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Assessing the Impact of Research Experiences on the Success of Underrepresented Community College Engineering Students

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Assessing the Impact of Research Experiences on the Success of Underrepresented Community College Engineering Students

Abstract

Cañada College, a Hispanic-Serving community college in California's Silicon Valley attracts a large number of students from traditionally underrepresented groups in engineering. Although many of these students enter with high levels of interest in engineering, their success and completion rates have been low due to a number of factors including low levels of preparation for college-level work, especially in math; lack of awareness of academic and career options; lack of financial, academic, social and cultural capital needed for success; and lack of self-efficacy (i.e., students do not believe that they can succeed in engineering). To address these barriers to student success, Cañada College developed and implemented a number of programs to keep students engaged and motivated towards achieving their academic goals. Among such programs is the *Creating Opportunities for Minorities in Engineering, Technology, and Science* (COMETS) program. Funded by a four-year grant from NASA through the Curriculum Improvements Partnership Award for the Integration of Research (CIPAIR) program, COMETS was developed through a collaboration with San Francisco State University – a large, comprehensive, urban university. The program aims to help students develop the skills they need for academic success, as well as provide exposure to the major fields of engineering in order to help solidify their particular areas of interest. Among the strategies developed through COMETS is a summer internship program designed specifically for community college engineering students. During the ten-week internship program, 16 freshmen and sophomore community college students are divided in to four research groups based on their academic interests and academic preparations. Each group consists of four interns, one full-time intern (a student who has completed most of the courses needed for transfer) and three half-time interns, and is supervised by a university faculty adviser and a graduate student mentor.

This paper presents the results of four years of implementation of the COMETS internship program, including the outcomes of the research activities of the participants and their perception of their research experiences. The paper will also discuss the impact of the program on strengthening students' identity as engineers and researchers; increasing student interest to further engage in research activities; and enhancing student self-efficacy for successfully transferring to a four-year university, completing a baccalaureate degree in engineering, and pursuing a graduate degree. It will also highlight lessons learned and future plans for the program, as well as best practices that are useful to other institutions in developing similar programs.

1. Introduction

The PCAST Report *Engage to Excel*: *Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics* states a critical need to dramatically increase the number of STEM graduates over the next decade. The report cites the low completion rate among STEM students, with many leaving the STEM field in the first two years of their program. Among the recommendations to address this issue of low completion rate is to engage students with research experiences in the first two years by funding implementation of research courses for students in the first two years, and establishing collaborations between research universities and small colleges, such as community colleges, to provide all students access to research experiences.[1]

There are many studies documenting the benefits of research opportunities for undergraduate students. Independent research experiences increase student engagement in their education[2-4], enhance research and laboratory skills[2-6], improve academic performance[4,7,8], increase understanding and interest for their discipline[2-6,9-12], strengthen oral and written communication skills[12,14], enhance problem solving and critical thinking skills[13,14], and enhance self-efficacy[14,15]. For students from traditionally underrepresented groups, the benefits may be even greater when compared to students from majority groups[3]. For underrepresented students, deep engagement in undergraduate research with a faculty mentor is positively correlated with improvement in student grades, retention rates, persistence to graduation, and motivation to pursue graduate school[16-19].

2. Overview of COMETS Program

A growing numbers of studies show that early and multiple exposures to undergraduate research experiences offer the greatest benefit. However, a recent extensive study of Research Experiences for Undergraduates (REU) programs shows that 91% of these research experiences are provided to junior and senior students[20]. Developing and implementing successful undergraduate research programs is particularly challenging in community colleges, most of which do not have on-going research programs. Establishing collaborations between research universities and community colleges is key to engaging students in research early in college.[1]

Cañada College's Creating Opportunities for Mathematics, Engineering, Technology, and Science (COMETS) program is a collaborative project with San Francisco State University. Cañada College is a Hispanic-Serving community college in California's Silicon Valley while San Francisco State University – a large, comprehensive, urban university. Funded by NASA through the Curriculum Improvements Partnership Award for the Integration of Research (CIPAIR) program, the COMETS program was developed to provide opportunities for underrepresented community college students to excel in STEM. Among the strategies developed through COMETS is the development of a research internship program that is specifically designed for freshmen and sophomore community college engineering students.

A focus group of engineering students at Cañada College identified common barriers to a successful research internship program for community college engineering students. For most undergraduate research internship positions, community college students are in competition with upper-division students who have taken more advanced and specialized courses, and are from four-year institutions that have provided students with exposure and access to research-quality laboratory facilities. Perhaps an even bigger barrier is the need for many of these community college students to attend summer session in order to fulfill the various transfer requirements of the institutions and programs to which they intend to apply. Due to the diversification of requirements of different majors and different institutions, community college students often take more classes compared to their counterparts in four-year institutions.[21] Since most summer research internship positions are full-time, community college students who are interested in participating in internship programs are often faced with the difficult choice between accepting a summer internship position or taking summer courses to ensure their timely transfer.

The ten-week COMETS Summer Research Internship Program has been designed to include full-time positions for students who have completed all lower-division course work, and half-time positions for students who have at least another year in a community college before transfer, in order to allow them to take courses they need for transfer while participating in the internship program. For the 2011 and 2012 COMETS internship programs, three research groups were formed, one in civil engineering, one in computer engineering, and one in electrical engineering. For the 2013 and 2014 internship programs, the mechanical engineering group was added. Each group consists of one full-time intern and three to four half-time interns. Each group is mentored by a half-time graduate student under the supervision of a university faculty.

Demographics of Program Participants

Selection of COMETS interns is done through an online application process that takes into consideration student GPA, intended major, STEM courses completed (minimum requirement is completion of the first semester physics course), extracurricular activities, statement of academic and professional goals, statement of research interest, and a recommendation letter from a STEM instructor. Although the primary consideration for assigning students to a particular research group is their declared major, student academic preparation (specifically engineering courses completed) is taken into consideration to ensure that they have the recommended background knowledge needed for the research projects.

Table 1. Demographics of 2011, 2012, 2013, and 2014 Summer Research Internship Program participants.

Demographics	**2011**		**2012**		**2013**		**2014**	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Gender								
Male	10	83.3%	11	84.6%	13	81.2%	11	68.8%
Female	2	16.7%	2	15.4%	3	18.8%	5	31.2%
Total	12	100.0%	13	100.0%	16	100.0%	16	100.0%
Ethnicity								
American Indian	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Asian	2	16.7%	0	0.0%	1	6.25%	3	18.8%
Black	0	0.0%	1	7.7%	1	6.25%	2	12.5%
Hispanic	10	75.0%	9	69.2%	11	68.75%	9	56.3%
Pacific Islander	0	0.0%	2	15.4%	1	6.25%	0	0.0%
White	0	8.3%	1	7.7%	2	12.5%	2	12.5%
Total	12	100.0%	13	100.0%	16	100.0%	16	100.0%

Table 1 summarizes the demographics of the community college students who participated in the COMETS summer research internship program in 2011, 2012, 2013, and 2014. Interns were predominantly male and Hispanic. Efforts have been made to increase participation among female students such that the number of female students in the program increased from two in both 2011 and 2012 to five in 2014. The program has been successful in recruiting underrepresented minorities (African American, Hispanic, and Pacific Islanders); about 80% of participants are from underrepresented minority groups.

Research Topics

The research topics and research activities assigned to the internship program participants were decided by the San Francisco State University faculty mentors based on students' level of preparation, existing research initiatives in the university, and the availability of graduate student mentors in these areas.

The 2011 Civil Engineering group conducted research on seismic systems, structural design, and time history analysis. Much of the research focused on moment-resisting frames; students relied on building codes to ensure the safety of the structure, and used the Equivalent Lateral Force Procedure (ELFP) to determine the loads and stresses of the structure. The interns also conducted research on time history analysis, which involves dynamic analysis of structures. Four sets of earthquake data – Landers, Loma Prieta, Kobe, and Northridge Earthquakes – were integrated into the simulation. Using Structural Analysis Program, SAP2000, students were able to examine story drift, and the bending of the structure's members. In addition to learning about Earthquake Engineering, the interns also developed and facilitated an interactive presentation to high school students to encourage them to pursue careers in math, science and engineering. Lastly, the interns created tutorials and videos to help improve community college and university engineering curriculum.

The 2012 Civil Engineering group focused on performance based seismic analysis of moment-resisting frames, and applied them to the design a five-story steel moment-resisting frame in the earthquake-prone San Francisco Bay Area, California near the Hayward fault. SAP2000 and MS Excel were used to design, simulate and analyze the structure. These analyses techniques were also applied to the design of space structures (such as space station) against similar seismic activities on other planets for human space exploration.

The 2013 Civil Engineering group worked on the design of a lateral-force resisting system for a three-story building in the earthquake-prone San Francisco Bay Area, California. Their design utilized steel plate shear walls as the structure's lateral-force resisting system, exploring how to implement current seismic technologies into a cost-efficient and environmentally friendly design. In addition to computer based analysis with SAP2000 and MS Excel, the students gained early exposure to governing building codes through the use of structural engineering and seismic design specifications such as ASCE 7-10 (American Society of Civil Engineering) and AISC 341-10 American Institute of Steel Construction). The students used SAP2000 to simulate and evaluate the response of their designed structure to selected ground motions from past earthquakes acquired from the USGS Pacifica Earthquake Engineering Research Center.

The focus of research for the 2014 Civil Engineering group was on real-time hybrid simulation of seismic response of large civil engineering structures. The purpose of the project was to evaluate the effects of delay on real-time hybrid simulation by comparing delayed and actual responses. MATLAB and Simulink were used to simulate the analytical and the experimental model responses for different cases of degradation. For 100 ground motion records and a maximum considered error, critical delay was calculated and its lognormal distribution parameters determined.

The 2011 Electrical Engineering group completed research on creating a data logger from a printed circuit board that records pressure and temperature changes due to magnets implanted inside of a patient with a hollow chest condition. The magnets gradually pull the sternum outwards to realign with the ribcage, and the data logger is designed to monitor subtle changes within the patient in real time. Creating the data logger required the use of software such as OrCAD Capture and PCB Editor. The group's responsibility was to construct the data logger so it can be manufactured into either a two-layer, or a six- layer printed circuit board. This involved gathering all the necessary datasheets and information on manufacturing capabilities, creating footprints for the components used, generating a bill of materials and a netlist, drawing a board outline and placing parts within the board outline, routing the board, producing the artwork, and generating the necessary manufacturing files.

The five interns in the 2012 Electrical Engineering group were involved in designing a world's smallest power harvesting apparatus for implantable medical devices (IMDs). Two of the five students engaged in circuit simulation using LT-SPICE to predict the device's performance. Two students were involved in programming the micro-controller, which controls the operation of the power harvest apparatus, and characterizing its performance. Another student designed and winded spiral coils used to harvest time-varying magnetic field. After students became familiar with the system, they were asked to improve the existing device by re-designing the electronic circuitry using the printed circuit board (PCB) technology altogether.

The 2013 Electrical Engineering group worked on the optimization of the wirelessly powered AC-DC boost circuit for power harvesting in IMDs. The students again utilized LT-SPICE to model the device's performance, and conducted significant tests to maximize power transfer through adjustment of the microcontroller-based transmitting circuitry and careful measurement of the device performance. Emphasis was placed on completely redesigning a PCB layout, and the group went through extensive revisions to finally arrive at an optimal and minimally sized design.

The 2014 Electrical Engineering group worked on integrating electromyography (EMG) sensors into the wireless control system of a wheel-based robot utilizing Bluetooth. The system involved the development of an algorithm that converts the changes in electric potential across muscles into digital signals that are interpreted as executable commands by the robot. A secondary specification of the interpretation algorithm was consistency across many users, regardless of minor variations in EMG sensor placement and muscle characteristics. The final outcome of this project is the development of an inexpensive platform of both hardware and software that can be ported to broader hands-free and handicap-friendly applications that require wireless control of device.

The 2011 Computer Engineering group worked on developing curriculum on Embedded Systems for graduate courses at San Francisco State University using an educational development board called Altera FPGA to understand embedded systems utilizing the Quartus II design software and the Verilog programming language. Additionally, instructional materials on using the educational development board were developed for upper-division and graduate courses in computer engineering. Despite the participants' limited prior knowledge of embedded systems, and limited previous experience or course work in computer engineering, the participants were able to achieve the program's major goals. Among the materials produced were instructional videos and laboratory manuals on a variety of topics including an Introduction to the DE2-115 Development and Education Board, Hardware Design Flow Using Verilog in Quartus II, and Hardware and Software Codesign Flow.

The focus of the 2012 Computer Engineering research group was on the analysis of performance degradation of integrated circuits due to transistor aging effects in nano-scale. In this research, analysis of transistor breakdown was performed through computer simulations to understand effects on circuit power and performance. A ring oscillator circuit was utilized as a generic logic circuit for this research. The breakdown was modeled by resistors placed between the transistor terminals. The value of the resistor represents the severity of the breakdown; large resistors represent fresh transistors, whereas low resistors represent a fully broken transistor. In addition to computer simulations, real ICs were studied by taking power measurements experimentally. This research aims to offer better insight into the impact of transistor breakdown and to improve IC design in nano-scale. Through this internship program, the undergraduate students not only contributed to research and discovery, but also gained valuable experience and knowledge of nano-scale circuits that could have not been achieved in traditional educational methods. Their research results show that the performance of integrated circuits degrades and the power consumption increases by transistor aging effects. They verified this observation by not only simulations but also experiments on an actual test chip.

The 2013 Computer Engineering group worked on the modeling and implementation of a brain-inspired neural network for edge detection and object recognition. Their system collected and analyzed data from a computer webcam with a software model of photo-receptive retinal cells to simulate the biology of the object recognition brain process. Each student in the group worked on a separate software module of the design. The various modules developed included functions to collect data from the webcam, a set of different eye cell stage functions, and an overall program to tie all the function modules together.

The 2014 Computer Engineering group's work built upon the results of the work done in 2013 on modeling and implementation of a brain-inspired neural network for edge detection and object recognition. In order to optimize previously developed software, the program was migrated from C++ language to MATLAB, thus, incorporating the ability to implement the new code in hardware. In addition, they applied Gabor filter functions for edge detection, which allows the detection of multiple edges in the same image an improvement to the previous version of the software. Another improvement was the use of multiple simple and complex cell functions to scan the image frame, allowing a better simulation of the biological brain function.

In 2013 the COMET's program was expanded to include a Mechanical Engineering group. The four interns in the group worked on the development of a low-cost dynamic plant and data acquisition Haptic Paddle laboratory apparatus for use in teaching upper division topics in control theory, mechatronics, and haptics at San Francisco State University. The Haptic Paddle is a single degree-of-freedom force-feedback joystick that is well suited to be used as a test bed for exploring both basic and advanced topics in systems and control theory, mechatronics and haptics. The research project entailed mechanical modifications, manufacturing, and testing of haptic paddles. The group improved the haptic paddle's manufacturability and strength, and reduced data acquisition system costs. In addition to designing a number of critical haptic paddle components, we have also developed detailed instructions for manufacturing and assembling the device, simplifying its duplication for other engineering departments.

The 2014 Mechanical Engineering group worked on optimizing the performance of a Punchtec Connect XL 3D printer by creating an enclosed environment. By utilizing an Arduino microcontroller, CPU fan, thermocouple, LCD digital display, and heating elements, the temperature of the enclosure was controlled using a closed-loop feedback control algorithm. The CPU fan in combination with the heating elements creates heated air to flow into the enclosure while the thermocouple measures the temperature near the part. Using the Arduino to interpret commands from the user interface, multiple temperature profiles can be set. The enclosure was constructed from acrylic and has a volume of 13824 in^3. Various quantitative tests were performed to compare an enclosed versus a non-enclosed system, which included resistance to tensile test, hardness test, surface roughness measurement, and temperature precision to determine the quality of prints and the effectiveness of the enclosure.

Assessing the Impact of the COMETS Research Internship Program

In order to assess the impact of the research internship program, pre- and post-program surveys were developed and administered electronically to the participants. Prior to the 2014 internship program, the student surveys used were designed by the COMETS team members. This survey consists of a number of questions designed to measure students' perception of their possession of specific skills related to performing research, designing/performing an experiment, creating a work plan, working as part of a team, writing a technical report, creating a poster presentation, and making an oral presentation. These questions (with a response scale of “1” for “nothing” and “5” for “a lot”) were given immediately before and immediately after the program. Additionally, a set of post-program survey questions were asked to measure students' perception of the usefulness of and satisfaction with the internship program, including whether it has been helpful in preparing them for transfer, solidifying choice of major, increasing likelihood of pursuing graduate school, and increasing likelihood of applying for other internships. The responses were given in a Likert scale, “1” for “strongly disagree” and “5” for “strongly agree.” The pre-program survey was administered at the beginning of the first day of the internship program, following the orientation, and the post-program survey was administered immediately following the student final presentations at the end of the internship program.

For the 2014 internship program, an additional survey was given to the program participants. This new survey was adopted from the Survey of Undergraduate Research Experiences (SURE), which is as a tool for assessing undergraduate research experiences. The SURE consist of 44 items, including demographic variables, learning gains, and evaluation of aspects of summer programs[22]. An adaptation of the SURE was done for two undergraduate research programs that target underrepresented students (Hispanic, in particular) at California State University, Long

Beach[23]. The survey was designed to measure student motivations for engaging research, student research and academic goals, as well as their perception of their skills needed for research and academic success. This survey was adapted to the needs of the COMETS internship program for community college students, and given as part of the electronic pre- and post-programs surveys for the 2014 internship program.

3. Results

Results from 2011 to 2014 Surveys

A comparison of the post-program survey on student perception of skills learned from participating in the program is shown in Table 2. For each of the categories, the average response is between "Quite a bit" and "A lot." Note that from 2013 to 2014, a statistically significant drop in the average rating was observed for two items: "Performing research" [$t(1,28) = 4.44, \quad p < .001$], and "Designing/performing an experiment" [$t(1,26) = 2.42, \quad p < .025$]. Further investigation is warranted to determine reasons for this decline. It should be noted that one aspect that is different in 2014 compared to the previous years of the program is the prolonged absence of the overall program coordinator, which may have contributed to less structure and inability of some of the research groups to stay on-track. Additionally, one of the 2014 research groups was not able to commence the project in time because of the delay in the delivery of required equipment.

Table 2. Summary of student responses to the post-program survey measuring the perceived benefit of participating in the research internship program.

Question: How much did you learn about each of the following? 1 – Nothing; 2 – A little; 3 – Some; 4 – Quite a bit; 5 – A lot.	**Average Rating**			
	2011	**2012**	**2013**	**2014**
Performing research	4.7	4.8	4.9	4.3*
Designing/performing an experiment	4.7	4.9	4.9	4.5**
Creating a work plan	4.5	4.8	4.8	4.7
Working as a part of a team	4.8	4.8	4.8	4.6
Writing a technical report	4.5	4.8	4.6	4.5
Creating a poster presentation	4.7	4.7	4.7	4.6
Making an oral presentation	4.7	4.6	4.8	4.5

*The decrease from the 2013 average rating is statistically significant [$t(1,28) = 4.44, \quad p < .001$].

** The decrease from the 2013 average rating is statistically significant [$t(1,26) = 2.42, \quad p < .025$].

Table 3 summarizes the results of the post-program student survey for questions designed to measure perception of over-all usefulness of the research internship program in 2011, 2012, 2013, and 2014. Results show that the research internship program was successful in achieving its goals of helping students prepare for transfer, solidify their choice of major, increase their confidence in applying for other internships, and enhance their interest in pursuing graduate degrees. It should be noted that there is also a slight decrease in the average rating for certain areas, although not significantly difference from the previous years. Overall, students were satisfied with the program, and would recommend it to a friend.

Table 3. Summary of student satisfaction with the summer research internship program.

Question: Tell us how much you agree with each statement. 1 – Strongly Disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; 5 – Strongly Agree.	**Average Rating**			
	2011	**2012**	**2013**	**2014**
The internship program was useful.	4.8	4.9	4.9	4.6
I believe that I have the academic background and skills needed for the project.	4.2	4.1	4.6	4.4
The program has helped me prepare for transfer.	4.3	4.5	4.6	4.2
The program has helped me solidify my choice of major.	4.6	4.3	4.8	4.2
As a result of the program, I am more likely to consider graduate school.	4.7	4.6	4.1	4.0
As a result of the program, I am more likely to apply for other internships.	5.0	4.8	4.9	4.8
I am satisfied with the NASA CIPAIR Internship Program.	4.7	4.8	4.8	4.6
I would recommend this internship program to a friend.	4.8	4.8	4.9	4.8

<u>Results from New 2014 Surveys</u>

Results of the survey of student motivation for participating in research is shown on Table 4 for the 2014 participants. The biggest motivation for engaging in research as selected by students is to gain hands-on experience in research, followed by good intellectual challenge, and getting good letters of recommendation. Note that there are no statistically significant differences in the pre- and post-program responses of students. Also note that these results are very similar to those reported by the CSU Long Beach research programs for underrepresented students[23].

Table 4. Motivation to conduct research: Response Scale: 1 – Strongly Disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; 5 – Strongly Agree.

Prompt: I want to do research to:	**Average Response**	
	Pre	**Post**
Gain hands-on experience in research	4.81	4.86
Clarify whether graduate school would be a good choice for me	3.94	4.00
Clarify whether I wanted to pursue a STEM research career	3.94	3.94
Work more closely with a particular faculty member	4.13	4.06
Get good letters of recommendation	4.50	4.44
Have a good intellectual challenge	4.81	4.75

Result of the pre- and post-program surveys on student perceptions of their skills and knowledge needed for research and academic success are shown in Table 5. Of the 21 items in the survey, statistically significant gains are observed in only two areas: understanding of how knowledge is constructed [$t(1,27) = 2.46$, $p < .020$], and understanding the research process [$t(1,24) = 2.88$, $p < .008$]. In contrast, survey results from the CSU Long Beach summer internship program showed statistically significant gains from pre- to post- for most of the items.[23] It should be noted, however, that pre-program survey responses for the current study (average = 4.25; range: 3.3–4.7) are significantly higher than the CSU Long Beach results (average = 3.94; range: 3.2–4.7). Even the post-program survey responses for the current study (average = 4.44; range: 4.1–4.8) are slightly higher than the CSU Long Beach results (average = 4.27; range: 3.5–4.8)

Table 5. Results of 2014 survey of student perception of skills and knowledge for academic and research success. Response Scale: 1 – Strongly Disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; 5 – Strongly Agree.

Question: Tell us how much you agree with each of the following statements.	**Average Response**		
	Pre	**Post**	**Change**
I have a clear career path.	4.38	4.38	0.00
I have skill in interpreting results.	4.38	4.38	0.00
I have tolerance for obstacles faced in the research process.	4.44	4.56	0.13
I am ready for more demanding research.	4.25	4.38	0.13
I understand how knowledge is constructed.	4.19	4.69	0.50*
I understand the research process in my field.	3.31	4.31	1.00**
I have the ability to integrate theory and practice.	4.06	4.25	0.19
I understand how scientists work on real problems.	4.00	4.06	0.06
I understand that scientific assertions require supporting evidence.	4.69	4.56	-0.13
I have the ability to analyze data and other information.	4.56	4.56	0.00
I understand science.	4.44	4.44	0.00
I have learned about ethical conduct in my field.	4.25	4.44	0.19
I have learned laboratory techniques.	4.00	4.13	0.13
I have an ability to read and understand primary literature.	4.50	4.38	-0.13
I have skill in how to give an effective oral presentation.	4.19	4.44	0.25
I have skill in science writing.	3.94	4.13	0.19
I have self-confidence.	4.50	4.63	0.13
I understand how scientists think.	3.94	4.31	0.37
I have the ability to work independently.	4.50	4.75	0.25
I am part of a learning community.	4.44	4.81	0.38
I have a clear understanding of the career opportunities in science.	4.31	4.63	0.31

* The change is statistically significant [$t(1,27) = 2.46$, $p < .020$].

** The change is statistically significant [$t(1,24) = 2.88$, $p < .008$].

4. Conclusion

The four years of implementation of the COMETS project has been successful in creating opportunities for students, especially those from underrepresented minority groups, to engage in advanced academic work that develops research skills and applies concepts and theories learned from their classes to real-world problems. The program has also helped students in solidifying their choice of major, improving preparation for transfer, enhancing student self-efficacy in pursuing careers in engineering, and acquiring knowledge and skills needed to succeed in a four-year engineering program. As a result of their research experience, the participants have also expressed that they are now more likely to apply for other internships and consider pursuing graduate degrees in engineering.

The research internship program has also provided opportunities for students to be engaged in advanced levels of academic activities and achievements—opportunities that are not commonly available to freshmen and sophomore undergraduate students, especially in community colleges. The research work done by the students has resulted in a number of student conference paper and poster presentations including paper and poster presentations that were selected as the only community college finalists in the undergraduate paper and poster presentation at the 2011 Society of Hispanic Professional Engineers National Conference. Papers and posters were also presented by students at the following conferences: 2012 and 2013 Interdisciplinary Engineering Design Education Conference (IEDEC); 2012, 2013, and 2014 American Society for Engineering Education Pacific Southwest (ASEE PSW) Conference, and the 2012, 2013 and 2014 Society for the Advancement of Chicanos and Native Americans in Science (SACNAS). In October 2014, one of the 2014 summer interns received one of the 2014 SACNAS Student Presentation Awards.

Although results from the first four years of implementations of COMETS have shown positive impact on students as evidenced by gains in research skills acquired, ability to work independently and collaboratively, enhanced self-efficacy for transfer success, and increased interest in future research and advanced studies, further analysis is needed to determine if these gains result in improved academic performance. Additionally, the perspectives of the research mentors and faculty advisors need to be integrated into improving future iterations of the program to further promote success and achievement among underrepresented students.

The collaboration between Cañada College and San Francisco State University School of Engineering developed through the COMETS program that has created opportunities for community college students to engage in research has been mutually beneficial to both institutions. Research activities that were directly developed by the COMETS program participants enriched academic experiences of students at both institutions while enhancing the research capabilities of the university and strengthening the engineering transfer program at the community college. The success achieved through the partnership has also been instrumental in securing additional funding—both individually and collaboratively—to further strengthen the partnership, better promote STEM education and improve the programs and services offered at both institutions, and serve as a model of collaboration for improving STEM education at public institutions of higher education.

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