Recruitment and Retention Efforts toBroadenParticipation in FourComputing andEngineering Programs

Dr. Alvaro Monge, California State University, Long Beach

Dr. Alvaro Monge has earned BS (UC Riverside, 1991), MS, and PhD (UC San Diego, 1993 and 1997) degrees in computer science. In 1997, he joined the Computer Science Department at the University of Dayton Ohio. In 1999, he joined the Computer Engineering and Computer Science Department at the California State University Long Beach (CSULB) where he is now a tenured full professor. CSULB is a teaching-intensive institution and thus, he has taught classes at different levels from introduction to programming and data structures; to junior level classes in database design; senior level classes on database, web development, and senior projects; and finally to graduate classes in database systems. In 2014, Dr. Monge joined a team at Google that created NCWIT's EngageCSEdu, an online living collection of peer-reviewed teaching instruments that use research-based techniques that retain and engage students, particularly effective in broadening participation in computing. Dr. Monge's research interests have evolved over time. Through his participation in an NSF sponsored project, he ventured into computer science education research. Recently, his primary focus has been on efforts to broaden participation in computer science by increasing recruitment and retention of students from underrepresented groups including women, Hispanic/Latino, etc. In addition his current research includes creating assistive technology to make content from web pages accessible to people with low vision.

Prof. Panadda Marayong, California State University, Long Beach

Dr. Panadda Marayong is the director of the Robotics and Interactive Systems Engineering (RISE) Laboratory and a Student Training Core Co-Director of the California State University Long Beach BUilding Infrastructure Leading to Diversity (CSULB BUILD) Program. Her primary research interests are in the areas of human-robot cooperative systems for application in rehabilitation, aviation safety, and manufacturing. Additionally, she co-directs numerous engineering outreach programs for underrepresented K-12 students. She has been the faculty advisor of the CSULB Society of Women Engineers chapter since 2008.

Dr. Shadnaz Asgari, California State University, Long Beach
Birgit Penzenstadler
Dr. Praveen Shankar, California State University, Long Beach

Recruitment and Retention Efforts to Broaden Participation
in Four Computing and Engineering Programs

Abstract— California State University Long Beach (CSULB) has low enrollments by women in computing and engineering majors. This paper presents strategies implemented to improve recruitment and retention of women in these majors to break this long-standing pattern. The recruitment strategies include outreach to admitted students while they're still in the decision process, improving language used on websites and publications, and roadshows to community colleges and high schools. The retention strategies include creating classroom modules that promote career exploration and strengthen problem solving skills, and holding professional workshops for faculty and staff to understand factors that influence success in engineering/computing majors by students from underrepresented groups.

I. Introduction

In Fall 2014, women represented only 11.3% of computer science and computer engineering, and 12.2% of aerospace and mechanical engineering students enrolled in these programs at California State University Long Beach (CSULB). Figures 1 and 2 show the applications and enrollments by first-time freshman (FTF) in the computer engineering and computer science programs from Fall 2003 thru Fall 2014. As can be seen from these figures, the one consistent trend is the low representation by women in applications and in enrollments, signaling a need for increased recruitment.

As is the case with nearly all of the computing programs in the US, demand for and enrollment in these majors continues to grow[1, 2]. However, it is also clear from the data that the growth at CSULB has not seen an equivalent increase in enrollment of women and students from underrepresented groups. The enrollment in computing majors by first-year students has more than doubled since 2003, yet the proportion of female students has actually decreased by more than half from 25% to 10%. There is a small increase in enrollment by women from Fall 2013 to Fall 2014 which may be a sign of improvement but it's too early to make this conclusion without more recent enrollment data.
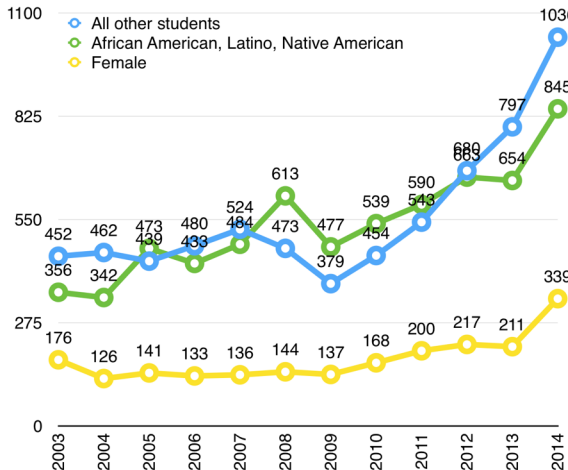

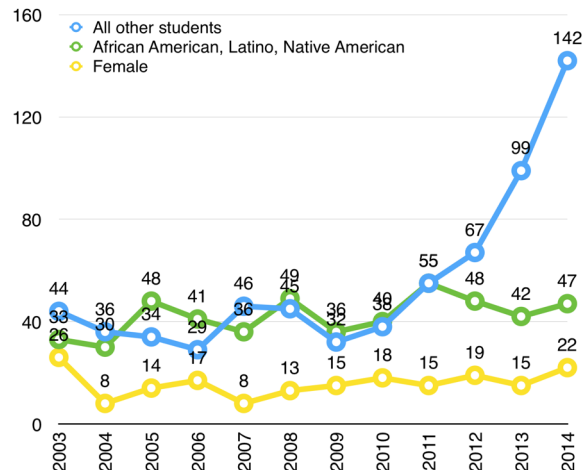Figure 1. Applications by FTF in CECS

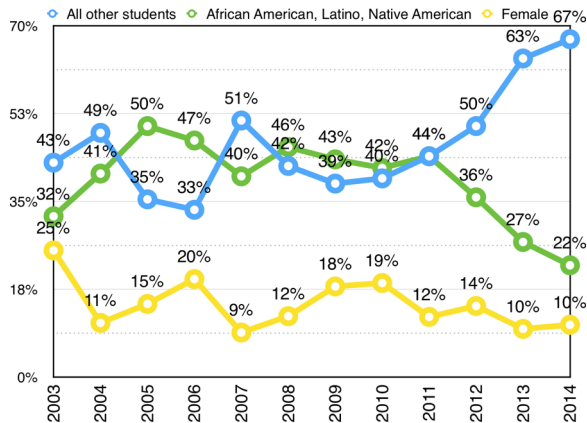

Figure 2. Enrollment by FTF in CECS
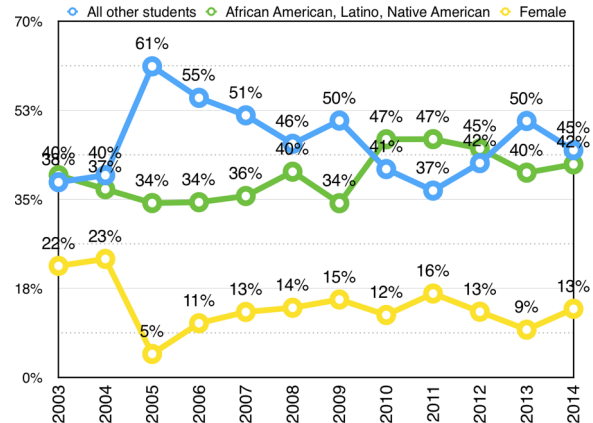
Figure 3. Enrollment as a % by FTF in CECS

Figure 4. Enrollment as a % by FTF in MAE

Figures 3 and 4 present the enrollment by first-time freshman as a percentage for the programs in Computer Engineering and Computer Science (CECS) and the programs in Mechanical and Aerospace Engineering (MAE). Figure 3 shows clearly the continued low enrollment by women and the precipitous drop in enrollment by students from underrepresented groups (African American, Latino, and Native American). Figure 4 also shows the low enrollment by women that has continued in the two majors of Aerospace Engineering and Mechanical Engineering. As with CECS, the percentage of women in MAE in Fall 2014 (13%) is nearly half of what it was in Fall 2003 (22%).

These facts are evidence for the need to step up the recruitment and retention of women to educational opportunities in fields that have high demand from industry. The low representation of women in these technical fields is a disservice to a society that continues to rely heavily on technology to communicate, travel, work, etc. We need to provide access to a diverse student body and retain them through the completion of their degree.

In Fall 2015, a team of faculty from the departments offering the computing, aerospace engineering, and mechanical engineering majors, as well as college advising staff, began implementing a number of recruitment and retention strategies to increase representation by women in these majors. The effort is part of our participation as a client in the Extension Services for Undergraduate Programs (ES-UP) from the National Center for Women and Information Technology (NCWIT, www.ncwit.org). An NCWIT consultant assists the team in identifying the activities to be undertaken, providing guidance throughout, and evaluating the efforts.

II. Entry Survey

The college of Engineering at CSULB has several outreach activities, though their focus is not necessarily on getting students to enroll at the university; it is to promote Engineering as a discipline. In addition to reviewing enrollment data, we gathered data on whether these outreach activities – as well as other criteria – have made an impact on students' decisions to enroll at CSULB. We surveyed students entering our programs to determine their interests in selecting their major and participation in events or activities that may have influenced their decision to attend CSULB and select their major. These surveys were distributed to students in three different semesters.

We received 320 responses in total from students who started in Spring 2015, Fall 2015, or Spring 2016. Some of the outreach activities attracted stronger participation. From our largest dataset, the Fall 2015 responses revealed that, on average, students had attended two outreach events by engineering and computer science in middle school as well as in high school and had talked to an engineering student and listened to one of their presentations twice. They reviewed the Engineering website three times on average before enrolling at CSULB and during their time at CSULB they took advising from the student success center and a professor in Engineering, also three times on average. Students surveyed also disclosed that they participated four times, on average, in events hosted by student organizations as well as in study groups; these were the most popular types of activities.

In summary, the more frequented activities included the following.

1. Receiving advising from the student success center
2. Receiving information about career paths in computing and engineering while at CSULB
3. Reviewing the Engineering website before enrolling at CSULB
4. Participating in a student Engineering organization
5. Participating in a study group with other students in Engineering
6. Receiving academic advising from a professor in Engineering

Based on the above observations, the NCWIT resources and publications, we designed a set of strategies and activities to strengthen several areas to improve recruitment and retention of women in computing and engineering.

III. Recruitment

We selected three recruitment strategies that NCWIT has identified as successful at other universities and that could be implemented at CSULB in a short timeframe [3]: a) increase outreach to accepted students, b) improve messaging on relevant websites and print materials, and c) conduct roadshows at area high schools and community colleges.

A. Outreach to accepted students

In Spring 2016, we began our recruitment by writing an email to students admitted for the Fall 2016 semester into one of the four computing and engineering majors. The email message consisted of a congratulatory message on their admission to CSULB and specifically to the computing or engineering program they had applied for. While our goal was to primarily reach out to women and students from underrepresented groups in the academic programs, we decided to reach out to all admitted students. The message provided highlights of the quality of an CSULB education and of our computing and engineering programs, and provided names and brief highlights of research by recently hired faculty. The list of faculty included four women and four men. The email went out to 2,252 students, and we received some informal, positive feedback on this activity from about 15 students expressing gratitude for the information, asking additional questions, and informing us about their decision.

A second message to the same admitted students invited them to visit the campus for a tour to be led by members of Engineering student organizations. A total of eight tours were held on three different days at three starting times. There was a total of 141 prospective students who registered for a tour – most students were accompanied by at least one additional guest, typically a parent.

There were 55 (or 39% of the 141) prospective students for Computer Science, 42 (30%) for Mechanical Engineering, 24 (17%) for Computer Engineering, and 20 (14%) for Aerospace Engineering. Of these students, 102 (72%) indicated they were still considering all options when asked if they had chosen the University they wanted to attend. The remaining 28% indicated they had already committed to attend CSULB. Each tour was convened in a classroom where a Computer Science faculty member (also the advisor for the undergraduate Computer Science program) provided students and their guests a general introduction to the four majors. This included an overview of the academic requirements and some of the key aspects of the degrees – e.g., highlighting the two-semester senior project requirement. Four female students then lead the tours of the Engineering labs and of the campus. Two of the tour leaders were Computer Science students graduating that semester; the other two students were both in Aerospace Engineering, one in her second semester as a transfer and the other one semester from graduating. All four students were active members and officers of student organizations, Association of Computing Machinery Women's chapter (ACM-W) and Society of Women Engineers (SWE) , and two of them were members in honor societies. The feedback received from the participants regarding the tours were unanimously positive. Also, everyone appreciated the information presented and the labs they toured which included the Collaborative Autonomous Systems Laboratory, the 3D printing lab by the Long Beach Maker Society, and the lab space where Mechanical and Aerospace Engineering students work on an annual Baja car, Formula car, and rockets.

B. Revise websites and printed publications

The second recruitment strategy was to review and improve the language used in websites and printed material that describe our academic programs. The goal was to ensure the language and images used were more inclusive and appealing to a diverse student population. The changes included creating ways to spotlight current students and alumni from the programs, with a focus on women and students from underrepresented groups. Such students/alumni spotlights can include the high school attended, experience in the first year, and impression of the campus, academic programs, faculty, and students. Continued support for these efforts will allow us to include spotlights on different professions to emphasize the breadth of jobs in computing and engineering – especially on professions not necessarily associated with these majors and which put these degrees in a more socially relevant light [6]. As the website changes are rolled out and our work on recruitment continues, we will assess whether they appeal to all students and whether students can identify with either the alumni or professions in the spotlight.

C. Visiting nearby high-feeder institutions

Recruiting at high-feeder community colleges and high schools is the third strategy. The recruitment events consist of identifying the institutions, making connections with key faculty/staff to help with logistics, and then for CSULB faculty and students to travel to the institutions to make presentations about the college and our academic programs. These events (roadshows) took place in the Fall 2016 semester as high school seniors and community college students prepared to submit their college applications – the deadline to apply was November 30. This effort used the information learned from the entry survey and faculty workshops (see below); like the campus tours, these were also partly lead by current students in computing and engineering majors.

There were seven roadshows to seven different high schools in close proximity to CSULB. A group of advising staff and current computing/engineering students lead the roadshows. Each visit consisted of immersing the students in a computing or engineering activity – for example, robotics

as mechnical devices that area programmable, thus mixing three of the four disciplines in our efforts. In addition, the students lead a presentation on computing and engineering programs at CSULB and the career possibilities these programs lead to. The workshops included pre and post surveys to measure the impact of the activities and of student interest in the disciplines. The surveys are still being transcribed from their paper form and the team will analyze the results at a later time.

IV. Retention

The retention strategy, designed to help promote self-efficacy and professional development, uses a two-pronged approach: a) creating modules for implementation within several first-year introductory courses in engineering and computing that promote a deep understanding of career options and strengthen problem solving abilities, and b) holding a series of faculty and staff development workshops focused on understanding factors that influence the success of underrepresented students in an educational environment.

A. Classroom modules to motivate Engineering/Computing students

Faculty on the team developed and coordinated the adoption of classroom modules and activities to promote career exploration and enhanced understanding of career options. Furthermore, modules and activities that involve problem-based learning were developed. The modules were incorporated into beginning level courses that introduce students to the major.

Introduction to Engineering Profession (ENGR 101) is the first of three 1-unit introduction to engineering course series that include Academic Success Skills (ENGR 102) and discipline-specific courses, including Introduction to Aerospace Engineering (MAE 101A), Introduction to Mechanical Engineering (MAE 101B), and Introduction to Computer Engineering/Computer Science (CECS 105). First-year students from all the Engineering and Computing disciplines take ENGR 101 and ENGR 102 in the fall semester of their first year. Students usually take ENGR 102 and their respective discipline-specific introductory course in the subsequent spring semester. Typical ENGR 101 class activities include lectures on careers in engineering, guest presentations from professional engineers, and group activities.

In Fall 2016, ENGR 101 served as the course for implementation of a retention strategy that includes presenting students with role models who have a diverse academic, career-level and demographic background to help inspire them to the engineering career. Specifically, professional engineers who are women and/or from underrepresented background were invited to give a talk that highlights their education and career path, experiences, struggles, and success. The team worked with the ENGR 101 instructors to help identify the guest speakers. Two sections of ENGR 101 were selected in the pilot study: one that received regular instruction and one with the enhanced retention strategy. The same instructor taught both sections. The same pre and post surveys were administered. Students were informed at the beginning of each survey about the purpose of the study, which is to learn about their interests in selecting and continuing in a computing or engineering major in order to improve their learning experience in the College of Engineering. In addition to a demographic questionnaire, both surveys include the same questions that assess their confidence level in engineering/computing career and their views on diversity. Table 1 provides the list of survey questions. Students were asked to respond using a Likert scale (strong disagree, disagree, neutral, agree, and strongly agree). Students voluntarily participated in the survey. In the Experimental group, 72 and 61 students in the class of 92 completed the pre and

post survey, respectively. In the Control group, 83 and 79 students in the class of 99 completed the pre and post survey, respectively. Table 2 gives the demographic breakdown of the survey groups.

Table 1. Pre and post Likert-scale survey questions for ENGR 101 classes

No	Question
Q1	I feel confident in my pursuit of an engineering/computer science degree
Q2	I feel that I belong in engineering/computer science
Q3	I have sufficient knowledge about career options in engineering/computer science
Q4	I have sufficient knowledge about what an engineering/computer science professional does
Q5	I believe that the engineering/computer science workforce is diverse in gender
Q6	I believe that the engineering/computer science workforce is diverse in ethnicity
Q7	I choose engineering/computer science because I would like to improve the quality of life of people in my family/community
Q8	I chose engineering/computer science because I would like to be a role model to people in my family/community
Q9	I chose engineering/computer science because jobs in this field have high salaries
Q10	I feel more confident when I see successful engineering/computer science professionals who share similar life experience/struggles as me
Q11	I feel more confident when I see successful engineering/computer science professionals who share similar cultural background as me

Table 2. Demographic data of the survey participants in each group

	Categories	Experimental Group		Control Group	
		Pre survey	Post survey	Pre survey	Post survey
Ethnicity	Asian or Pacific Islander	38.9%	42.6%	34.9%	36.7%
	Black or African American	1.4%	1.6%	0.0%	0.0%
	Hispanic or Latino	34.7%	29.5%	36.1%	38.0%
	Native American or American Indian	0.0%	0.0%	0.0%	0.0%
	White	19.4%	16.4%	21.7%	17.7%
	Other	4.2%	9.8%	6.0%	7.6%
	Decline to state	1.4%	0.0%	1.2%	0.0%
Gender	Female	19.4%	19.7%	14.5%	12.7%
	Male	80.6%	80.3%	85.5%	87.3%

Figure 5 compares the two groups on the overall percentage changes in the agreeable responses (the combined number of strongly agree and agree responses) on the eleven survey questions
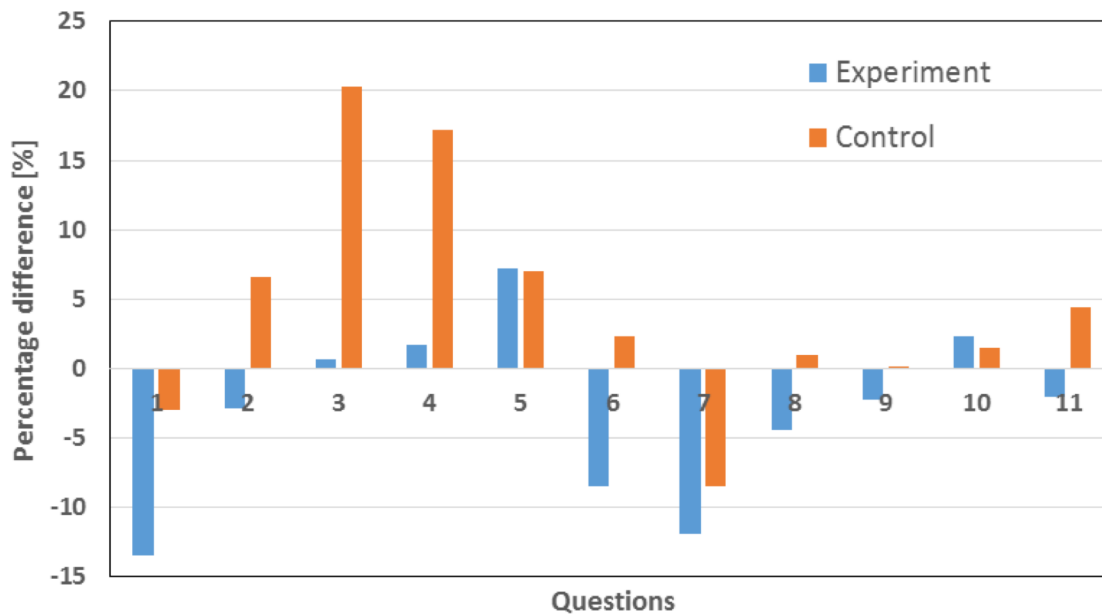

Figure 5. Comparison of the percentage changes in the number of agreeable responses (strong agree/agree) between the pre and post survey of the Experimental and the Control group

shown in Table 1. Positive percentage difference indicates an increase in the agreeable responses, whereas the negative difference indicates a reduction of the agreeable responses. Interestingly, the Control group shows a larger positive change in student's perception relating to their confidence in pursuing the engineering/computing degree and the role of cultural and diversity in the engineering/computing fields (Q2-6 and Q11). The students in the Control group surprisingly show lower levels of confidence in engineering/computing degree based on their responses to Q1 and Q2. The results certainly contradict our hypotheses and require further analysis of the data. In the surveys, students were also asked to provide a unique identification key that allows us to anonymously track their responses in the pre and the post survey. This information will be used to further analyze the data of students who completed both the pre and the post survey. The responses based on their demographic groups will also be compared.

During the Spring 2017 semester, additional activities that focus on problem solving are being implemented in the discipline-specific introductory courses for aerospace and mechanical engineering (MAE 101A and MAE 101B). The activities emphasize developing self-efficacy and problem solving skills. Students participate in individual and in-class team activities to develop engineering solutions to a real-life problem designed to promote creativity and problem-solving skills. The lectures also discuss engineering applications and impact in everyday life and include presentations from role models from the respective disciplines. To help students develop success skills, the classes include workshops on time management and growth mindset. For the activity, students will create an Individual Development Plan to help them evaluate and develop strategies

to improve their skillsets needed to achieve their short-term and long-term goals. A survey will be designed and administered in these classes to obtain student feedback on the learning activities.

B. Faculty Development Workshops

Four professional development workshops were held for faculty and staff on social-emotional factors that contribute to student persistence and retention. The factors include but are not limited to reducing stereotype threat and unconscious bias, providing encouragement, and facilitating a growth mindset in students [4, 5, 6, 7]. The first two workshops were organized in Spring 2016 and were led by two post-doctorate researchers with the CSULB Motivation and Social Identity Lab; each has a PhD in Social Psychology. The first workshop provided a review of research on factors that draw underrepresented groups into engineering and the barriers they encounter in entering the field. One of the key points of the workshop was how women place more value on communal values or goals then they do in mastery, recognition, or power [6]. The second workshop provided recommendations on how to structure curricula and classroom interactions to mitigate unique challenges that underrepresented students face in Engineering/Computing.

Two additional workshops were held in Fall 2016. One workshop was led by a faculty from Harvey Mudd College focusing on the transformations of the computer science programs at UC Berkeley and Harvey Mudd College. Both have had significant increases of women enrolling in computer science with Harvey Mudd now at 40%. We discussed several tips to create inclusive classrooms, including (a) caring about all students, (b) showing the breadth of the field, (c) challenging the stereotypes, (d) introducing student to psychology vocabulary such as imposter syndrome and growth mindset, (e) building community, (f) providing peer tutoring, and (g) improving the physical surroundings with warm colors and paintings. The workshop included a discussion on splitting the introduction to computer science courses into one for students with prior experience and another for students with no prior experience.

The faculty development workshop series concluded with a workshop on "creating and fostering a growth-minded classroom" by faculty from the sciences and mathematics at CSULB. Growth mindset is a concept discovered by Carol Dweck, a psychologist at Stanford University, which states that "basic abilities can continue to be developed through hard work and dedication."[7] The workshop facilitators presented best practices for fostering a growth mindset environment, including: creating high expectations, creating a risk-tolerant learning zone, providing feedback focused on process, introducing students to the concept of the malleable mind, writing a syllabi with positive and promising language, promoting desired student behaviors. There was much discussion on the challenges to implement these and on creating activities and assessing them to foster a growth mindset.

V. Conclusion

The team of faculty and staff undertaking these efforts expect to learn the effectiveness of the recruitment and retention activities proposed and implemented. This will be done through evaluation surveys of the participants and by tracking the enrollment in our programs. Even with survey and enrollment data and its evaluation, we may be limited in what we can conclude about the impact that our strategies have in recruiting and retaining students. It is only through continued efforts as presented here that we can improve the diversity of our classrooms and programs, and while some of the activities are sustainable, others need the financial and administrative support of the departments, college, and University.

As a society, we need a well-educated diverse workforce. CSULB strives to provide a highly valued degree; computing and engineering degrees are some of the most sought-after and well rewarded by employers. Unfortunately, women have been underrepresented for many years in the computing and engineering programs studied in this paper. The proposed strategies described are a way forward to increase the enrollment, retention, and graduation of women in these programs leading to a more diverse student body in Computing and Engineering programs at CSULB thereby improving the diversity of the profession.

Bibliography

[1] T. Camp, S. Zweben, D. Buell, and J. Stout. "Booming Enrollments: Survey Data," *ACM Technical Symposium on Computing Science Education* (SIGCSE '16), pp. 398-399, March 2016.

[2] W. M. DuBow, B. A. Quinn, G. C. Townsend, R. Robinson, and V. Barr. "Efforts to Make Computer Science More Inclusive of Women." *ACM Inroads* 7, 4 (November 2016), pp. 74-80. DOI: https://doi.org/10.1145/2998500

[3] NCWIT. (2016, April 28). Recruit Strategically: A "High Yield in the Short Term" Workbook for Attracting Women to Undergraduate Computing and Engineering. [Online]. Available: https://www.ncwit.org/sites/default/files/resources/recruitstrategicallyworkbook_print.pdf

[4] R. W. Grossman, S. Kim, S. Tan, and T.E. Ford. "Stereotype Threat and Recommendations for Overcoming It: A Teaching Case Study." National Center for Case Study Teaching in Science. [Online]. Available: http://sciencecases.lib.buffalo.edu/cs/files/stereotype_threat.pdf

[5] C. Frieze, O. Hazzan, L. Blum, and B. Dias. "Culture and Environment as Determinants of Women's Participation in Computing: Revealing the 'Women-CS Fit'." *ACM ACM Technical Symposium on Computer Science Education*, pp 22-26, March 2006.

[6] C. Corbett and C. Hill. 2016, April 28. "Solving the Equation: The Variables for Women's Success in Engineering and Computing". The American Association of University Women. March 2015.

[7] S. Walters. "Growth Mindsets: A Literature Review". [Online]. Available: http://www.temescalassoc.com/db/el/files/2015/02/Growth-Mindsets-Lit-Review.pdf