A Reflection on Diversity and Inclusivity Efforts in a Software Engineering Program

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***Abstract*—This Innovative Practice Full Paper is an experience report that presents a collection of initiatives, circumstances, and teaching practices that coincide with improvements in gender diversity in the undergraduate software engineering program at California Polytechnic State University at San Luis Obispo. The percent of females in the software engineering capstone increased from an average of 3.81% in the first five years of the program (2003-2007) to 18.82% in the most recent four years (2014-2017). Multiple initiatives were instituted beginning in 2009 to improve a gender imbalance, addressing recruitment and retention of women. One key initiative was the creation of a new introductory course with multiple themes (e.g. art, mobile, music, robotics) from which incoming students could choose. These courses were designed to include significant collaboration, rapid application development in interesting domains, and strategic selection of tools and languages that reduced the advantages of previous student programming experience. Additional initiatives included club activities, sending large numbers of female students to the Grace Hopper Celebration of Women in Computing Conference, K-12 outreach, and a vibrant and mature SE capstone experience. Also during this timeframe, course scheduling changes were imposed which naturally created informal cohorts of software engineering students earlier than in previous years. Student self-evaluations collected in the SE capstone were analyzed, comparing male and female responses, as well as teams with different gender mixes. This analysis indicates no significant difference between male and female enjoyment of the capstone projects overall, and no significant difference between team enjoyment regardless of the percentage of females on the team.**

I. Introduction and Context

The gender imbalance in computer science has been a well-known issue for years and this is not different in software engineering education. In this paper we aim to describe department-level and program-level initiatives for increasing diversity, inclusivity, student success and retention, that might have positively affected our increasing number of women in the software engineering undergraduate program at Cal Poly.

Cal Poly (California Polytechnic State University) is a public primarily undergraduate polytechnic university located in San Luis Obispo, halfway between San Francisco and Los Angeles on California's Central Coast. Founded in 1901 it is currently one of only two polytechnic universities in the 23-member California State University system. Comprising six distinct colleges, the university offers 64 bachelor's degrees, 34 master's degrees, and 13 credentials. Cal Poly has one of the largest (in acres) college campuses in the United States and the second largest land-holding university in California.

Cal Poly's mission is *to foster teaching, scholarship, and service in a Learn by Doing environment in which students, staff, and faculty are partners in discovery. As a polytechnic university, Cal Poly promotes the application of theory to practice. As a comprehensive institution, Cal Poly provides a balanced education in the arts, sciences, and technology, while encouraging cross-disciplinary and co-curricular experiences. As an academic community, Cal Poly values free inquiry, cultural and intellectual diversity, mutual respect, civic engagement, and social and environmental responsibility* [1].

According to PayScale's projections, Cal Poly has a 20-year net return on investment of $669,800. This ROI is the highest in the California State University system and is higher than all of the University of California schools except UC Berkeley. Cal Poly features about 1,400 academics and 21,000 students. The average student-to-faculty ratio is around 19:1.

The Department of Computer Science and Software Engineering features 30 tenure/tenure-track faculty, and about 10 lecturers. In terms of enrollment, the department features 550 computer science and 180 software engineering undergraduates, 450 computer engineering undergraduates, and 100 students in the graduate and Blended BS+MS programs.

The SE program at Cal Poly was started informally in 2001, formalized as a major in 2003, and first received ABET accreditation in 2007. The SE program has increased in size from an average of 15.1 students per year in the first ten years to 37 in the most recent five years and 52.5 in the most recent two years. Capacity was increased in 2012 to allow two cohorts (about 50 students). Applications to the program are very strong with acceptance rates currently in the ten percent range. Capacity is limited primarily based on number of faculty and physical space. The SE program is closely integrated with the department. Approximately one-fourth of the courses are taught by faculty whose primary area is software engineering. Many introductory, upper-level, and elective courses are shared with computer science and computer engineering students.

In the next section we describe the most important initiatives that might have positively influenced inclusivity, retention, and student success in our programs. Section III presents organic changes that was made at department level, especially those

[1] https://president.calpoly.edu/welcome-cal-poly

related to our software engineering major. Section IV provides a quantitative data analysis to give evidence and show that our department's work in the long-term process of increasing diversity and inclusivity has led to positive outcomes, especially in terms of gender in our software engineering program.

II. Initiatives

In 2009, the Cal Poly Computer Science and Software Engineering Department conducted a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. Through a series of workshops they identified strategic initiatives for the department. High on the final list was a set of initiatives intended to improve gender diversity through recruitment and retention. A key element in these efforts was the creation of a unique introductory (CS0) computing course labeled CSC 123 that was required for all incoming computer science, computer engineering, and software engineering students. This section will report on this CSC 123 effort as well as some related initiatives that occurred during the past eight years.

A. CSC 123 Intro to Computing

Prior to Fall 2010, first-year computer science, computer engineering, and software engineering students typically started with the CSC 101 Fundamentals of Computer Science I course in their first quarter at Cal Poly. This course was a traditional CS1 course taught in C at the time. It focused primarily on language constructs and problem solving in a command-line input/output environment. Some students who had scored a four or five on the AP Computer Science exam would jump in to the CSC 102 Fundamentals of Computer Science II course. CSC 102 was a traditional first object-oriented programming course using Java. Some years students also had the option to take CSC 108 Accelerated Introduction to Computer Science which covered the content of CSC 101 and 102 in a single quarter.

Many students struggled in CSC 101, resulting in high failure rates and poor retention to future courses. Faculty conjectured that students were disillusioned with the command-line nature of the projects which was very different from the web, GUI, and emerging mobile applications that they envisioned developing, and that they were frustrated with the solo-programming policies. An idea hatched to create the new CSC 123 cornerstone course that immediately placed students in the domains, tools, and teams that they envisioned embracing in their careers. A menu of CSC 123 flavors was offered, starting with gaming, mobile, music, and robotics. Students were allowed to select the flavor that most matched their interests. The courses took a pair or team-based problem-based learning approach [1].

A total of 205 students took the first CSC 123 course in Fall 2010, and the results were immediately positive. The failure rate in CSC 101 reduced by over 4% and the number of students receiving A's increased by over 10%. Similarly, retention to CSC 102 improved by almost 12% [2].

A more recent study [3] reported that four- and five-year graduation rates also significantly increased after introducing CSC 123. In addition, students' attitudes towards their major significantly increased after this change.

B. WISH

During this same timeframe since 2007, many activities occurred directed at improving recruitment and retention of a diversity of students, and particularly women. A Women in Software and Hardware (WISH) student club was founded in 2007 by females of the Computer Science and Software Engineering Department as a student organization. This student group was founded with two primary aims:

- Provide a community of support for females in computing majors and minors including computer science, software engineering, computer engineering, and electrical engineering
- Continually put effort towards rectifying the gender gap in computing majors and minors and evaluating the systemic problem

WISH organizes a wide variety of events and programs each quarter such as technical talks hosted by industry, a mentor/mentee program, study sessions, resume workshops, and social outings. The mentor/mentee program provides the opportunity for an incoming freshwoman to get in touch with a senior female student in her major. The provided feedback by WISH students emphasize that this mentor/mentee trust relationship helps female students retain in their major and gain confidence. Similarly, WISH successfully hosted expanding engineering event in 2016 and 2017. Expand Engineering is a one-day event that brings students from different high schools to Cal Poly to learn about the different aspects of computer science. 115 high school students attended the event in 2016 and 2017. Different sessions of coding such as Computational Art, Security, Robotics, Mobile App Development, and Web Development were offered by WISH members during the event. The following are some results from a survey that was given to the participating students during the 2017 Expand Engineering event.

- 76.8% said they are on free lunch.
- 65.6% will be first-generation college students.
- 6.25% identified as part of the LGBTQ+ community.
- 50% said they are more likely to pursue computer science.
- 40% said they would consider computer science.

Lean in Circle is another event hosted by WISH to provide support and a safe environment in which to discuss challenges/experiences of being a woman in tech. This event is a chapter of the global Lean in Circle [2].

C. Celebration of Women in Computing

Celebrations such as Grace Hopper Celebration of Women in Computing (GHC) help retain women in the computing field. A recent study [4] showed that these celebrations can significantly increase the number of women who choose to study computer science and other technical majors. The Computer Science and Software Engineering Department has

[2]https://leanincircles.org

sponsored female students to attend the GHC since 2010. The number of students attending GHC increased from 10 in 2010 to 80 in 2017. The department also sponsored female faculty members to accompany students on their trip.

Celebration of Women in Computing in Southern California (CWiC-SoCal) is a regional conference modeled after GHC which focuses on the contributions of and opportunities for women in computing [3]. It brings together students, faculty, and industry professionals from southern California to network. This conference began in 2012 as a way of offering the GHC experience without impeding on students desire to attend classes and reducing costs to make it more affordable. Similarly, the Computer Science and Software Engineering Department has sponsored around 25 female students every year to attend this conference since 2012. Fundraising from department alumni, IAB members, and companies with alumni leaders were utilized for sponsoring the students to attend these conferences.

D. Outreach

The Computer Science and Software Engineering Department has very limited control and input on recruitment and admissions at Cal Poly. However, several activities were undertaken that may have indirectly affected the number of incoming women into the program. For example, in the first year after the SWOT analysis, faculty called female prospective students who had been accepted to the computer science and software engineering programs. Software engineering faculty informed the accepted female SE students of the new introductory CSC 123 courses, explained the software engineering program, and encouraged them to matriculate. In addition, faculty and students were actively involved in Cal Poly's Open House, a Friday/Saturday event designed to showcase Cal Poly's programs and clubs to admitted prospective students shortly before the May 1 college decision day.

Several department clubs such as WISH, SWE[4], and ACM[5] put on outreach events such as the "Build an Engineer Day" for middle school students. In addition, a few department faculty instigated and participated in strategic outreach programs for K-12 students and teachers such as EPIC and CS4HS. Although these programs may not have directly resulted in increased numbers of new female students in the SE program, we have observed enthusiastic participation by current female SE students in these outreach activities perhaps resulting in increased retention and overall enthusiasm for the program.

1) EPIC: The Cal Poly College of Engineering started a summer camp titled Engineering Possibilities for College (EPIC)[6] for middle and high school students beginning in 2009. EPIC started as a single one-week day-camp, and has grown to four one-week residential camps. Currently, the first week is for middle school students, and the following three weeks are for high school students. Each week accommodates approximately 160 campers. College of Engineering students are hired as counselors.

"The program's primary goals are to attract more female, first-generation and low-income students to the field of engineering and inspire them to choose it as a career path."[7] EPIC accomplishes these goals by giving students hands-on learning experiences with a variety of engineering disciplines. Campers attend eight two-hour labs throughout the week. The labs are taught mostly by Cal Poly College of Engineering faculty, as well as a few graduate students, area K-12 teachers, and professionals from industry. Campers get placed into tracks based on their interest (e.g. Software, Aero), but all tracks include labs from a variety of engineering disciplines.

At least four faculty from the Computer Science and Software Engineering Department have taught EPIC labs over the years, and one of the authors has taught EPIC labs every year since it began. Labs covered topics such as computer art, security, and robotics. The software engineering labs have utilized drag-and-drop programming environments such as Scratch[8] and App Inventor for Android[9]. Scratch is primarily used for middle school students and App Inventor is used for high school students. The labs typically begin with some directed exercises to learn the development environment and possibilities. With the App Inventor lab, campers then specify requirements for their app, design the user interface, add functionality, and deploy it to an Android phone.

2) CS4HS: One of the authors of this paper was awarded three Google CS4HS grants that were used to develop and foster a community of K-12 educators [5]. The first CS4HS event in 2011 consisted of a workshop for area educators to raise awareness of the need for computing education, job demand, and national initiatives such as the NSF CS10K[6] project and what later became the new AP CS Principles course[10]. Area school administrators were specifically invited, along with computing and related middle and high school teachers. This workshop resulted in strategic relationships with area schools. For instance, one middle school principal invited two Cal Poly CS4HS faculty organizers to provide input on their plans for a new 6th-grade STEAM program, and deliver a two-day workshop to teach how to incorporate computational thinking into all middle school disciplines. All teachers from history to music learned to write Scratch programs using discipline-specific application ideas.

Additional CS4HS workshops were run in 2012 and 2016. The latter workshops focused on helping schools teach the new AP CS Principles course for the first time. In the 2016-2017 academic year, three Cal Poly faculty and four computing students, two male and two female, met monthly and went to the high school classrooms bi-weekly. Faculty and students presented guest lectures and provided assistance with course projects.

[3]https://cwicsocal18.ics.uci.edu
[4]http://societyofwomenengineers.swe.org/
[5]https://www.acm.org/
[6]https://epic.calpoly.edu
[7]https://epic.calpoly.edu/faq/
[8]https://scratch.mit.edu/
[9]http://appinventor.mit.edu/explore/
[10]https://apcentral.collegeboard.org/courses/ap-computer-science-principles/course

Many informal interactions have occurred as a result of the community developed through the CS4HS workshops. Cal Poly computing students, mostly from WISH, are regularly invited to come into high school classrooms to present on computing majors and careers. When a local high school computer classroom caught fire, the Computer Science and Software Engineering Department quickly donated a classroom set of computers and Android mobile devices to enable the computing classes to restart immediately while waiting on insurance funds to arrive.

E. Software Engineering Capstone

The Cal Poly software engineering major includes a three-quarter capstone experience. The capstone courses are titled CSC 402 Requirements Engineering, CSC 405 Software Construction, and CSC 406 Software Deployment[11]. The courses include traditional components such as lecture, readings, student presentations, and exams, but the primary activity of the SE capstone is to develop a significant software product in teams for an external customer. Recent sample projects have included a database capture and replay tool for Amazon Web Services, a pen-based messaging app for Microsoft, and a mobile student club organization/communication app for Cru[12].

The software engineering capstone explored several models in the first few years. One model involved pairing the senior-level SE capstone with a set of junior-level software engineering courses. In this model the capstone students served as managers and team leads for the junior-level students. In another model, multiple external customers worked with a single section of students. In this model each team worked on a completely different project with a unique external customer [7] [8] [9].

Since 2006, the SE capstone has generally followed the following model. Students are organized into teams of five to seven students. Sections typically include 25 to 30 students, so five to six teams are formed. All teams in a section develop the same product, starting with a common product vision. However, each team does requirements elicitation separately with an assigned customer, and they are given the freedom to propose and implement their own software architecture. As a result, students see multiple solutions to the same problem. In some cases, groups of teams collaborate such as when one team implements an Android and another an iOS client for a common backend.

The SE capstone also includes typical academic content such as readings, presentations, and exams. An emphasis is placed on student presentations of course-related topics.

Several initiatives were incorporated into the SE capstone designed to create an inclusive and welcoming environment where all students would thrive.

1) Team Selection: Teams of five to seven students are formed at the beginning of the SE capstone. The teams remain together throughout the nine-month-long project. The instructor determines team composition, balancing a variety of concerns such as student skills (e.g. UI, database, iOS), interests (e.g. team lead, QA, UI), and teammate preference. Students are given the opportunity to privately submit to the instructor names of students whom they do and do not prefer to work with on the project. Incorporating teammate preferences has been extremely popular among the students. Although a few students offer no preferences, most students have at least one other person with whom they really would like to work. Anecdotally, female students very frequently request another female student on their team. These requests are prioritized and almost always honored.

2) Soft Skills: The SE capstone includes many discussions on what some call the softer skills of software engineering. In addition to the harder, technical skills such as programming, automated testing, and installation scripts, soft skills include topics such as communication, leadership, and empathy. Students are assigned to read Peopleware [10] which is used as a basis for many seminar-style class discussions on topics such as team jell, retention, and management styles.

Students also have many opportunities to reflect on team dynamics and effectiveness through quarterly retrospectives, weekly status updates, and daily standup meetings. The weekly status updates are submitted to the instructor electronically, and they request responses in the areas of tasks, roadblocks, and team.

3) Retrospectives: Retrospectives are a popular mechanism for reflecting on a team's project experience [11]. The SE capstone includes formal retrospectives at the end of each quarter. These are used both as a way of teaching a variety of retrospective techniques, but also to genuinely reflect on the team experience and improve it. An emphasis is placed on identifying actionable items to improve team dynamics.

4) Social Events: Following the example of Peopleware's Spaghetti Dinner, each team is asked to schedule a social event within the first week of forming. When brainstorming ideas for the social events, students are told that everyone has veto power. This way no one is placed in an uncomfortable situation. For instance, if the team suggests going rock-climbing, but one person is afraid of heights, then the idea gets vetoed and they keep suggesting ideas. Social events are again scheduled at the beginning of the second and third quarters. Some teams find these so enjoyable that they schedule them almost weekly. Others combine them with project work in events like coding or defect hunting parties. These events tend to build strong bonds among teammates.

At the end of the first quarter, all SE capstone students are invited to the instructor's home for a social event the weekend before final exams. Activities typically include table-tennis and classic video game tournaments, along with holiday foods. The family nature of this event has been expressed as a highlight by many of the students.

5) Customer Selection: Recruiting and selecting excellent external customers is one of the most important challenges for a successful SE capstone experience. The SE capstone

[11] http://users.csc.calpoly.edu/~djanzen/setopics/capstone/

[12] https://itunes.apple.com/us/app/cru-central-coast/id1157344027?mt=8

has been very fortunate to have consistently found customers who connected well with the students, were committed to both the project completion and student learning, and offered interesting project ideas. Some project sponsors have provided a single point of contact who met with all of the teams in a section, while others provided up to one customer per team. The project technologies have varied from high-performance C++ applications with simple GUIs to mobile apps with rich UI/UX requirements. The domains have varied widely which has occasionally been a concern whether this might disinterest some students and possibly affect one gender or ethnic group more severely than others. Some comments have been received along these lines. For instance, some female students were less interested in the project on visualizing downhole data in scientific drilling applications. Also, some male students were less interested in the handwriting messaging app for Microsoft Surface Pro devices. However, the instructor has observed that students seem to be more interested in who they are working with and what technologies they are using than with the actual problem they were solving. For example, one team with three females and two males reported having an absolutely delightful time building a sense and avoid system for drones. Their delight was in the project challenge and the team dynamics, not necessarily in the project domain.

6) Instructor Consistency: The same instructor has taught all sections of the SE capstone for ten of the past twelve years. This consistency enabled continuous incremental improvements in the capstone experience, carrying lessons learned forward from multiple previous experiences. This faculty member has extensive experience in both academia and the software industry. The instructor has consistently high student course evaluations, and is generally perceived as welcoming and approachable by students.

III. Organic Changes

During this same time period, several changes occurred within the department that were not intentional or planned to improve diversity, yet may have had some effect. The department began to experience significant capacity issues as a result of decreased state funding and increased student interest in computing degrees. The department was unable to provide sufficient course sections to meet student demand.

Two decisions were made regarding the software engineering program to help mitigate this challenge. First, there was significant pressure from the California State University Chancellor's Office and Cal Poly administration to increase four- and five-year graduation rates. One of the initiatives to accomplish this was to reduce the number of units required for graduation in majors above 180 quarter units. Software engineering was above 180-units, so we were asked to consider removing a required course. The faculty approved removing the Operating Systems course from the list of required courses for software engineering, reducing the total number of units required by four. The Operating Systems course was considered by some students to be a difficult, low-level course, so it's removal may have incentivized some students to persist in or transfer to the software engineering major.

The second more significant change was with the junior-level software engineering courses. When the software engineering major was started, all computer science and software engineering students were required to take a set of two-quarter junior-level courses title CSC 308 Software Engineering I and CSC 309 Software Engineering II. An alternative one-quarter course titled CSC 307 Introduction to Software Engineering was also an option for the computer science majors. However, for many years the software engineering faculty declined to teach the CSC 307 course because they believed it provided insufficient topic coverage for the computer science students, most of whom went on to take software engineering jobs. When the enrollment and budget challenges grew and there were insufficient software engineering faculty to teach enough sections of CSC 308 and 309 for all software engineering and computer science students, they had no choice but to start offering CSC 307. As a result, over the past five years the CSC 308 and CSC 309 courses were primarily populated with software engineering students, while the computer science students primarily took CSC 307. This change had the positive consequence that many of the software engineering students got to know each other before they reached the software engineering capstone. Prior to 2012, software engineering students often didn't know each other before coming to capstone. Now, many students worked on teams together in CSC 308 and CSC 309, forming informal cohorts. Anecdottaly, female students seem to especially appreciate this earlier connection with other SE students. As a result, they often request to work together (or not) in capstone teams.

IV. Outcomes

Establishing causality in hindsight is challenging. As described earlier, the department engaged in several initiatives to improve gender diversity over the years, and saw positive results. However, it is difficult to establish exactly which initiatives were most effective. This section reports on two assessments of the initiatives that were undertaken.

A. Exploring Causality

A survey was conducted with students in June 2018 during the final week of their SE capstone courses. Forty-four of the fifty-three students in the capstone responded to the survey. Students were asked if they participated in certain initiatives, and if so to rate the following statements on a likert scale from Not at all (1) to Enormously (5):

1) To what extent did CSC123 positively affect your retention in the Software Engineering Major?
2) To what extent did attending the Grace Hopper Conference positively affect your retention in the Software Engineering Major?
3) To what extent did you feel welcome and included in the SE Capstone this year?

4) To what extent did participating in Outreach activities positively affect your retention in the Software Engineering Major?
5) To what extent did participating in WISH activities positively affect your retention in the Software Engineering Major?

In addition, students were given the opportunity to provide free-response feedback to the following questions:

1) What elements of capstone made it a welcoming and inclusive environment?
2) What elements of capstone made it an unwelcome or non-inclusive environment?
3) What else can you tell us about your experience in the Cal Poly Software Engineering major regarding feeling welcome and included, and how that affected your persisting to the end of the program?

Table I reports the results from the student responses to the first set of questions. Thirty-six students indicated that they had taken the CSC123 course. Some students do not take CSC123 such as in cases where they have transfered into the major. Although over sixty percent of the students selected above the midpoint (4 or 5), there is clearly not universal sentiment that CSC123 is a positive thing. In fact, several of the open-ended responses revealed negative experiences in CSC123 where they either felt intimidated by others who had more previous experience, or they were not excited about the flavor presented.

Fourteen students attended the Grace Hopper Conference, and they were very positive on this experience for encouraging them to stay in their major. One male student expressed frustration in the open-ended responses that there was nothing like the Grace Hopper Conference for him. Sixteen students participated in WISH activities, and most viewed this positively, although 6.3% reported that their WISH experiences did not contribute to their retention in the major.

Only eight students reported participating in Outreach activities. Sentiments were somewhat positive, but again not universal. Based on the open-ended responses, about half of the responders participated in Outreach activities before coming to Cal Poly.

All of the students who responded to the survey reported with a 4 or 5 that they felt welcome in the SE capstone. Typical positive comments in the open-ended responses cited things like early capstone social activities, discussions on psychological safety, a friendly professor and teammates, and getting to work with students whom they had enjoyed positive experiences in previous team-based courses. There were very few negative comments, but a couple of students did cite the competitive nature of individual grades within a team and multiple teams working on the same project.

B. Evaluation of SE Capstone Enjoyment

The aim of this section is to quantitatively check if there is a difference in the way the SE capstone is enjoyed and performed among students of different gender. This is used as a proxy for student enjoyment of the software engineering major, and as an opportunity to evaluate whether there is a difference between male and female students on their experiences in the software engineering program. Thus, the independent variables are the gender of the student and the proportion of females in a group. As discussed in section II-E, student teammate preferences were given high value when assigning teams for the SE capstone. As a result, the percentage of females in a team varied from zero to 55%.

The dependent variables are the students' perception as measured by a survey we have provided to students at the end of each capstone quarter. This survey is part of an end-of-quarter self/peer evaluation that is used to help students reflect on their capstone project experience and to provide additional grading insights to the instructor. Specifically, each student rated 19 different statements in the following likert scale: Strongly agree (5), Agree (4), Neither agree or disagree (3), Disagree (2), Strongly disagree (1), or I do not know (Null). The statements students rated are:

1) I have a good understanding of our project as a whole.
2) I understood what was expected of me during this project.
3) I understood what my teammates were doing during this project.
4) I made significant contributions to our project.
5) Others were aware of my tasks and task status.
6) Others were aware of my perspective and opinions.
7) I produced high quality project artifacts.
8) I was a reliable and responsible team member.
9) Each member of my team contributed equally to the project.
10) I understand the requirements of our customer.
11) Our requirements match our customer's needs.
12) Our architecture matches the projects requirements.
13) Our system accurately demonstrates the viability of our architecture.
14) I understand the technologies used in our system.
15) The things I learned will be useful to me when I leave Cal Poly.
16) Our team used tools or technologies that were not familiar to me.
17) I felt comfortable learning new tools and technology.
18) I enjoyed working on this project.
19) I would like to continue working on this project.

In order to measure the level of students' perception we look at the average score among those 19 statements and at statements #18 and #19 specifically.

Our dataset comprises the data of 12 SE capstone quarter classes from Fall 2014 to Spring 2017. During this time frame there were 29 teams and we received 465 individual answers for each of the 19 statements. Of these 465 answers, 369 are from male and the remaining 96 are from female. Of the 29 teams, 16 teams (i.e., 57%) have at least one female member.

Figure 1 reports the distributions of scores for male and female in average on all 19 questions and for statements #18 and #19. According to Figure 1 there is no difference in

TABLE I
SE CAPSTONE

Question	# Participating	% Not at all (1)	% (2)	% (3)	% (4)	% Enormously (5)
CSC123	36	11.1%	13.9%	13.9%	41.7%	19.4%
Grace Hopper Conference	14	0.0%	7.1%	21.4%	28.6%	42.9%
Welcome in Capstone	44	0.0%	0.0%	0.0%	20.5%	79.5%
Outreach	8	12.5%	12.5%	37.5%	37.5%	0.0%
WISH	16	6.3%	6.3%	25.0%	43.8%	18.8%

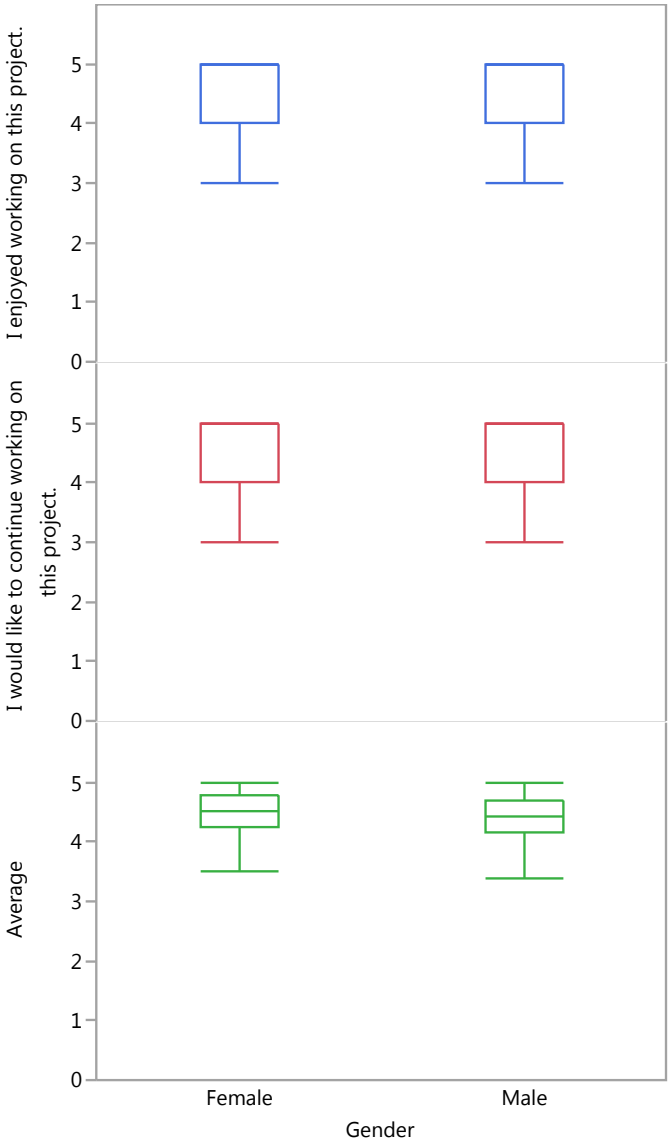

Fig. 1. Distribution of students enjoyment among gender.

the score provided by students of different gender. We also performed a non parametric Wilcoxon test and the p-value resulted, in all three cases, much higher than the standard alpha of 0.05. Thus, we cannot claim there is a difference in the way students of different gender perceive our capstone.

Figure 2 reports the average scores of members in a team with different proportion of female team members. According

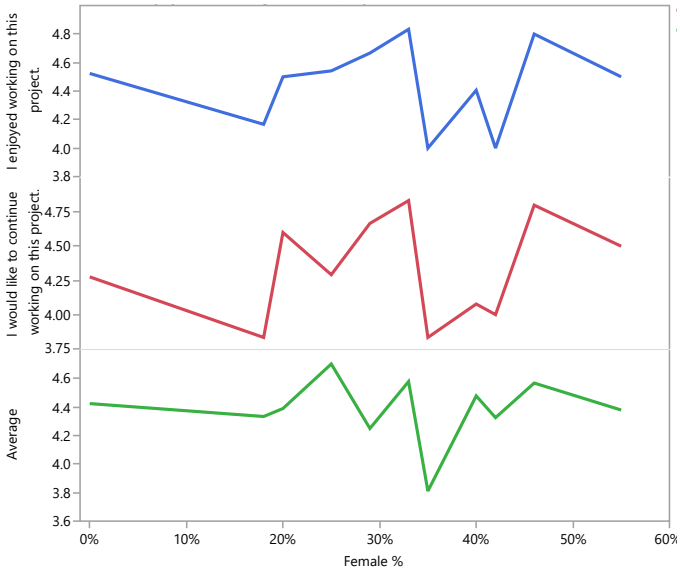

Fig. 2. Distribution of students enjoyment among students belonging to groups with different proportion of female students.

to Figure 2 there is no difference in the score provided by students belonging to groups with a different proportion of females. Specifically, the variation is within 1 point in all three cases.

In short, students report that they enjoyed the SE capstone project, and there is no significant difference in this enjoyment between male and female students.

V. RELATED WORK

Rather than reporting results of a research investigation, this paper reports our experience over a collection of initiatives, circumstances, and teaching practices that coincide with improvements in gender diversity in the undergraduate software engineering program at California Polytechnic State University at San Luis Obispo. Undoubtedly, we are not alone in this endeavor as several other software engineering and computer science programs around the world have experienced an increase in gender diversity and inclusivity in general after trying similar initiatives.

One of the most similar studies to our study is [12]. Alvarado et al. explain the challenges they faced to recruit and retain women in Computer Science at Harvey Mudd College (HMC). HMC is a science and engineering focused liberal arts college with approximately 740 undergraduate students. Initially the percentage of women CS majors was less than

10%. The authors raised this hypothesis that women did not really understand what CS is and thus were not interested. In order to verify this hypothesis they implemented three practices. First, they offered a CS1 course as a breadth-first view of the discipline. Second, they began offering trips for first-year women to the Grace Hopper Celebration of Women in Computing (GHC). Third, they provided research opportunities for women after their freshman year. They found that these three practices succeeded in increasing the number of women in computer science at HMC. The first and second implemented practices in this study are similar to our initiatives explained in Section II. Additionaly, we consider the mentorship and outreach activities in to order to recruit and retain women in Computer Science.

Shapiro et al. [13] investigate the factors that contribute to women's selection of and persistence in STEM majors such as the role of educational settings. They found that preparation in science and mathematics during the middle and high school years has an important influence on women's decisions to enter or exit STEM majors in college. This finding supports our hypothesis in section II-D that our outreach activities such as "Build an Engineer Day", EPIC and CS4HS have resulted in increased numbers of new female students in the SE program.

In [14], the authors examined the many influences contributing to the gender gap in computing. They interviewed more than 100 computer science students of both sexes from Carnegie Mellon University over a period of four years, as well as conducted classroom observations and conversations with hundreds of college and high school faculty. The authors also described educational reforms that have made a dramatic difference at Carnegie Mellon University, where the percentage of women entering the School of Computer Science rose from 7% in 1995 to 48% in 2016.

Recently, researchers from Rutgers University [15] analyzed a dataset that spans thousands of CS students across 3.5 academic years. They found that a large percentage of women taking the introductory CS1 course do not intend to major in CS, which contributes to a large increase in the gender gap immediately after CS1. Then, they correlated their findings with initiatives that some CS programs across the country have taken to significantly improve their gender diversity.

VI. Conclusion and Future Work

We are very pleased to see the percentage of female students in the software engineering program at Cal Poly improve from a paltry 3.81% to 18.82% over the course of a decade. Multiple department-wide initiatives were attempted such as the creation of the CSC 123 course and sending female students to the Grace Hopper Conference. Additional SE-specific efforts were also undertaken, especially related to the SE capstone. Simultaneously many things changed beyond our sphere of influence. This includes everything from external budget and enrollment pressures to the global growth of mobile computing. As a result, we cannot claim any causality. We can only report our efforts, observations, and improvements in gender diversity. We have faith and anecdotal evidence that our initiatives were impactful, and hope that by sharing them others will be inspired.

We recognize that we still have much work to do. As a state university, our hope is to better reflect the demographics of the state. As software engineering faculty, we aim to continue to increase gender diversity, while also improving our balance of ethnic, economic and viewpoint diversity. We've only just begun to think about these other types of diversity. We recognize that the diversity and convictions of department faculty are key. For example, an instructor recently organized a group of students to attend a Lesbians Who Tech conference. Another instructor advises Christian and Asian-American clubs on campus, and they recently started working with a predominantly Hispanic-serving institution partially in hopes of learning ideas for helping that population at Cal Poly. The SE faculty hope to create an inclusive, diverse, and welcoming SE club that includes social events, mentoring, and early gathering of SE students such as in the CSC 123 course in order to meet each other and the SE faculty.

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