LAunchPad: The Design and Evaluation of a STEM Recruitment Program for Women

Cheryl K. DeMatteis
Rossier School of Education
University of Southern California
Los Angeles, California, USA
cdematte@usc.edu

Emily L. Allen and Zilong Ye
College of Engineering, Computer Science, and Technology
California State University, Los Angeles
Los Angeles, California, USA
eallen3@calstatela.edu, zye5@calstatela.edu

Abstract*— *This paper presents the design and evaluation of a university-sponsored summer STEM recruitment program for young women between their junior and senior year in high school. The College of Engineering, Computer Science, and Technology (ECST) currently has a female enrollment of only 15%, which is below the national average of 20%. The College has set a goal of increasing the percentage of women to 25% by 2025. The recruitment program described in this paper is one of the strategies the ECST will use to reach its goal. The objectives of the recruitment program, LAunchPad, were to increase the students' interest in engineering and computer science, and to achieve a 50% participant matriculation rate into the College of Engineering, Computer Science, and Technology. LAunchPad established a gender-inclusive learning environment, with scaffolded instruction and hands-on activities to reinforce the learning. The students were also introduced to two groups of female role models; the first group was early-career alumni that held technical positions with local companies, and the second group was mid- to senior-level engineers, computer scientists, and executives. A post-event survey revealed that the students' interest in pursuing an engineering or computer science career increased by 29%; seventy percent applied for admission to the University for the following Fall. Results suggest that contributing factors to the students' increased interest are an increased understanding of engineering and computer science, increased confidence, access to diverse role models, and the ability to establish peer networks.

Keywords—STEM, recruitment

I. Introduction

Women are underrepresented in engineering and computer science fields of study. In universities, although women enroll in college at a higher rate than men, they enroll in STEM at disproportionately lower rates. The 2016 National Science Board (NSB) Science and Engineering Indicators report described the persistent gender gap in engineering [1]. For example, in 2007 women declared engineering as a major 10% less than men, and the 2013 graduation rates were lower for women in engineering by 7%. Locally, some state universities see similar trends regarding enrollment, but experience higher gender gaps in their engineering and computer science programs.

California State University Los Angeles (CSULA) is a comprehensive public university with the mission to serve the local population. Hispanics comprise 63% of the student body and 73% of the students identify as low income, first generation to attend college. The University was recently ranked number one in the country in upward mobility by the Equality of Opportunity project. [1] The percentage of women at the university has hovered around 60% over the last decade (see Figure 1); however, within the College of Engineering, Computer Science, and Technology (ECST) that percentage has been close to 15% (see Figure 2). The University has increased enrollment from 16,000 ten years ago to the current level of 28,000, and much of this growth occurred in STEM programs; the College of ECST enrollment has almost tripled in the last five years. Even though the number of women has increased from nearly 200 to nearly 500 over the last decade, the percentage remains below the national average. Over the same decade, many highly selective universities have increased the percentage of women significantly in both engineering and computer science to above 40%, this remains a challenge at institutions which serve a local access mission and for which the engineering college does not have control over admissions. Strategies available must most focus on recruiting women from our "service area," and on retaining women in the College. To increase the enrollment rates of women, the College of ECST developed a summer STEM recruitment program for high school women: LAunchPad.

[1] "Mobility Report Cards: The Role of Colleges in Intergenerational Mobility," Raj Chetty, Stanford University and NBER, John N. Friedman, Brown University and NBER, Emmanuel Saez, UC-Berkeley and NBER, Nicholas Turner, US Treasury, and Danny Yagan, UC-Berkeley and NBER (January 2017). Available at http://www.equality-of-opportunity.org/

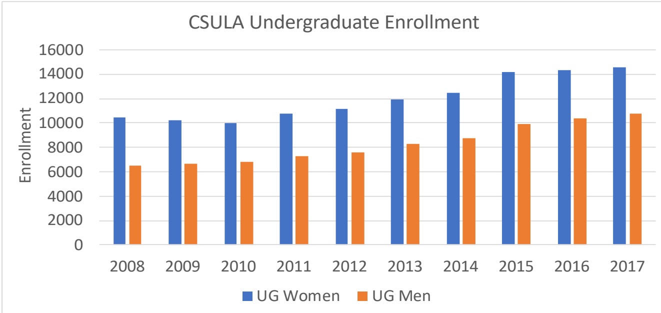

Fig. 1. CSULA Enrollment Data by Gender

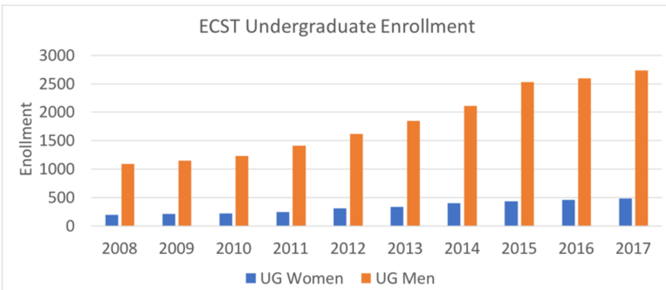

Fig. 2. College of ECST Enrollment Data by Gender

II. LAunchPad Program Design and Delivery

The LAunchPad program is a summer STEM recruitment program focused on increasing the enrollment of women into the CSULA College of ECST. The program objectives are to increase the participants' understanding of computer science and engineering, to allow them to gain hands-on practical experience in multiple areas of engineering, and to introduce them to female role models who work as engineers. Participation in hands-on learning activities and exposure to female role models have demonstrated a positive impact on women in engineering and computer science [2]. The design of the program activities used scenarios that would be beneficial to the environment and would allow the participants to extend simple concepts into ideas that would be helpful to others. Demonstrating that engineering and computer science can be used to improve the environment and help others can have a positive influence on field of study and career choices of women [3][4].

The program exposed the participants to various disciplines such as Civil Engineering (CE), Mechanical Engineering (ME), Electrical Engineering (EE) and Computer Science (CS). The participants were involved in interactive lectures and extensive hands-on labs and projects. For example, the participants (1) performed environmental research (e.g., hydrology labs and climate research) during their CE sessions, (2) built smart-phone controlled robotics in their ME and EE sessions, and (3) learned basic Python programming skills and conducted machine learning and data science projects in the CS sessions. Through these activities, it was expected that at the end of the LAunchPad summer program, the participants would be able to differentiate between different disciplines in the ECST college, and envision themselves as engineers and computer scientists in the future.

The LAunchPad program was developed by a team of five faculty (from CE, CS, and ME), several industry partners, a graduate student from a neighboring university, two student success staff and five student assistants from the college. The faculty were responsible for developing the technical content and delivering the interactive lecture and labs, while the student assistants helped the participants with the lab activities. The student success staff were responsible for coordinating the events and communicating with the students before and after the summer program. The industry partners provided input based on their experience as women in the field of engineering, and the graduate student designed and implemented the evaluation of the program.

A. LAunchPad Activities

The theme of the summer program was to learn how engineering and computer science can make the world a better place. Environmental research was chosen as the overarching theme, which guided the development and design of the program activities. In the CE session, the participants learned background knowledge of environmental research, e.g., how to sample the air/water data and how to evaluate the quality of air/water. In the EE and ME session, the participants learned how to build, program and control a robot (with the ultimate purpose of being able to navigate the robot to collect environment samples in places that are not easy for human to reach). Eventually, in the CS session, the participants learned basic programming skills and machine learning techniques to utilized data science analyses, e.g., predict forest fires or climate change. Table 1 provides the program agenda and schedule and the details of the program activities, by discipline, are described in the following sections.

1) Civil Engineering

The CE sessions consisted of two topics: climate research and hydrology research. The climate research session explored the drivers of climate change, the carbon cycles, human activities that contribute to the increase of carbon emissions, and sustainability practices that can decrease the carbon emissions. The participants performed labs and exercises through online simulations [5][6], and they practiced drafting an environmental sustainability action plan using EPA E3 sustainability tools [7]. In the hydrology session, the participants were involved in many hands-on activities to study how to measure the water quantity and quality. They performed water velocity measurements through using manual methods (distance traveled over time) and sensor-based methods. They also participated in a competitive water purification exercise using plastic bottles, sand, coffee filters, cotton balls and Erlenmeyer flask to build a filtration system to clean the dirty water. During the CE session, students gained basic knowledge of environmental research and learned the importance of protecting the earth and preserving resources for sustainability development.

2) Mechanical and Electrical Engineering

The ME and EE sessions focused on building a robot using an Android™[2] cell phone. The participants were involved in various hands-on experiments related to mechanical design, circuit design, and logic programming. They first learned the basic elements of a circuit diagram and how to design the circuit diagram for a robotic simple differential drive system. Then, they mounted wires and assembled the electronic components to build a robot. After the above hardware development was finished, they received instruction on how to use the MIT App Inventor [8] and conducted logic programming to control the robot using a smart phone. More specifically, they used the modular components in the App Inventor to program the robot to perform some actions based on voice commands. In addition, the robot can be navigated to places by following some routines. At the end of the ME and EE sessions, the participants gained hands-on experience and received fundamental training in both hardware and software design.

3) Computer Science

In the CS sessions, the participants first learned basic programming skills, such as flowchart design, sequential programming, selection/branch and iterations (while/for loops). Python was selected as the programming language for this event because it is easy to learn and use for beginners and also it is widely used in many machine learning and data science projects. After the students learned basic coding skills, they were exposed to fundamental machine learning techniques, such as linear regression and classification. During the hands-on labs, they applied what they have learned to real-world computer science applications. They practiced using these techniques to perform big data analysis, such as predicting forest fire risks and predicting climate changes. Basic aspects of computer programming, machine learning, and data analytics were used as tools to help the participants to explore and solve real world problems in engineering and computer science fields.

4) Other activities

In addition to the above in-class activities, field trips were organized to expose the students to industrial worksites (e.g. Disney Imagineering) were they could see first-hand what real-world engineering projects are being performed by diverse teams of engineers and computer scientists. The students were also treated to the IMAX version of the film “Dream Big” to learn how a diverse population of engineers can develop solutions that make the world a better place.[3] To further motivate the participants to choose engineering and computing related majors, two groups of female engineers and computer scientists were brought in for a panel discussion with the participants. The topics of discussion included the challenges that women encounter in the workplace, the hurdles that each of the panelists overcame to become successful, and the benefit of engineering and computer science careers. In the second week of the summer program, the participants worked in groups and participated in a “Futurethon” competition, in which they proposed a project that they would be working on as an engineer in the year of 2025. The participants worked with an industrial partner on defining a project, pitching their ideas and designing solutions to address the engineering challenges based on what they learned in the engineering lecture and labs.

TABLE I. LAUNCHPAD AGENDA AND SCHEDULE

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1					
Morning 9am – 12pm	Welcome Ice Breaker Engineering Activity	CS: Python Basics I	CS: Python Basics II	CS: Python Basics III	Field Trip –Science Center “Dream Big – Engineering Our World”
Lunch 12pm – 1pm			Industry Guest Panel		
Afternoon 1pm – 4pm	CE: Atmosphere I	CE: Atmosphere II	CE: Hydrologic I	CE: Hydrologic II	Field trip – Industry Location
Week 2					
Morning 9am – 12pm	CS: Data Science and Python	CS: Data Science and Python	CS: Data Science and Python	CS: Data Science and Python	Presentation Prep ECST Lab Tours
Lunch 12pm – 1pm			Industry Guest Panel		
Afternoon 1pm – 4pm	ME: Robotics I	ME: Robotics II	ME: Robotics III	ME: Robotics IV	Presentation Rehearsal

[2] Android is a trademark of Google LLC.

[3] https://www.dreambigfilm.com/

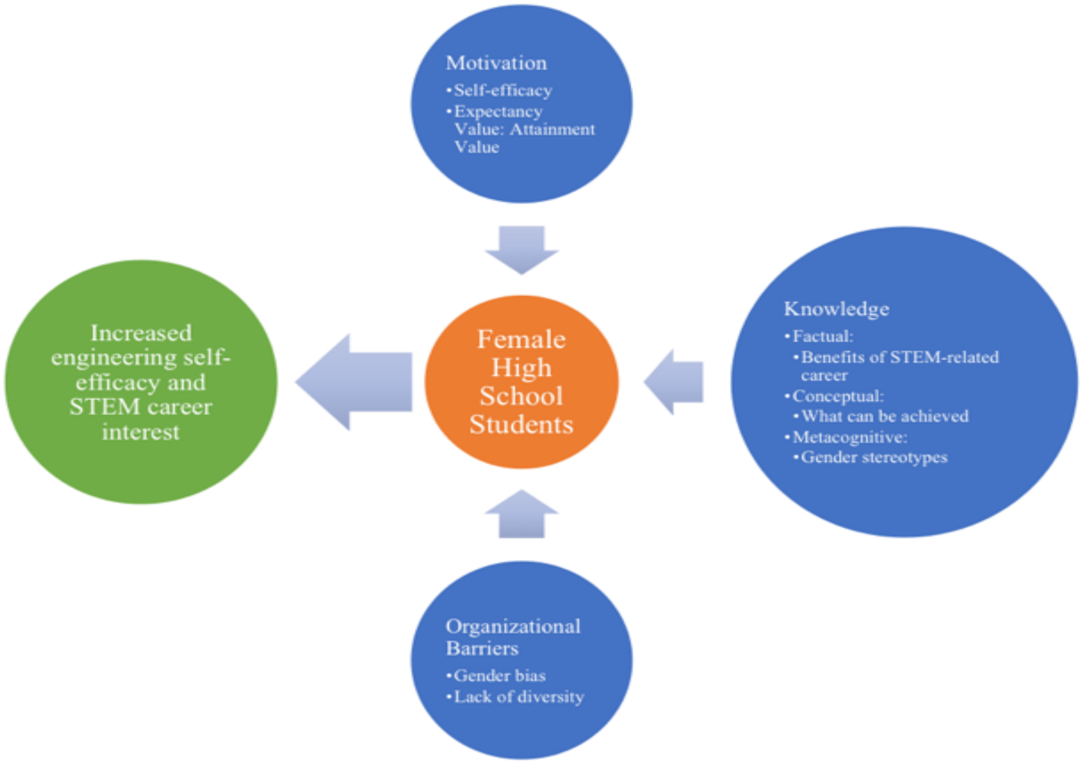

Fig. 3. Conceptual Framework

B. *Purpose of the Study*

The evaluation focused on determining the effectiveness of the LAunchPad program, and the research component performed a Clark and Estes [9] gap analysis of the assumed knowledge, motivation, and organizational factors that affect the lower enrollment rates for women in engineering and computer science [10]. The research questions that guided this study were:

1. What are the knowledge, motivation, and organizational factors that contribute to the STEM-related career decisions and field of study selections that female high school students make?
2. What knowledge, motivation, and organizational factors does the LAunchPad program influence such that the female high school student participants are more likely to enroll in engineering or computer science, and/or pursue a career in engineering or computer science?
3. What are the recommended knowledge, motivation, and organizational solutions that will increase the number of female students that choose a STEM-related career, resulting in an increased enrollment of female students in the CSULA College of ECST?

This paper will focus on research question 2.

III. Methodology

A. *Conceptual Framework*

Diversity in STEM is a limitless topic that has been studied by many. As a research topic, STEM diversity would be intractable without narrowing the focus. The application of the Clark and Estes gap analysis, an approach to diagnosing and providing solutions to organizational performance problems, was used to narrow the focus of this study and provide the conceptual framework, shown in Figure 3. The assumed knowledge factors that influence young women are knowledge of the benefits of a STEM-related career, knowledge of what can be achieved with a STEM-related career, and self-knowledge of gender stereotypes. The assumed motivational factors that affect the female students are self-efficacy and attainment value.[4] The assumed organizational barriers are gender bias and lack of diversity in role models.

B. Data Collection

The research design used for this study was a transformative convergent parallel mixed methods approach (Creswell, 2014). A combination of surveys and observations were used to collect data for this study. Three surveys were administered for this study, two written surveys and one administered via email. The first survey was administered to all students during the morning of the first day of the LAunchPad program. The second survey was administered at the end of the program during the afternoon of the final day. The third survey was administered via email three months after the conclusion of the program. Each survey took no longer than 30 minutes and was based on two existing survey instruments: (1) a validated Assessing Women and Men in Engineering (AWE) Pre-College Longitudinal Assessment of Engineering Self-Efficacy (LAESE) survey [10], and (2) a pilot-tested survey developed by Dr. Lisa Flores and Dr. Rachel Navarro (L. Flores & R. Navarro, personal communication, May 16, 2017). The Flores-Navarro survey used components from work done by Dr. Robert Lent (L. Flores, personal communication, January 10, 2018). In addition to the surveys, observations were performed by the researcher throughout each day of the two-week LAunchPad program.

IV. Analysis and Results

A. Program Participants

The participants were recruited by the CSULA Mathematics, Engineering, Science Achievement (MESA) program coordinator, from 15 local area high schools. The selected students needed to identify as female, be between their junior and senior year in high school, and attend a high school that was considered within the CSULA local service area. The goal was to select students from each of the nominating high schools in groups of two or more, but not too large; instances of a single student from one high school or dominating groups were avoided . A majority of the students identified as Latina/Latino (61%), and Asian Pacific American (29%); if they pursue a college degree, most of them will be first generation college graduates. In addition, the median GPA for the group of students was 3.94, with a standard deviation of 0.51. The LAunchPad program began with 28 participants on the first day; one student dropped out on the third day, reducing the number of participants that completed the two-week program to 27. The response rates for the first and second survey were 100% with n= 28, and 26 respectively. The response rate for the third survey was 63%, n=17.[5]

B. Results

The surveys evaluated the impact the LAunchPad program had on the participants in the context of the engineering and computer science intent, college intent; and knowledge, motivation, and organizational influences. Furthermore, survey questions measured the participants' intent to enroll in college, an engineering and/or computer science field of study, and CSULA.

1) College and Engineering Intent

All of the LAunchPad participants indicated that there was 100% chance that they would be going to college. When asked what was the chance that they would study engineering or computer science, the median of their students demonstrated an increased intent in pursuing engineering or computer science after the LAunchPad program. The students were asked to use a sliding scale to declare what the chance was, in percentages, that they would study engineering or computer science. At the end of the program, the median response increased from 65% to 78% between the pre-LAunchPad and post-LAunchPad surveys (see Figure 4), and from 75%, to 88%, and 96% respectively across all three surveys (see Figure 5). Furthermore, 70% of LAunchPad participants submitted their college application to California State University Los Angeles: 58% of the applicants applied to ECST, 32% applied to other STEM majors, and 11% applied to non-STEM majors.

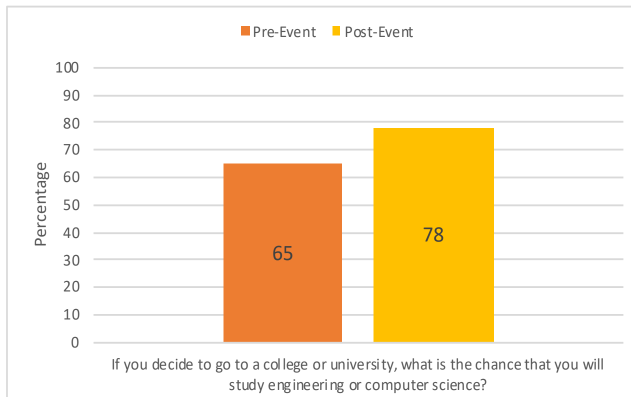

Fig. 4. Median responses at the end of the program (n=26).

[4] Attainment value is one of the four concepts within Eccles' expectancy value theory and is the connection that an individual has between the task at hand, and their personal identity and preferences [11].

[5] One of the surveys was lost, so n=26 for the second survey even though 100% (27) of the surveys were completed and submitted.

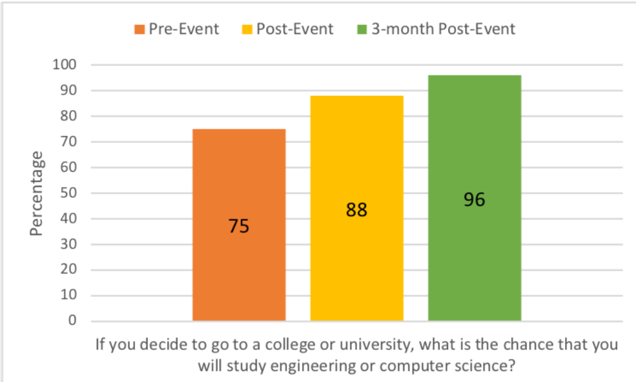

Fig. 5. Median responses across all three surveys (n=17).

2) LAunchPad Impact

The LAunchPad participants were asked about the impact the program had on topics such as their understanding of engineering and computer science, their career goals, and their confidence. The following Figures (6 – 11) illustrate the participants responses to the questions asked in the post-LAunchPad survey. The responses were 100% positive, and the questions that received the strongest positive response were those regarding the impact on the students' understanding of engineering and computer science, and their understanding of their own career goals.

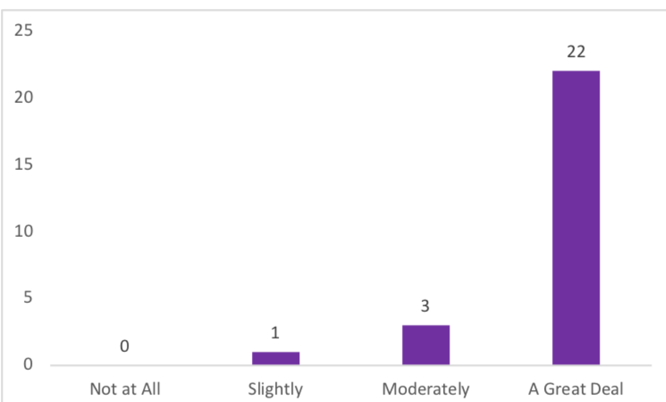

Fig 6. Question: How much did participating in LAunchPad help me understand Engineering better? 85% of the students responded with *A Great Deal* (n-26)

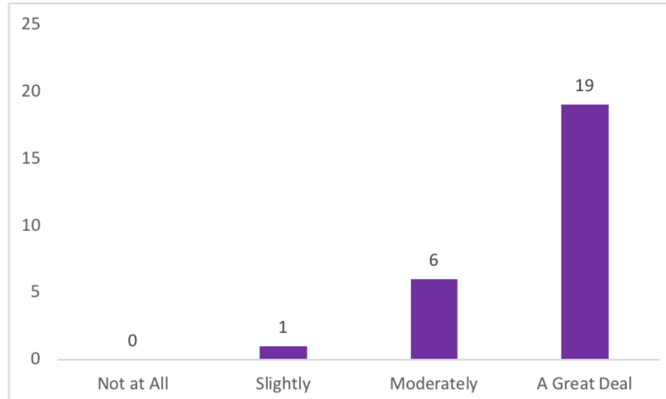

Fig 7. Question: How much did participating in LAunchPad help me understand Computer Science better? 73% of students responded with *A Great Deal* and 23% responded with *Moderately* (n=26)

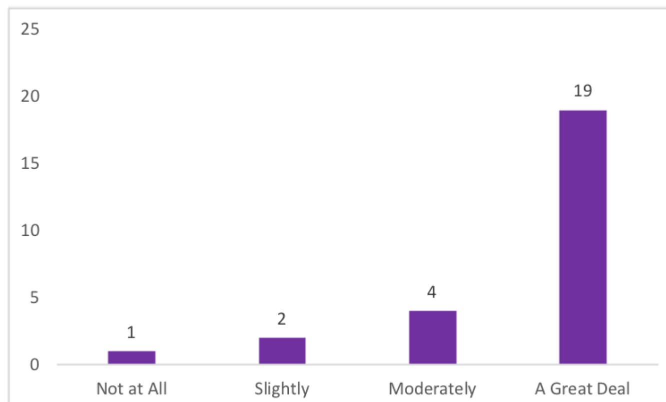

Fig 8. Question: How much did participating in LAunchPad make me think more about what I will do after graduating from high school? 73% of students responded with A Great Deal, 15% responded with Moderately (n=26).

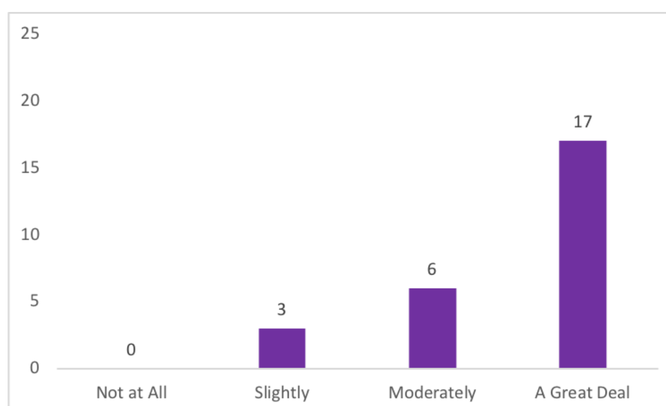

Fig 9. Question: How much did participating in LAunchPad increase my confidence in my ability to participate in computer science and engineering projects or activities? 65% of students responded with *A Great Deal*, 23% responded with *Moderately*, and 12% responded with *Slightly* (n=26).

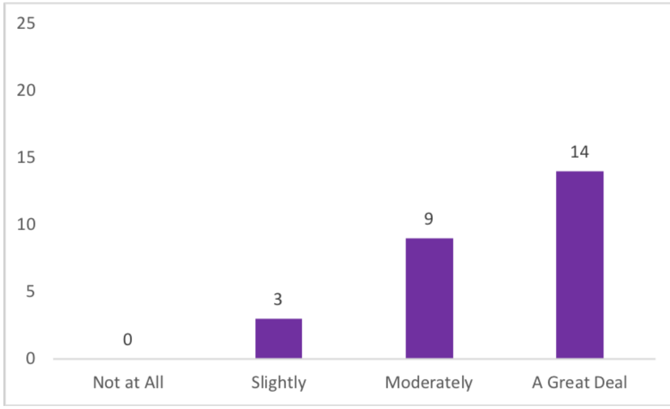

Fig 10. Question: How much did participating in LAunchPad lead me to a better understanding of my career goals? 54% of students responded with *A Great Deal*, 35% responded with *Moderately*, and 12% responded with *Slightly* (n=26).

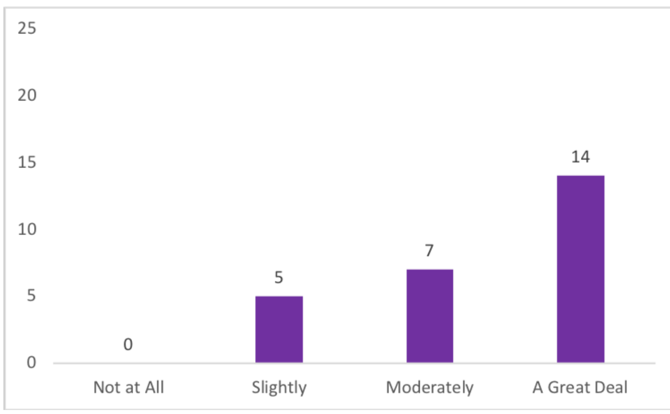

Fig 11. Question: How much did participating in LAunchPad increase my interest in studying computer science or engineering in college? 54% of students responded with *A Great Deal*, 27% responded with *Moderately*, and 19% responded with *Slightly* (n=26).

The positive nature of the responses described in Figures 6-11 persisted in the 3-month post-LAunchPad survey. Moreover, the responses to the open-ended aspect of the survey questions reinforced these results. The qualitative data analysis (coding) produced 30 instances of statements regarding a better understanding of engineering and computer science; the students attributed their increased understanding to LAunchPad. One student stated that what she liked about the program was "that [she] was able to learn more about the different engineering fields. It allowed [her] to understand engineering better to decide which field to go into." Eight of the students discussed increased confidence in their responses, and attributed this increase to the LAunchPad program. For example, one student claimed "after LAunchPad, I became more confident in my math skills," another asserted that "I am also more confident in my abilities to become an engineer." In addition, an analysis of the open-ended survey questions revealed that the students were positively impacted by the panelists. Their responses claim that the panelists made a positive impact by showing them "that it was possible to pursue an engineering career even if you're female." In addition, there were nine responses that discussed the networking opportunities that were made possible through the LAunchPad program. One student discussed that she "was able to meet people with interests like mine," and another "liked being able to talk with others with similar interests."

3) Limitations

The participants in the LAunchPad program were all female high school students who had either demonstrated an interest in STEM through the MESA program or were nominated for the program by a high school teacher because of their classroom performance. The results of this study cannot be generalized to a broader population. Nevertheless, the LAunchPad participants indicated increased interest in engineering or computer science at the conclusion of the program and 70% of the participants applied to CSULA.

V. Implications

Recommendations for improving the LAunchPad program were developed using The New World Kirkpatrick Model [12]. If implemented, it is expected that the LAunchPad program will result in increased interest in engineering and computer science by the participants, which will in turn contribute to the ECST organizational goal of increased enrollment by women. To increase the effectiveness of the LAunchPad program, the following recommendations were provided:

- Knowledge: Provide the students with information about the accomplishments they will be able to achieve with a degree in engineering or computer science.
- Motivation: Use scaffolded instruction with frequent hands-on activities; increase the use of speaker panels to introduce positive role models; and use materials and examples that focus on solving real-world problems and helping people.
- Organization: Provide training on gender-inclusive pedagogy to the faculty, administrators, and volunteers that will be involved in LAunchPad, increase the number of women faculty and graduate students who are involved in LAunchPad, and create a more gender-inclusive environment.

Although the results of this study are limited, they are encouraging. The young women who entered the LAunchPad program demonstrated math and science self-efficacy, but they did not believe they could complete a degree in engineering or computer science. However, 70% of the LAunchPad participants applied to CSULA in the Spring: 58% of the applicants applied to the ECST, and 32% applied to other STEM majors. The LAunchPad program showed promising results as a pilot program. The participants demonstrated increased knowledge in several areas: understanding engineering and computer science, and career goals. In addition, they demonstrated increased confidence in their ability to succeed in computer science or engineering, and an increased interest in studying computer science or engineering in college. Furthermore, they were positively impacted by the female panelists that were brought in to discuss their experiences, and the ability to establish peer networks.

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