL include fostering active learning, interpersonal and collaborative skills, open inquiry, real-life problem solving, critical thinking, intrinsic motivation, and the desire to learn for a lifetime [13], [14], [15], [16]. Hence, PBL allows students to move beyond the mental understanding of information and learn to apply concepts to real-life formats. In addition, since the knowledge is also grounded in context, which requires the use of problem-solving skills, educators purport that the conceptualization of knowledge better prepares students for future careers. [17]

This paper aims to showcase problem-based learning for social justice, pairing the PBL pedagogy with real-world projects. Our paper will describe the background perspectives and participation objectives from each stakeholder, including Bronco Urban Gardens (BUG) - Santa Clara University’s Food Justice Outreach Program, Community-Based Engineering Design (CBED) - a project-based engineering course, and students formerly enrolled in CBED. Next, results from the collaboration will be given and some excerpts from student electronic portfolios will be reviewed. Finally, challenges that emerged from this partnership will be discussed along with how these challenges might be addressed.

## **II. Background Perspectives and Participation Objectives**

The partnership between BUG and CBED is a reflection of the University’s mission to educating students of competence, conscience, and compassion. In this section, we illustrate the use of three different perspectives to explore the collaboration between these programs including 1) the BUG coordinator, 2) the course instructor (and author), and 3) students previously enrolled in the course.

### BUG, Santa Clara University’s Food Justice Outreach Program:

BUG is an outreach program of the University that works in solidarity with marginalized neighborhoods by supporting their urban garden projects and spaces and creating hands-on learning experiences for students of all ages and backgrounds. BUG provides technical support and garden-enhanced education that serves to increase ecological literacy and raise nutritional

awareness as well as food access. While officially part of the Center for Sustainability at Santa Clara University, the outreach program is embedded in the communities it serves.

BUG has three hubs that include a partnership with a local shelter and two school gardens in the San Jose Unified School District. CBED student projects have been incorporated into the Washington Elementary and Gardner school gardens, which are located at the base of downtown San Jose. As Title I schools, Washington Elementary and Gardner Academy receive additional federal funding to help serve their student populations who face significant challenges related to systemic poverty in their neighborhoods. Their students often enter the school day hungry, tired, and not fluent in the language spoken around them. 94% of Washington and 76% of Gardner's students are on the free and reduced lunch program. 70% of Washington students are English Learners, while 60% of Gardner students are English Learners [18]. These statistics reflect a stark reality; however, the resilient nature of each school community has led to unique approaches to the challenges they face. [For example, at Washington Elementary a group of mothers has created a volunteerism program-- Madre-a-Madre [19] --a weekly discussion and support group for mothers at Washington Elementary School, covering topics from helping students in school to working on issues of self-esteem and stress.] In addition to seasoned teachers, Washington Elementary also has a robust support staff and a range of enrichment programs orchestrated by their principal, Stephanie Farias. On the Gardner campus, principal Daisy Rosas has begun the work of connecting with community partners that range from Second Harvest Food Bank to Estrella Family Services. Her consistent leadership has increased collaboration, serving to create a more cohesive network of support. Both school communities embrace working with Santa Clara University, showing a willingness to collaborate with BUG and CBED.

BUG core objectives focus on learning from the resilience so well exhibited by these vibrant communities and achieved through the meaningful connection between Santa Clara University's undergraduates and community members. It is through this connection that undergraduates learn with and from community members. The BUG undergraduate engagement is best understood through a 3-tiered partnership model, beginning with our Ignatian Center partnership, as shown in Figure 1. This partnership places approximately 15 undergraduates each quarter in BUG hubs through the Arrupe Weekly Engagement. The second tier of engagement is supported by partnerships directly with a specific undergraduate course or student project, and the number of students involved vary each quarter. The Early Education Internship is the final tier of engagement, where a student partners directly with BUG. This is a relatively new BUG program, which provides garden time for Transitional Kindergarten (TK) students at Washington Elementary.

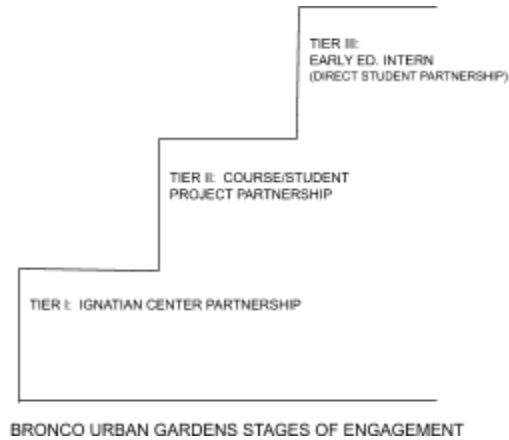


Figure 1: BUG partnership model illustrating stages of engagement

The CBED partnership falls within the second tier of engagement, and the partnership supports the school gardens of the Washington Elementary and Gardner Academy. The community liaison is the BUG Coordinator, who works directly with students in this class on specific projects, providing a community context for the design objectives set by the professor. For CBED, the community is defined as individuals potentially using the educational builds designed for the school gardens. This community encompasses the K-5 classrooms, extended day programs, as well as BUG garden-education programs. It is worth noting, especially with respect to Gardner Academy, the homes surrounding the school gardens should also be considered as part of the community. The student work in CBED aims to increase the use and educational value of the garden as well as the overall look of the space, serving to deter vandalism and dumping in this part of the neighborhood.

#### Community-Based Engineering Design:

CBED is a 10-week project-based course, where student teams are partnered with a local community business or organization and complete a design project from problem identification through final prototype. The purpose of the course focuses on “hands-on” experience in project management, building cross-disciplinary team skills, communication, and prototyping. CBED also fulfills Santa Clara University’s Civic Engagement core requirement. As a Civic Engagement course, the primary learning objectives include “critically evaluating the role of public organizations” and tasks students to “analyze and evaluate civic issues by engaging in active and collaborative learning [20].” Thus, social justice is a theme throughout the course and it is embedded in many course activities.

Some examples of course activities include an initial design project where students build a playing card tower in-class. Some project constraints exist for the card tower, but an unspoken objective is for students to ask the ‘customer’ [the professor and TA for the course act as the customer for this initial exercise] for more input through the design phase. Students quickly realize that not requesting or clarifying the customer’s input will lead to a less successful project.

Another early course activity involves student teams interviewing their community partner on-site at the project location; in this case, students partnered with the San Jose Unified School

District actually visit the schools (Washington Elementary or Gardner Academy) with the BUG Coordinator. This exercise is meant to illuminate project parameters defined by the actual space and aid in determining critical customers for their project. For the BUG hub schools, projects completed are often aimed for K-5 children and can be used as part of curriculum for the teachers to enrich learning. This activity, along with reflective assessments geared toward understanding the social and civic realities of the targeted community, help the student design toward community needs. By the end of the term, students will have designed and built a project conforming to project specifications determined through this community partner/student collaboration, which is managed by the course instructor and the BUG Coordinator.

CBED student learning objectives are fulfilled when students are more aware of their target community and its particular wants and needs, are able to develop a design which meets those needs, are successful in communicating their designs, and are able to satisfy the community partner with their project results. Project documentation for this course is recorded through use of an electronic portfolio. Students record information regarding their own biography, team membership, community partner, and project information. The project information requested includes a weekly reflective log entry of their individual efforts towards the project, along with team documentation such as team contracts, Gantt chart project timelines, and team assignments including reflections and a final project report and presentation. Format for the electronic portfolio is largely open-ended as students are allowed to use any web platform they wish, and many opt for free website platforms such as Wix, Weebly, and Wordpress.

#### CBED Students:

Students participating in this course are diverse in age, major, and experience. In a typical class, approximately half to three-quarters of the students are engineers and the remaining students are from the College of Arts and Sciences or the Business School. A majority of the students are juniors and seniors, but enrollment spans from first-years to super-seniors. Students are placed on 2- to 5-member teams, which are vertically integrated and disciplinarily-mixed to ensure diversity of experience and perspective.

It is also worth noting a few student demographics about the undergraduate student at Santa Clara University. Overall, the student population at Santa Clara University is around 51% white, 18% hispanic, and 19% asian [21]. About 62% of undergraduates are from California. While 77% of students receive some kind of financial aid, the median family income of a student is \$193,100 [22]. This is significant, because a majority of our students will not have had first-hand experience with a community such as the BUG hub school sites. Thus, students must work to empathize with the school community, as well as the community surrounding the school gardens, to ensure that their project designs will effectively meet community needs.

Students take CBED for a variety of reasons. Some students are simply hoping to fulfill their Civic Engagement core requirement, but many students are looking for actual projects to build and impact a local community. A few self-identified student goals for enrolling in the course include “improve my engineering skills and use my creativity in a way to benefit society,” “create a working, functioning product or prototype for a community that has an actual positive

impact on the residents and their daily life,” and “gain some engineering experience, learn about the engineering design process, and work as a team.”

### III. Collaboration and Project Results

Through the ongoing collaboration between CBED, BUG, and the San Jose Unified School District schools, several student projects have added educational dimensions to the school gardens and created a positive visual impact on the spaces. In a two-year period, over the course of three 10-week quarters, student teams were able to ideate, design, and build three different projects for the Washington and Gardner elementary schools including a Mobile Cold Frame (Figure 2), a Weather Station (Figure 3), and a Root Viewer and Scale (Figure 4).



Figure 2: Mobile Cold Frame installed at Washington Elementary (Spring 2016)



Figure 3: Weather Station installed at Gardner Academy (Fall 2017)





Figure 4: Root Viewer and Scale installed at Gardner Academy (Fall 2015)

The success of each project is determined by its incorporation into garden-based learning programs. The BUG Coordinator reports that the CBE students *“have designed and built key educational features at Washington Elementary and Gardner Academy.”* The elementary school’s Garden Lab and Garden Clubs are enrichment programs that directly benefited from the collaboration. For example, the CBED weather station was incorporated into the earth science curriculum of 4th and 5th grade classrooms. The elementary students use the station as a launching point into a series of weather investigations, as they learned about how to measure and track the weather in their school garden. Additionally, in 2018, the elementary schools reported 48 Garden Lab lessons with an average of 28 community members for a total of 1,344 hours of community engagement and 42 Garden Club meetings with an average of 22 community members for 1,386 hours of community engagement. While the CBED student projects cannot take credit for all of this community engagement, the installed projects helped to increase these numbers and add additional dimensions to the programming. One quote from a teacher illustrates the value added by the installed projects, *“CBED builds provided an educational dimension to the school garden space that will continue to be used as a primary coordinator of all garden-based learning at the schools. Project features serve to enhance our lessons and activities in the gardens indefinitely, and they are deeply valued as they enrich the community's experiences and bring beauty to the garden.”*

While each CBED project helps to build out the existing space to support multiple learning purposes in each school garden, the builds should be seen as byproducts of community engagement. This is illustrated by the fact that while the schools lie only one mile apart, these BUG school garden sites differ drastically in scale and layout. The student work generated in CBED thus responded to the uniqueness of each site, creatively finding ways to further define each school garden as learning space and serving to evolve the overall feel of the garden. Each student team had to factor in environmental constraints, both physical and contextual in nature. The threat of theft and vandalism was a significant concern at Gardner Academy, making it necessary for installations to be permanent as well as developmentally appropriate. Physical space in the Washington school garden is limited, due to its location in the central courtyard of the school. This required the students to create a mobile design that could be tucked away when garden programs were not in session.



CBED students and community stakeholders, including BUG, have mutually benefited from the relationship formed through PBL engagement. The CBED student benefit, from the perspective of BUG, is the opportunity to engage in the school garden, explore a range of content their projects might support, and witness the joy and resilience of the community through interaction.

*“I have observed the tremendous benefits that have resulted from the residents’ involvement in Garden Club. Many of the kids develop a strong interest in the natural world and . . . pride in their stewardship of a community garden. They have become much more interested in healthy foods. My own child, who is usually reluctant to eat anything that isn’t covered in frosting, has actually tried and enjoyed many healthy foods. The kids have greatly increased their knowledge and interest in growing healthy foods.” (Nicole Trujillo, Mother living at HomeSafe)*

The relationship with community members is shaped by how well CBED students actively listen, ask probing questions and show a willingness to engage. One excerpt from a recent CBED student states:

*“Getting the chance to actually go into the school and interact with the students was a very helpful experience, I loved seeing how curious they were with the environment and how hands on they liked to be. This suggested to us that our design should be something very tangible, where the students could feel the instruments and wouldn't have to worry about breaking it. Similarly, seeing how distracted they were when it came to following instructions inspired me to use bright and bold colors that would draw their attention. Getting to know the students also completely changed our perspective on sizing of the weather station, as they turned out to be significantly smaller than we had imagined them to be. Finally, a lot of our design was influenced by you, both by your enthusiasm for the garden, and by your suggestions on what would best suit the academic curriculum of the students.” (Marina Predovic, CBED Student)*

Marina explains how a meaningful connection offers undergraduates the space to practice and apply what they are learning in the classroom back on campus; moreover, how partnerships can support the creation of engaging educational spaces that offer inclusive learning opportunities for all participants.

From the course instructor’s perspective, it is always rewarding to see how students progress through the quarter, build their team dynamics, manage projects, develop communication skills, and ultimately design a team project that has a direct impact on a local community. This project-based course allows students to learn more effectively as they directly experience community partner interactions, visit school communities, and build a physical project. The experience of taking a project from initial ideation all the way through project installment is extremely rewarding for the students, and they often find the engineering, or technical aspects, to be the least challenging. Another huge aspect to the experience offered to students is in having community partners who allow creative freedom for the student teams. When a partner can allow a design to grow organically as student ideas mature, students feel much more engaged in the

design process and invested in the final design. Additionally, the rewards from community impact are more personally felt. A student said it best:

*“The BUG Coordinator was a huge assistance for us towards our project mainly because she set very few requirements and allowed us to be creative. She trusted our adjustment and allowed us to be innovative in our approach.” (Catherine van Blommestein, CBED student)*

Directly from the CBED student perspective, students have been very proud of their project accomplishments and their community impact. Some quotes from a self-reflection assignment for each project that revolve around connection with their partner and target community are provided below in Table 1. In addition to these student quotes which highlight the projects’ community impact, the students also reflected on other course learning objectives attained. Objectives specifically mentioned included the importance of teamwork, especially for multiple perspectives gained, the value of communication, both between team members and between the partner and team, as well as their improved ability to manage their project both in understanding and communicating user needs and organizing their time management. One student quote affirms this point:

*“I never thought that a small 2 unit class... would turn into a project to improve the quality of life for people.” (Francesco Petrini, CBED student)*

Table 1: Student reflection on community project development

Project	CBED Student Reflective Quotes
Mobile Cold Frame	<ul style="list-style-type: none"> <li>● <i>“The BUG program helps educate kids about gardening and helps them get off their phones and disconnect from technology for a little while, providing more balance in their life. It also provides them with a safe haven from their troubled neighborhoods and a way for parents of the kids to connect, as many of them are volunteers in the garden.” (Ben Brown)</i></li> <li>● <i>“Personally, it was great to know that I was making a difference in the lives of elementary kids, as well as creating a means of education for them and the process has been a really rewarding experience.” (Ben Brown)</i></li> <li>● <i>“My group and I are providing far more than gardening equipment to our community partner—we’re providing a tool for community engagement” (Francesco Petrini)</i></li> </ul>
Weather Station	<ul style="list-style-type: none"> <li>● <i>“[This course] made [our team] appreciate being able to create something that our community would really appreciate.” (Marina Predovic)</i></li> <li>● <i>“I realized how important understanding your environment, your partner, and your customer are in making a project that would be able to stick around for awhile.” (Christi McKnight)</i></li> <li>● <i>“My project gave me a sense of purpose, a target that I could map out and construct, that I knew would positively impact the students.”</i></li> </ul>

	<p><i>(Marina Predovic)</i></p> <ul style="list-style-type: none"> <li>● <i>“The BUG organization works with Santa Clara University to help out many schools around the area create a garden setting for students to learn in. It is through this organization that we were able to help out the Gardner Academy and the kids to attend. I believe that it is through this organization that we are going to be able to impact these kids in a positive way.” (Christi McKnight)</i></li> </ul>
<p>Root Viewer and Scale</p>	<ul style="list-style-type: none"> <li>● <i>“Both we here at Santa Clara University and all of the people we worked with on the community partner’s end have the final goal of providing the children of Gardner Academy education and opportunities that will allow them to grow into productive members of society.” (Paula Back)</i></li> <li>● <i>“The community consists primarily of low-income families in the San Jose area, and we hope to improve their civic lives by improving the BUG garden and civic values it promotes. ... I hope they enjoy the new scale and root viewer in their garden. I hope this project will inspire children to be more interested in STEM areas and environmental awareness.” (Gregory Fay)</i></li> <li>● <i>“The soil board and scale will give the kids better knowledge of how nature works first hand and develop an appreciation for the environment.” (Astha Singh)</i></li> </ul>

**IV. Collaboration and Partnership Challenges (and Opportunities)**

While the collaborations between community partners and CBED have largely been successful and rewarding, there also exist many challenges to these collaborations. The first challenge, from the BUG perspective, lies in time constraints imposed by a quarterly academic calendar. As the CBED faculty member works to secure projects, keep students on schedule, and meet course objectives, it is challenging to maintain communications with the community partner/liaison. The schedule of highly collaborative projects can leave little time for the course instructor and community partner to reflect on questions that emerge from the collaboration. For example, while all CBED projects have supported multiple learning purposes in each school garden, it is worth exploring the potential for deeper student engagement in the community. The garden builds benefit garden-based learning programs, and by extension its community partnerships; however, from the perspective of BUG, there remains an opportunity for CBED students to have greater interactions with the community members their work supports. It would be interest to explore how that interaction might be facilitated as well as observe how the design process would be impacted by increased engagement.

Furthermore, after several student projects, more questions have begun to form about this community partnership. Questions which include how projects are budgeted and funded, what support expectations are required of the community partner or liaisons, and are there guiding questions/prompts to ask the student teams during community partner meetings to increase

engagement? We have also reconsidered how to best define the community partner. Upon reflection, the question of how a community partner being defined exclusively as ‘a client with a problem or need’ might be problematic. As a client with a problem to solve, the students may not view them as community members with their own expertise. In one project completed for Washington elementary, the course instructor struggled to keep the student team communicating with the BUG Coordinator. The student team often would make design decisions for the project the way they thought best, overlooking the expertise of the BUG Coordinator. Therefore, it may be worth considering how defining the community partners’ role could enhance the productivity of both the university and community stakeholders to collaborate more effectively.

A final challenge is on how to quantify success metrics for these projects. BUG focuses mainly on hours of engagement (# of students x length of program). This is difficult to quantify for these projects as they are simply incorporated into curricula and programming which already exists. In future collaborations, we will work to conceptualize more meaningful measurements beforehand and the BUG Coordinator has volunteered to be of assistance in collecting that data.

The course instructor in CBED has their own set of challenges including juggling 4-5 project teams each academic quarter, where each team has a different project and often also has a different community partner. Finding community partners with community needs that can be explored by a physical design project in just 10 weeks by a student team often requires extreme organization and communication. Additionally, project-based courses require a lot of time and resources that typical lecture-based courses might not. For example, at every class meeting each team gives an informal project status to the professor. At these meetings, the professor helps guide design, gives feedback, and provides resources for project materials for projects to progress. Furthermore, project management and other “soft skills” (also often known as “interpersonal” or “people skills”, “EQ” (Emotional Intelligence), or “communication skills”) are taught as part of the course. Frequently students have no experience in these areas and thus their introduction takes time to implement meaningfully as part of student projects. Furthermore, each community partner is unique and has differing ideas on how to approach project design, student teams, communication, etc. While BUG has been a great community partner liaison, allowing student ideas to evolve within project constraints, other partners have had much more specific ideas about what they want built and student teams have had frustrating experiences trying to manage partner expectations with their own team desires. Through all these challenges, the BUG partnership has been very successful, yielding highly impactful student learning experiences and successful projects implemented and valued at their target school communities.

Student challenges often revolve around time management and project communications. For example, students often struggle to find common time outside of class to meet as a team or interact with their community partner. A common frustration from the partner perspective is that students don’t provide regular updates, leaving them in the dark regarding design decisions. Students can then feel disheartened by project results when their design doesn’t meet some community needs or expectations and the customer isn’t fully satisfied with the end result. Managing these interactions is partially the job of the professor, but also is a great learning experience for the students. Additionally, students also struggle with communicating design specifications and progress throughout a 10 week quarter. While design communication is

extremely important, students often find it difficult to put into words their design work and progress. The communication format for their design work is an electronic portfolio. Students must weekly update an individual project log of their personal activities toward the project, and also update a team project section detailing any meetings or activities held outside of class. One student remarked:

*“I know the [electronic] design notebooks are important, but they can be such a chore!” (David Kim, CBED)*

A final student challenge to note is the ability to manage a project. Because students have very little experience in bringing a project idea through to build and installation, student projects often come up against unexpected time delays and challenges. These delays are commonly due to material availability, weather, unexpected installation requirements (e.g. when design doesn't meet reality). Overall, this project-based learning experience profoundly impacts student learning, as witnessed by a final student quote:

*“I wish everyone had to take this class prior to taking Senior Design [Capstone Experience]. This class is so helpful in learning how to manage a project! I learned more from this experience than I did from my other [engineering] courses about design.” (Bernardo Quevedo, CBED)*

## **V. Conclusion**

The ongoing collaboration between CBED, BUG, and the San Jose Unified School District has been successful from each perspective, delivering student projects which have added educational dimensions to the school gardens and created a positive visual impact to the spaces. Both students and community stakeholders are mutually benefiting from the relationship formed through engagement, clearly indicating how partnerships can support the creation of projects which offer inclusive learning opportunities for all participants. Students are also gaining important engineering skills and mindsets through real-world project development and design solution creation. Overall, while challenges exist, the class will continue to evolve and hopefully the partnerships will continue to be meaningful to all involved.

## **VI. References**

- [1] National Academy of Engineering (NAE). *The engineer of 2020: Visions of engineering in the new century*. Washington, D.C: The National Academies Press, 2004.
- [2] A. Shekar, "Project-based Learning in Engineering Design Education: Sharing Best Practices", <https://peer.asee.org/22949>, 2014. [Online]. Available: <https://peer.asee.org/project-based-learning-in-engineering-design-education-sharing-best-practices>. [Accessed: 01- Feb- 2019].
- [3] S. Haag, N. Hubele, A. Garcia, and K. McBeath, “Engineering undergraduate attrition and contributing factors,” *Social and Personality Psychology Compass*, 01-Jan-1970. [Online]. Available: <https://asu.pure.elsevier.com/en/publications/engineering-undergraduate-attrition-and-contributing-factors>. [Accessed: 01-Feb-2019].

- [4] P. Howard and P. Wolfs, *Balancing project based and lecture centric education in a restructured engineering degree*. Rockhampton: Central Queensland University, 1997.
- [5] National Academy of Engineering (NAE). *Educating the engineer of 2020: Adapting engineering education to the new century*. Washington, DC: The National Academies Press, 2005.
- [6] J.E. Mills and D. F. Treagust, "Engineering education - Is problem-based or project-based learning the answer?," *Australasian Journal of Engineering Education*, vol. 3, pp. 2-16, Jan. 2003.
- [7] S. Palmquist, "Active Project Based Learning In Structural Analysis: Field Inspection Of A Steel Truss Bridge," *ASEE PEER Document Repository*, 10-Mar-2015. [Online]. Available: <https://peer.asee.org/2036>. [Accessed: 01-Feb-2019].
- [8] D. Q. Nguyen, "The essential skills and attributes of an engineer: A comparative study of academics, industry personnel and engineering students." *Global Journal of Engineering Education*, vol. 2, no. 1, pp. 65–74, 1998.
- [9] C. E. Vergara, M. Urban-Lurain, C. Dresen, T. Coxen, T. MacFarlane, K. Frazier, and T. F. Wolff, "Aligning computing education with engineering workforce computational needs: New curricular directions to improve computational thinking in engineering graduates," in *Frontiers in Education*, San Antonio, TX, 2009.
- [10] G. Wilson, "Integrating Problem-based Learning and Technology in Education." In *Enhancing Thinking through Problem-based Learning Approaches*, edited by O.S. Tan. Singapore: Thompson, 2004.
- [11] J. B. Biggs, and C. S. Tang, *Teaching for Quality Learning at University: What the Student Does*. 3rd ed. Maidenhead: Open University Press, 2007.
- [12] R. Fogarty, *Problem Based Learning, a collection of articles*, Hawker Brownlow Australia, 1998.
- [13] H. S. Barrows and R. M. Tamblyn, *Problem-Based Learning: An Approach to Medical Education*, vol. 1, New York: Springer Publishing Company, 1980.
- [14] C. E. Hmelo-Silver, "Problem-based learning: What and how do students learn?" *Educational Psychology Review*, vol. 16, no. 3, pp. 235-266, 2004.
- [15] M. Savin-Baden, *Problem-based learning in higher education: Untold stories*. Philadelphia, PA: SRHE and Open University Press, 2000.



- [16] L. Springer, M. E. Stanne, and S. S. Donovan, "Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis." *Review of Educational Research*, vol. 69, no. 1, pp. 21-51, 1999.
- [17] A. Yadav, D. Subedi, M. Lundeberg, and C. Bunting, "Problem-based Learning: Influence on Students' Learning in an Electrical Engineering Course." *Journal of Engineering Education*, vol. 100, pp. 253–280, 2011.
- [18] "EdData - District Profile - San Jose Unified", Ed-data.org. [Online]. Available: <http://www.ed-data.org/district/Santa-Clara/San-Jose-Unified>. [Accessed: 10- Dec- 2017].
- [19] B. Baldwin, "Giving What You Have: Community Development in the Washington Neighborhood, San Jose, California", Practical Visions, 2015. [Online]. Available: <http://sites.tufts.edu/uepblog/2015/11/27/giving-what-you-have-community-development-in-the-washington-neighborhood-san-jose-california/>. [Accessed: 12-Dec-2017].
- [20] "Explorations - Santa Clara University", scu.edu, 2018. [Online]. Available: <https://www.scu.edu/provost/core/explorations/#civic-engagement>. [Accessed: 01-Feb-2019].
- [21] "Class Profile - Admission - Santa Clara University", scu.edu, 2018. [Online]. Available: <https://www.scu.edu/admission/undergraduate/choosing-scu/class-profile/>. [Accessed: 17-March-2017].
- [22] "Economic diversity and student outcomes at Santa Clara", Nytimes.com. [Online]. Available: <https://www.nytimes.com/interactive/projects/college-mobility/santa-clara-university>. [Accessed: 15- Dec- 2017].