Paper ID #20608

Boosting engineering identity of rising sophomore engineering majors through service learning based bridge program

Dr. Deborah Won, California State University, Los Angeles

Deborah Won is an Associate Professor in Electrical and Computer Engineering at California State University, Los Angeles. Her specialization is in Biomedical Engineering and her scientific research area focuses on neuro-rehabilitative technology. Her educational research interests include use of Tablet PCs and technology to better engage students in the classroom as well as pedagogical and advisement approaches to closing the achievement gap for historically under-represented minority groups.

Dr. Gustavo B Menezes, California State University, Los Angeles

Menezes is an Associate Professor in Civil Engineering Department at CalStateLA and president of the International Society for Environmental Geotechnology (ISEG). Since becoming part of the faculty in 2009, Menezes has taught 9 undergraduate courses, is the current adviser of the American Society of Civil Engineers student organizations and has participated in several teaching workshops, including one on ”Excellence in Civil Engineering Education” and another in ”Enhancing Student Success through a Model Introduction to Engineering Course.” He is currently the PI of TUES project to revamp the sophomore-year experience at the college of engineering (esucceed.calstatela.edu). He has developed an open access, web-based audience response system (educatools.com) and is currently the ABET coordinator for his department. Currently, Dr. Menezes is the Director of First Year Experience (FYrE) at ECST - Cal State LA.

Prof. Adel A. Sharif, California State University, Los Angeles

After finishing his BS in Mechanical Engineering at California State University, Los Angeles, Adel A. Sharif continued with graduate studies in Materials Science and Engineering at University of California, Irvine. He earned his MS and Ph.D. in Materials Science and Engineering in 1995 and 1998, respectively. Upon graduation, he accepted a postdoctoral position at Los Alamos National Lab, where he worked on development of ultra-high temperature structural material among other things. In 2000, he accepted a tenure track faculty position at University of Michigan, Flint and stayed there for two year. Finally, he joined the Department of Mechanical Engineering at California State University, Los Angeles in 2002 where he is currently a full professor. Dr. Sharif's expertise in materials science is in deformation mechanisms, specifically at high temperatures.

Dr. Gisele Ragusa, University of Southern California

Gisele Ragusa is a Professor of Engineering Education at the University of Southern California. She conducts research on college transitions and retention of underrepresented students in engineering and also research about engineering global preparedness and engineering innovation. She also has research expertise in STEM K-12 and in STEM assessment. She chairs USC's STEM Consortium.

Dr. Arturo Pacheco-Vega, California State University, Los Angeles

Arturo Pacheco-Vega did his undergraduate studies in mechanical and electrical engineering at the Universidad Iberoamericana in Leon, Mexico. His graduate work was at Universidad de Guanajuato in Mexico, and at University of Notre Dame, as a Fulbright scholar, where he obtained his Ph.D. in 2002. From 2003 to 2008 he was a faculty member in the Department of Chemical Engineering at the Universidad Autonoma de San Luis Potosi in Mexico. In 2008 Dr. Pacheco-Vega joined the Department of Mechanical Engineering at California State University, Los Angeles, where he is currently a full professor. His research interests are related to the thermal and fluid sciences, and include thermal/energy systems, thermal control, system optimization, soft computing techniques, heat transfer enhancement, nonlinear dynamical systems, micro-scale thermal/fluid devices, and biological systems.

Boosting engineering identity of rising sophomore engineering majors through service learning based bridge program

1. Abstract

The BOOST program (Bridge Opportunities Offered for the Sophomore Transition) was developed to strengthen Engineering major students' professional identity and boost their motivation and perseverance to persist through the challenge and rigor of the Engineering program. Teams of rising sophomores, along with junior- or senior-level peer mentors, spent six weeks of their summer innovating, creating, and working collaboratively on Engineering projects which served their local community. BOOST partnered with three highly impactful urban service-focused community organizations - two non-profit organizations and a public elementary school. Despite most BOOST students being first-generation college students, and no BOOST student having had any previous engineering design experience prior to participation in the program, the students completed three substantial design projects which were all very well received by the community partners. Assessment results indicate that students greatly benefited from participating in design projects, providing service to their community, working in teams, peer mentorship, and interaction with faculty advisors. Most noticeably, BOOST students' engineering innovation and creativity scale increased by 50% ($p<.01$) according to pre-post-BOOST comparisons on Ragusa's ECPII validated scale. In addition, BOOST students appeared to be more STEM-focused after BOOST than their matched control counterparts. Furthermore, the BOOST experience appeared to provide some immunity to the typical "sophomore slump", as the BOOST group's GPAs dropped from pre-BOOST (first couple terms of freshmen year) to post-BOOST (last term of freshman year through their first term of sophomore year) by 49% less than their matched control group's average GPA. Taken together, the quantitative results and the qualitative feedback provided by the community partners indicate that the BOOST experience helped BOOST students to identify better as engineers and to attain the intrinsic motivation and innovativeness that breeds successful engineers.

2. Rationale for BOOST – Bridge Opportunities Offered for the Sophomore Transition.

Most universities recognize that the transition from high school to college requires extra support and therefore offer college summer bridge programs. However, the transition from the freshman to sophomore year is a critical formational period and yet often neglected in student success initiatives [1-3]. Their sophomore year is a defining moment in their college career, and also a time that is filled with uncertainty and a sense of loss of support they had in their freshmen year [2, 4-6]. The faculty who developed the BOOST program recognized a need for students to gain more practical exposure to engineering, to experience the engineering design process, and to strengthen their motivation and resolve to persevere through the challenges that tend to hit them particularly hard when they reach their first engineering courses, typically in their sophomore year. We hypothesized that service learning projects during the students' freshman-to-sophomore transition would address these needs and thus build engineering identity and improve their academic performance in their sophomore year, especially for students who start with low academic integration, which is typical of Cal State LA students matriculating in engineering majors as freshmen. First generation college students make up 59% of our Engineering student population, and Hispanic students make up 61%. Studies have shown that the lack of academic integration of first-generation students is correlated with their lower persistence rates than those of non-first generation college students [7] and that academic integration, particularly through faculty interaction, is often lacking but can have a significant positive impact on persistence [7, 8].

Service learning would provide our students with an engineering opportunity applied to not only a practical project but one with the added motivation of actually seeing the benefit their work can bring to their community. Studies in non-STEM fields have shown that the focus on giving through service learning leads to academic success by addressing the sense of aimlessness and student disengagement that negatively impacts their education [9-11]. Ironically, until recently a vast majority of the service learning literature was in non-Engineering fields, such as sociology. The literature shows some very impactful service learning programs in Engineering, such as Prof. William Oakes' EPIC program at Purdue University, but which do not specifically target the fresman-to-sophomore transition [12, 13]. We therefore created a program that begins in the last term of their freshman year and allows them to work on service learning projects for a local community organization in the summer. The design projects, with its inevitable need to revisit design choices, teaches students to learn from mistakes through the iterative process of design, build, and test and to build grit. It also builds their engineering identity and see themselves more as real-world problem solvers. The service learning aspect enables students to see the impact of their engineering abilities on their local community and motivates them to persevere through the challenges and rigor of engineering degree programs. The teamwork, peer mentorship, and faculty interaction required to carry out these service learning projects all contribute to building social capital which in turn enhances students' ability to thrive, especially for first-generation college students. Participation in service learning projects was expected to increase academic integration by building the students' identity as engineers, and to break down any amotivational perspective of college by helping students to see the impact their work could have on their community and how they could contribute to their team's success and morale.

3. <u>Structure and implementation of BOOST</u>

With administrative support from the University's Educational Participation in Communities Center, partnerships were forged with three local community organizations. BOOST faculty met with leaders (e.g., President, Director of Community Relations, and Assistant Principal) of each of the community partner organizations to identify projects which would both serve their organizations' needs and provide students with an opportunity to practice engineering design.

In the Winter quarter of 2015, students were recruited from the freshmen class who matriculated in the College of Engineering, Computer Science, and Technology in Fall 2015; an orientation was provided just before the start of the Spring quarter. Eighteen students enrolled in a special section of a required Engineering Ethics course, and at the beginning of the course, took field trips to the partnering sites. These activities allowed students to connect with the community partner organizations, understand and delineate project objectives, and start forming project teams. The BOOST projects provided contexts in which to apply ethical principles, as well as professional practices, learned in class.

During the summer quarter, students met 5 days a week for at least 4 hours a day. A typical schedule for the earlier half of the BOOST summer session is outlined in Table 1. More time was devoted just purely to working on the projects during the latter half of the summer.

<table>
<tr><th>Time</th><th>Mon</th><th>Tue</th><th>Wed</th><th>Thu</th><th>Fri</th></tr>
<tr><td>12:30 - 14:00</td><td rowspan="2">Analysis/ Problem Solving ET C18</td><td rowspan="2">Engineering tools workshops ET C254</td><td>Comm. / Presentation Workshop ET C159</td><td rowspan="2">Engineering tools workshops ET C254</td><td rowspan="2">Analysis/ Problem Solving ET C18</td></tr>
<tr><td>14:00- 14:30</td><td rowspan="2">Projects ET C159</td></tr>
<tr><td>14:30 - 15:00</td><td rowspan="3">Projects ET C159</td><td rowspan="3">Projects ET C159</td><td rowspan="3">Projects ET C159</td><td rowspan="2">Projects ET C159</td></tr>
<tr><td>15:00 - 16:15</td><td rowspan="2">Outdoor / Recreation</td></tr>
<tr><td>16:15- 16:30</td><td>Reflections</td></tr>
</table>

Table 1) Typical weekly schedule during the BOOST summer session.

On the last day of the 6-week summer session, a banquet was held at which time the students gave oral presentations on their projects. This gave students the opportunity to present their work to, as well as celebrate the students' achievements together with, representatives of the partnering organizations, College and University administrators, and other members of the College who supported the program operation.

4. Carrying out the design process: Sample student work

The students gained valuable engineering experience by actually carrying out the complete engineering design process from start to finish. The projects, and the community organizations for whom we carried out these projects, are described briefly here:

1) Hillsides, a non-profit organization to provide residential care and/or special education to vulnerable youth, mostly in the foster care system – We built a portable, collapsible stage which could be used for the Hillsides youth rock band to perform outdoor concerts around their campus.
2) Kennedy Elementary School, in an socio-economically disadvantaged neighborhood a mile away from Cal State LA – We created two computer games to encourage their fifth graders to practice fractions and gain a deeper understanding of fractions.
3) El Arca, a non-profit organization – We built a retractable cover for their patio community garden.

To illustrate the design process the students experienced, we detail the Hillsides' groups progress through each design phase.

4.1. Project definition

Students visited each community partner site, learned about the community's needs, and defined their project objectives with guidance from the faculty advisors. The Hillsides team produced this statement of objectives:

"To build a stage that is portable and safe for the students to engage in events. We must design the stage in order to enhance the hillsides community's experiences. The stage will be able to allow the students to further their bonds with their community."

They also drafted their project specifications.

Specifications			
Characteristics / features	min	typ	max
Load	700	980	2000
failure stress	2000	n/a	2500
Latches	4 latches	4 latches	6 latches
Wood	90 sqr ft	100 sqr ft	135 sqr ft
rubber underlayment	90 sqr ft	100 sqr ft	135 sqr ft
wood/metal poles	16	16	20
nails	84	84	80

Table 2) first draft of design specifications for Hillsides project

4.2. Conceptual design

Students brainstormed ideas with input from the faculty advisors and performed a trade analysis of different design options. Pictured below is a sketch of the first design option the team brainstormed.

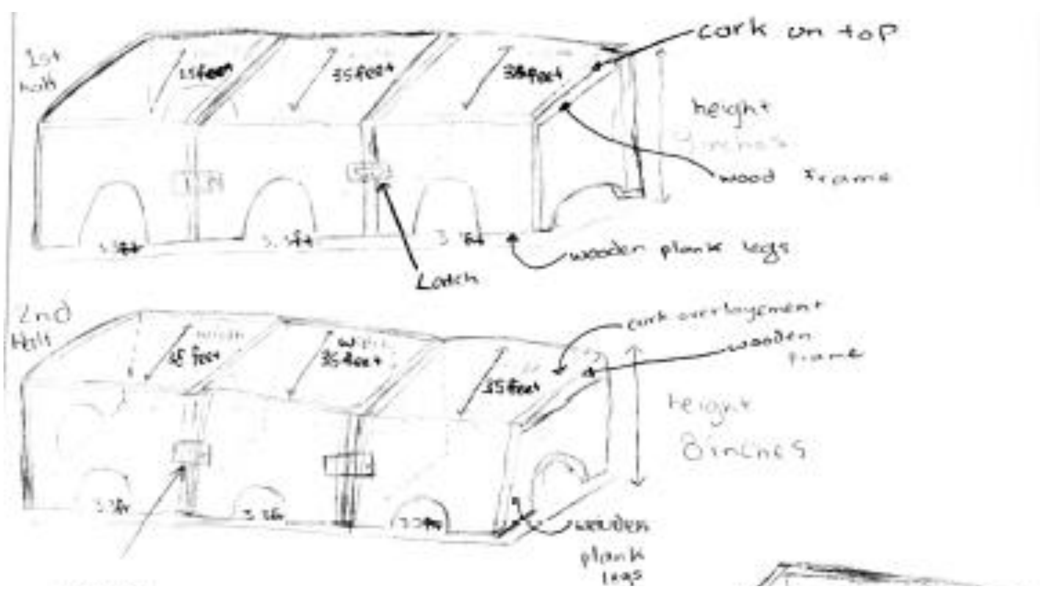


Figure 1) Preliminary sketches of one of their brainstormed designs

Preliminary design

Students analyzed each of the most promising designs, making calculations to determine whether the design met project specifications.

Plywood:

$\rho = 40.2 \text{ lb/ft}^3$

Douglas Fir:

$\rho = 32 \text{ lb/ft}^3$

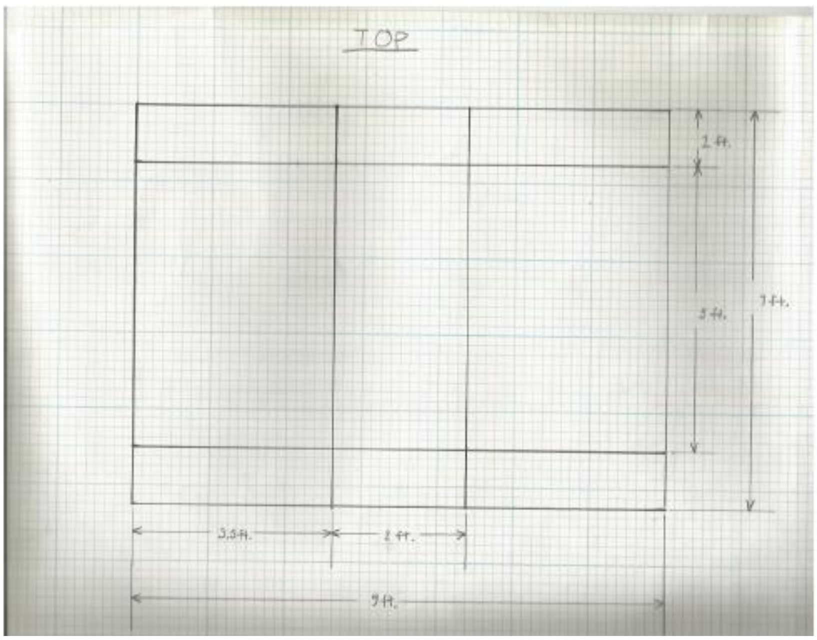


Figure 2) Dimensioning and weight calculations

4.3. Detailed design and implementation

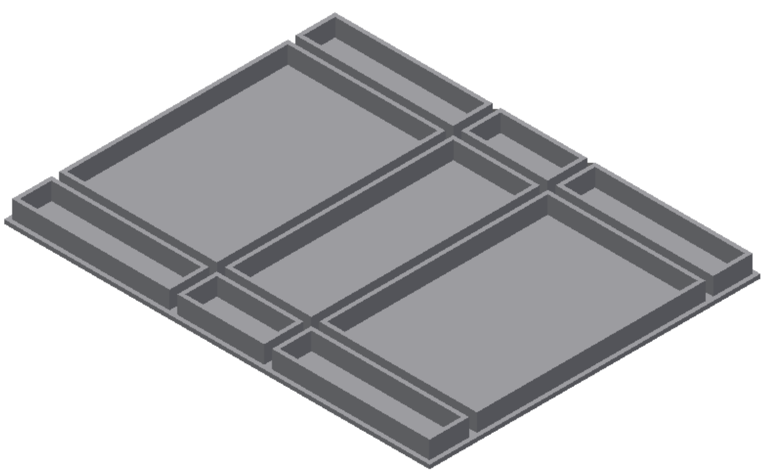
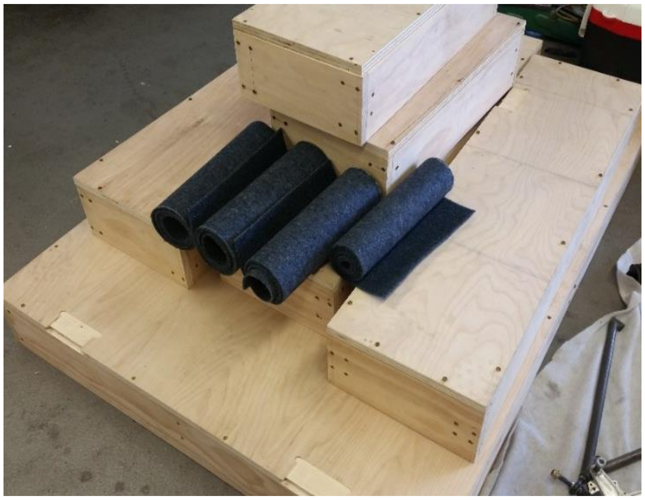


Figure 3) Bottom view of CAD drawing for the selected design.

After iterating through a couple first cuts at building sections of the stage, the students nailed down a streamlined process of building consistently precise sections of the stage. They also tested out different hinges and coupling mechanisms for connecting the sections as well as different types and placement of wheels to make the stage portable.



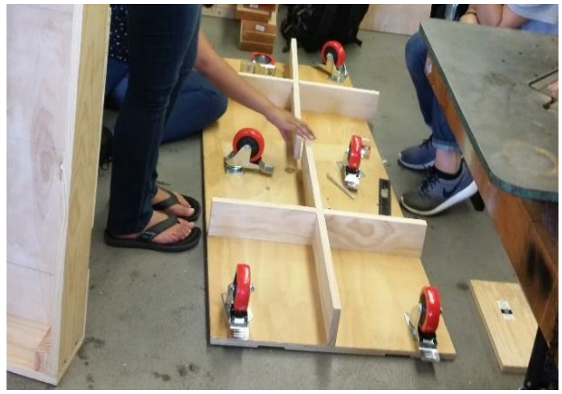


Figure 4) Students finalize design and construct the individual sections of the stage before the final assembly and

4.4. Project delivery

Students and faculty tested the various features of the stage (Fig. 5 and 6; collapsible, portable, and weigh-bearing capacity) and made final tweaks before delivering the stage to Hillsides.

Figure 5) BOOST faculty advisor tests the hinges on the stage.

5. <u>Assessment</u>

One student had to disenroll early in the program due to personal issues; therefore, assessment results are provide for the 17 students who actually participated beyond the first two weeks of the Spring quarter. A control group of 17 students who were in at least the same or higher math level as the BOOST students and were approximately frequency-matched for major (24% Civil Eng. majors in both groups, 29 and 35% Mechanical Engineering majors in BOOST vs. control,

Figure 6) Some of the student members of the Hillsides team completed some last modifications and demonstrate the ability to collapse the stage so that it could be easily stored.

respectively), first-generation status (53% for BOOST and 59% for control), and ethnicity (76% Hispanic for both BOOST and control groups). A summary of the descriptive data is provided in Table 3. The BOOST group had almost 30% more females than the control group, while the control group on average had greater math aptitude, according to SAT math (SATM) scores.

5.1. Effect on STEM course grades

	DESCRIPTIVE DATA					OUTCOMES		
	SATV score	**SATM score**	**His-panic**	**Female**	**First Gen. College**	**Sp'16-F'16 STEM GPA**	**□□STEM GPA (post – pre)**	**# post-boost STEM units**
BOOST	441	493	76%	47%	52.9%	2.93	-0.35	370
Control	446	539	76%	18%	58.8%	2.63	-0.69	178

Table 3) Comparison of BOOST students with a frequency-matched control group.

Grades in any Physics, Math, or engineering (EE, ME, CE) classes were obtained and averaged across the terms before the BOOST program began – i.e., for Fall '15 and Winter '16 (their 1st two terms of college) to yield what we call their "pre-BOOST STEM GPA". Similarly, we also averaged their grades for those STEM classes in the terms following the start of BOOST (i.e., for Spring through Fall '16). We also tallied up the total number of units in these STEM classes that all the students in each group took in the post-BOOST period. A couple interesting results emerge from these results: 1) BOOST students seemed to become much more STEM-centric, and took more than twice as many units on average than their non-BOOST counterparts. 2) There was a drop in GPA from their first couple terms in their freshmen year to their latter terms which begin to include engineering major degree courses. This drop is characteristic of the sophomore slump, and exists in both groups. However, despite the heavier STEM load and despite being at a lower math level and aptitude than the control group, the BOOST students' GPA did not drop as much as the control group; in fact, the control group's GPA on average dropped by nearly twice as much as the BOOST group's.

5.2. Engineering Creativity and Propensity for Innovation Index

A questionnaire measuring Ragusa's validated Engineering Creativity and Propensity for Innovation Index, Engineering Global Preparedness, and College Social Capital [14, 15] was administered to the BOOST students at the beginning of the Spring quarter just after the program orientation ("pre-BOOST") and at the conclusion of the BOOST program just after the final presentations ("post-BOOST"). None of the students had had engineering project experience prior to BOOST. Figure 6 illustrates the change in average score from pre- to post-BOOST experience. While the BOOST students started the program well below national average in engineering innovation and creativity as well as college social capital, the average score increased with statistical significance on all 3 scales, with the largest gain in engineering innovation and creativity.

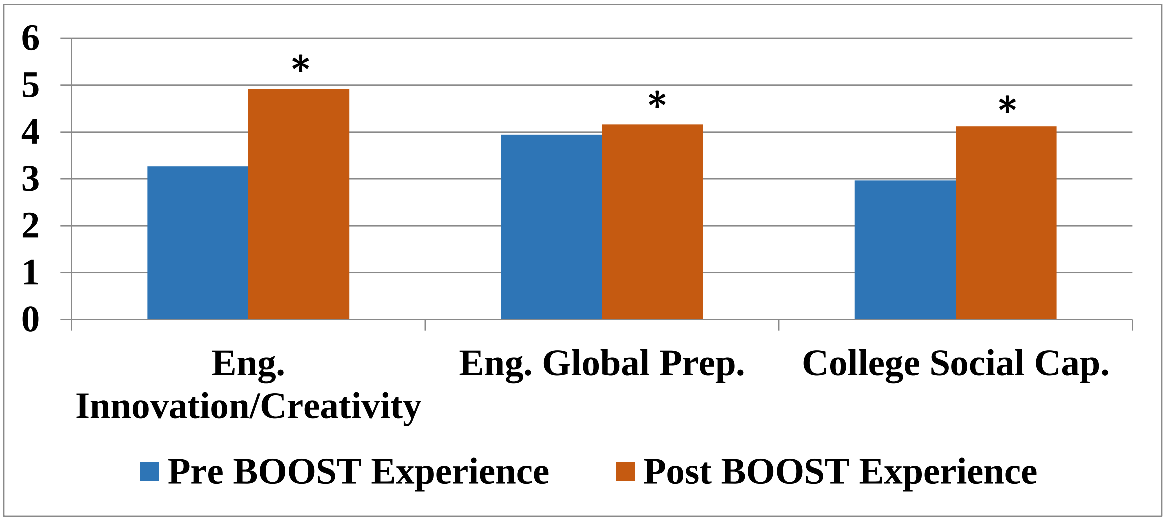


Figure 6) The average index for engineering innovation and creativity increased by 50%, engineering global preparedness by 6%, and college social capital by 39%. * significantly different from pre-score, $p<.01$

5.3. Impact on community

All three community partners expressed appreciation and enthusiasm for not only the value added by the projects the BOOST students delivered, but also for the interaction and engagement the BOOST students had with their community. The teachers at the elementary school expressed gratitude for the way the BOOST students served as a role model for their 5th graders. The Hillsides Education Center Specialist, and Director of the Hillsides Band expressed great enthusiasm when the stage was delivered, saying "*Thank you so much to you and your team for your hard work in building the stage. It is awesome!!*"

The President of El Arca stated addressed the BOOST students after their final presentations: "*Above and beyond what engineering experience you are gaining… the long-term value is what you're doing for the community... for folks w/ developmental disabilities. This has turned out to be a great, great project. It's giving them the ability to build up more self-esteem, and giving them a vocational skill…. This is something that you really can't place a value on…. [You] come in with so much energy. …You can tell you're on fire, [you] want to do this… The Cal State LA students were awesome*".

All three community partners expressed a desire to continue partnering with the BOOST program this year.

5.4. What the students valued about BOOST

A focus group interview was conducted during the 5th (or second to last) week of the summer session. The responses are summarized in Table 4.

Category	Freq.(%)	Examples
Team Experiences	14 (30.4)	Our mentors they are like telling us, you guys need to work in groups, and I understand cause me as an electrical engineer, I cannot do the stuff that civil or the mechanical would do. But l could, let's say a civil engineer would build a building. And me as an electrical engineer, I would be the one to wire the building." "So, it's a good thing to be able to go out of the box. Out of the box of electrical engineering in my team."
Engineering Design	9 (19.6)	"I think the design part was just right. Because, I mean the mentors explained to us when you're doing engineering, your first design isn't always going to be the right one. And that way we kind of got to see you know it's a process. You're going to have to make adjustments."
Application of Engineering Technical Skills	9 (19.6)	"It's good cause uh just like what she said we are able to uh experience the hands on engineering project. Cause you know um in other classes we just did like in inside the classroom. " "I haven't even taken physics yet, but we're.. I'm learning it through the hands on process, and you get to learn um… kind of how the information you're learning in class is going to be applied in to the real life situation." "I think as far as physics.. like taking physics. I feel like it will give you like a better understanding cause you see like in real time how forces kind of.. what you're kind of noticing."
Service Learning/Community Experience	7 (15.2)	"The project it's not just for us but, we were able to use what we learned to help other people." "Right, it's a cool place to work. You can see that you can really help people. "
Mentorship/ Faculty Guidance	5 (10.9)	"Just by telling us, like their stories and how they got over, and just always helping each other. Like if we were.. like in the physics… if we're like stuck on something. Like they'll take their time to actually explain every step by step. Making us feel like we're at home." "

Ethics	2 (4.3)	"Ethics came out in working at the sites. You have to be people first in designing things and listen to your customers."

Table 4) The students' responses during the focus group interviews indicated six of the most valued aspects of the program.

In addition, during the Q&A after final presentations, students provided some insight into the value they perceived in a program like BOOST. For example, one student, while reiterating the value of getting to actually experience the design process, pointed out that one key aspect of that experience is inevitably finding mistakes and iterating through multiple designs; i.e., learning from your mistakes.

"The best thing we learned is since we are doing the engineering major, really we came to realize the whole process of actually doing all the engineering and realizing how even though we mentioned the design process was the first week, really we came to realize that the design process takes all throughout and is about improving the first design. And if there is a flaw, making adjustments to fix it and come up with a solution."

One student divulged the fear she felt as a female student entering the program, but indicated a palpable increase in self-efficacy:

"As a girl, I have more confidence, even though in a male-dominated major… I know in the beginning I was really intimidated. There were only 2 girls here…. THIS helped me to get a lot of engineering experience. I'll be more prepared."

6. Conclusion

The BOOST students, a majority of whom are first generation college students and most of whom are from underrepresented minority groups, entered the program underprepared for their engineering major degree programs in terms of math level and below national average on a validated engineering innovation scale. Motivated by the societal impact they could see themselves making, BOOST students devoted half days for 6 weeks of the summer in addition to an hour a week during the spring quarter to engineering service projects and introductory workshops on computer aided design, computer programming, microcontrollers, as well as materials science and physics. Not only did students reap the benefits of exposure to engineering tools that they will likely need to use throughout their college education and on into their professional career, they also deepened their motivation and confidence to persevere through the inevitable challenges they will face on their road to earning a bachelor's degree in Engineering. The community partners were all very pleased with the BOOST students' work and touched by their desire to give back to their community. As the BOOST students learned to work in groups and how to solve real engineering problems, they also built their own resilience and increased their ability to innovate. The quantitative results support the conclusion that can be drawn from qualitative analysis; namely, that BOOST, with its engineering design service project focus, bolstered the students' identity as engineers, enabling them to weather the storm that comes with the freshmen-to-sophomore transition.

Acknowledgements

This work was supported by NSF Contract #DUE-1505087 and CSULA's Instructionally Related Activities funding. The authors would like to gratefully acknowledge the vital logistical and fiscal support of Hasmik Simon, Evelyn Li, Jonathan Marquez, Lin Tong, Alexis Barajas, and Ted Nye, as well as to recognize the work of Yusuke Kuroki and Dr. Michele Dunbar from Institutional Research to provide data for our analysis. We also thank Blake Cortis and Dan Roberto for their technical support and training in the workshop; Victoria Mosqueda, Erica Martinez, Anh Hong, and Taffany Lam for the roles they played in establishing partnerships with our community organizations.

References

1. Hunter, M.S., et al., *Helping sophomores succeed: Understanding and improving the second-year experience*. 2010, San Francisco: Jossey-Bass.
2. Gardner, E.D., *From drift to engagement: Finding purpose and making connections in the sophomore year*, in *Visible solutions for invisible students*, L.A. Schreiner and J. Pattengale, Editors. 2000.
3. Gahagan, J. and M.S. Hunter, *The second-year experience: Turning attention to the academy's middle children.* About Campus, 2006. **11**(3): p. 17-22.
4. Lipka, S., *After the freshman bubble pops.* Chronicle of Higher Education, 2006. **53**(3): p. 42.
5. Boivin, M.J., G. Fountain, and B. Baylis, *Sophomore slump or sophomore shipwreck? A crisis of meaning and purpose for students in American higher education.* , in *Visible Solutions for Invisible Students: Helping Sophomores Succeed.*, J. Pattengale and L.A. Schreiner, Editors. 2000, National Resource Center for the First-Year Experience and Students in Transition, University of South Carolina Press: Columbia, SC.
6. Seaver, S., *The Sophomore Slump: A careers course to address the needs of second-year students*: candi.wikispaces.umb.
7. Próspero, M. and S. Vora-Gupta, *First-generation college students: motivation, integration, and academic achievement.* Community College Journal of Research and Practice, 2007. **31**(12).
8. Choy, S., *Students whose parents did not go to college: Postsecondary access, persistence, and attainment (NCES 2001-126).* , 2001, U.S. Department of Education, National Center for Education Statistics: Washington, DC.
9. Howells, K.G., *Teaching Gratitude in Education.* SensePublishers, 2012: p. 125-141.
10. Gray, M.J., Ondaatje, E. H., Fricker, R., Geschwind, S., Goldman, C. A., Kaganoff, T., Robyn, A., and M. Sundt, Vogelgesang, L., & Klein, S. P, *Coupling Service and Learning in Higher Education: The Final Report of the Evaluation of the Learn and Serve America, Higher Education Program.* . 1998: The RAND Corporation.
11. Astin, A.W. and L.J. Sax, *How Undergraduates are Affected by Service Participation.* Journal of College Student Development, 1998. **39**(3): p. 251-263.
12. Oakes, W. *Service-Learning Partnerships: Improving Education and Addressing Community Needs*. in *American Society for Engineering Education Annual Conference*. 2011. Vancouver, B.C.
13. Tsang, E., *Projects That Matter: Concepts and Models for Service-Learning in Engineering. AAHE's Series onService-Learning in the Disciplines*. 2000, Washington, D.C.: American Association for Higher Education.
14. Ragusa, G. *Engineering creativity and propensity for innovative thinking in undergraduate and graduate students*. in *American Society for Engineering Education*. 2011. American Society for Engineering Education.
15. Menold, M.J., et al., *A critical review of measures of innovativeness.* age, 2014. **24**: p. 1.