AC 2012-2937: ENGAGING UNDERREPRESENTED COMMUNITY COLLEGE STUDENTS IN ENGINEERING: A MODEL OF COLLABORATION BETWEEN TWO-YEAR AND FOUR-YEAR INSTITUTIONS

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Engaging Underrepresented Community College Students in Engineering: A Model of Collaboration between Two-year and Four-year Institutions

Abstract

Cañada College, a federally designated Hispanic-Serving community college in California's Silicon Valley attracts a large number of students from underrepresented groups in engineering. Although many of these students enter with high levels of interest in engineering, their success and transfer rates have been low primarily due to low levels of preparation for college-level work, especially in math, resulting in years of additional remedial coursework. To keep these students engaged and motivated towards achieving their academic goals, Cañada College's Engineering Department collaborated with San Francisco State University School of Engineering to develop the Creating Opportunities for Minorities in Engineering, Technology, and Science (COMETS) program. Building on a previously successful collaboration in developing a two-week Summer Engineering Institute for incoming engineering students, the COMETS program funded by NASA through the Curriculum Improvements Partnership Award for the Integration of Research (CIPAIR) program includes a number of strategies developed to enhance the success of underrepresented community college students in engineering. To increase student engagement and success in foundational math and engineering courses, contextualized teaching approaches that incorporate NASA-related content as hands-on activities and projects are developed. A ten-week summer research internship program specifically designed for community college students has also been developed to provide research opportunities on various engineering topics including performance-based earthquake engineering, circuit design for biomedical applications, and embedded systems design. Additionally, a group of community college students are selected to participate in year-long upper-division and senior design courses at San Francisco State University to help develop skills and attributes needed to succeed in a four-year engineering program. Results from the first year of implementation of the program show success in achieving program objectives as evidenced by positive student responses to the curriculum enhancements, the quality of the results of student research activities, the overwhelming positive faculty evaluation of student performance both in the summer internship program and in the upper-division courses, and the encouraging student feedback on the various program components and activities. The partnership between Cañada College and San Francisco State University previously established through the Summer Engineering Institute and strengthened through the COMETS program has the potential to serve a model of collaboration between a community college and a four-year engineering program to increase the participation and improve the success of underrepresented students in the engineering profession.

1. Introduction

Community colleges serve as the gateway to higher education for large numbers of students in the U.S., especially minority and low-income students. Yet for many students, the community college gateway does not lead to success. Only one in four students wanting to transfer or earn a degree/certificate did so within six years, according to a recent study of California community colleges[1] (Shulock & Moore, 2010). African American and Hispanic students have even lower rates of completion. According to the study, only 14% of African American students and 20% of Latino students completed a degree or certificate within six years, compared to 29% of white students, and 24% of Asian students.

For science and engineering fields, lower success and retention rates for minority students are observed at both community college and university levels resulting in underrepresentation of minority groups in these fields. For instance, while comprising about 28% of the U.S. population, African Americans and Latinos make up less than 9% of the individuals who are B.S. or higher-degree holders in the science and engineering fields[2] (NSF, 2011).

At Cañada College, the discrepancy in the levels of preparation among different ethnicities is manifested in student persistence. During a recent planning initiative led by the College President, a cohort study of newly enrolling students at Cañada was performed. Table 1 shows a summary of one-year and two-year persistence rates of students by ethnicity. Among Hispanic students the one-year persistence rate was 59.4%, and the two-year persistence rate was 28.8%. The one-year persistence of African American students was 46.7%, and the two-year rate 20%, significantly lower than those of white students whose one-year and two-year persistence rates were 72.5% and 54.4%, respectively. Given these low patterns of persistence for Hispanics and African Americans, low transfer and completion rates for these students are not surprising. Clearly, much needs to be done to improve the retention and success of underrepresented students, especially in STEM areas.

Persistence by Ethnicity				
Percentage	**Fall Yr1**	**Spring Yr1**	**Fall Yr2**	**Spring Yr2**
Hispanic	100.0%	59.4%	38.9%	28.8%
Caucasian	100.0%	72.5%	59.7%	54.4%
Asian	100.0%	76.2%	52.4%	40.5%
African American	100.0%	46.7%	33.3%	20.0%

Table 1. Semester-to-semester two-year persistence rates of Cañada students by ethnicity.

In 2008, to increase the participation, retention, and success of underrepresented, underprepared and educationally disadvantaged students interested in pursuing careers in STEM fields, Cañada College developed a program titled Student On-ramp Leading to Engineering and Sciences (SOLES). Funded by the US Department of Education through the Minority Science and Engineering Improvement Program (MSEIP), SOLES addresses some of the barriers to the successful transfer of community college engineering students to a four-year institution including low success rates in foundational math courses, lack of practical context in the traditional engineering curriculum, and inadequate relevant internship opportunities for lower-division engineering students. The program employs strategies that have been proven effective in increasing the retention and success of minority students such as mentoring programs,[3,4] introducing context in introductory courses,[5] alternative instructional strategies,[6] summer programs,[7,8] and academic support services such as tutoring, Academic Excellence Workshops (AEWs), and peer mentoring.[9] Among the specific programs developed through SOLES are the Math Jam and the Summer Engineering Institute. Math Jam is a two-week intensive summer mathematics program designed to improve students' preparation for college-level math courses. The Summer Engineering Institute (SEI), a two-week residential program held on campus at San Francisco State University, aims to introduce students to the engineering educational system and the engineering profession, recruit students into an engineering field, increase student awareness of resources and skills needed for college success, and increase student knowledge of specific engineering topics. These two programs have contributed to a significant increase in enrollment and success of underrepresented minority students in transfer-level math, science and engineering courses.[10,11]

With the resulting increase in the enrollment of underrepresented students intending to transfer to a four-year engineering program, additional programs need to be developed in order to ensure the success of these students and facilitate their successful transfer and completion of their academic goals. In 2010, in response to this need, Cañada College collaborated with San Francisco State University to develop the Creating Opportunities for Mathematics, Engineering, Technology, and Science (COMETS) program. Funded by NASA through the Curriculum Improvements Partnership Award for the Integration of Research (CIPAIR) program, the COMETS program involves collaboration among math and engineering faculty of a community college and engineering faculty of the closest neighboring four-year institution that has an established relationship with a NASA Ames Research Center. This paper summarizes the results of the first year of implementation of the COMETS program.

2. COMETS Program Objectives and Activities

One of the main goals of the project is to improve student engagement in foundational math, science and engineering courses by introducing NASA-themed content in classroom activities and demonstrations, laboratory exercises, and course projects. This has been done in four math courses (Trigonometry, Precalculus, Calculus 1, and Calculus) and two computer science courses at Cañada College, and several engineering courses at both Cañada College and San Francisco State University.

2.1 Curriculum Enhancements at Cañada College

In addition to low initial math placement, the timely transfer of engineering students to four-year institutions is adversely affected by poor performance in two foundational math courses: trigonometry and pre-calculus. Table 2 shows retention and success rates for math courses required of engineering students at Cañada College from 2001 to 2009. The retention and success rates for trigonometry (71.5% and 48.7%, respectively), and pre-calculus (75.4% and 54.3%, respectively) are significantly lower than all the other math courses whose overall average success and retention rates are 90.7% and 82.2%, respectively. Clearly, trigonometry and pre-calculus are two critical courses in the math sequence where improvements need to be made in order to significantly increase the number of successful engineering students.

Trigonometry is one of the earliest math topics that link algebraic, geometric, and graphical reasoning. It is an area of mathematics that students believe to be particularly difficult and abstract compared to the other subjects of mathematics.[12] The initial stages of learning trigonometric functions can be difficult.[13] Since trigonometric functions are operations that cannot be expressed as arithmetic operations, students have difficulty understanding these operations as functions,[14] or understanding their numerical and geometric relationships with triangles.[13] Current teaching practices are not geared towards developing deep conceptual understanding of trigonometric functions, and many approaches to teaching trigonometry focus on procedural skills and memorization and not on conceptual understanding.[15]

Course	**Retention Rate**		**Success Rate**	
	Average	**Std Dev**	**Average**	**Std Dev**
Trigonometry	71.5%	12.8%	48.7%	13.3%
Pre-Calculus	75.4%	13.3%	54.3%	19.1%
Applied Calculus 1	88.4%	11.8%	76.4%	11.0%
Applied Calculus 2	96.2%	4.6%	94.2%	4.6%
Calculus 1	94.2%	12.9%	75.4%	15.5%
Calculus 2	88.3%	8.8%	81.5%	11.2%
Calculus 3	90.9%	10.3%	82.6%	13.4%
Linear Algebra	91.3%	6.2%	86.4%	6.8%
Differential Equations	85.4%	9.0%	78.9%	10.0%

Table 2. Cañada College average retention and success rates for STEM math courses from 2001 to 2009. Retention is defined as completing the course, and success is defined as receiving a passing grade (A, B, or C) in the class.

There are numerous studies that have concluded that the standard approaches to teaching trigonometry and pre-calculus are ineffective, resulting in students who have difficulty completing many basic tasks,[14] or retaining knowledge and skills they have learned,[15] and students who frequently make algebraic errors that indicate a lack of conceptual understanding.[16] Other studies have also shown that the use of active and collaborative learning results in improvements in student motivation,[17,18,19] and increases in learning gains.[13,15,17,19,20,21,22] Moreover, students from traditionally underrepresented groups benefit greatly from a collaborative learning environment.[23]

Recently, the California Community Colleges Basic Skills Initiative has identified contextualized teaching and learning as a promising strategy to actively engage students and improve learning in basic skills courses and career/technical education.[24] Contextualized learning has been defined as a “diverse family of instructional strategies designed to more seamlessly link the learning of foundational skills and academic or occupational content by focusing teaching and learning squarely on concrete applications in a specific context that is of interest to the student.”[25] Contextualized learning promotes critical thinking and creative problem solving by connecting math to real-life situations, thereby making it easier for students to transition from concrete, hands-on examples to more abstract mathematical concepts.[26]

As part of the COMETS strategy to use contextualized teaching and learning to improve retention and success of underrepresented students, curricular enhancements have been introduced in foundational math courses in trigonometry, precalculus and calculus. NASA-related themes and content using research and real-life data as contextualized science-based hands-on activities and exercises have been introduced. Among the modules developed and implemented in trigonometry include electricity consumption, Coronal Mass Ejections, NASA STEREO Spacecraft, solar probes, using actual tide observations to explore sinusoidal functions, and on solar probes. For precalculus, modules on exponential and logarithmic functions using Moore's Law on the increasing complexity of computer microchips, sinusoidal functions using actual tide height observations, Law of Sines and Law of Cosines using data from two NASA STEREO satellites, calculating earth-sun distance from Venus transit, and earth-moon distances have been developed. For calculus, modules on solar wind, stellar stereography, radiation from stars, parameterization of a moon's orbit around a planet have been developed.

Curricular enhancements using contextualized approaches have also been introduced in foundational engineering courses at Cañada College including a course module on introduction to robotics and programming using LEGO Mindstorms in Introduction to Engineering, designing and building a Mars rover in Engineering Graphics, a module titled "How do you launch a satellite" in MATLAB Programming, and introduction to circuits and robotics using the Parallax Boe-Bot in Circuits Laboratory.

2.2 Curriculum Enhancements at San Francisco State University

A number of engineering courses at San Francisco State University have also been revised to incorporate NASA-themed content. For the Introduction of Microelectronics course, students are asked to characterize the circuits with a RLC resonator, pn diodes, MOSFETs and BJTs. Furthermore, students are trained on how to layout a Printed-Circuit-Board (PCB) and assemble the related components.

A graduate course on Embedded Systems has been revised to reflect the state of the art in embedded systems design. A new hardware platform has been introduced to allow defining the embedded processor specifications, memory organization, and logic, and build the firmware needed to realize the embedded application. The t-pad development kit, by Terasic, which is based on the DE2-115 development board design around the Altera's Cyclone IV Field Programmable Gate Array (FPGA) provides a suitable platform for hands-on education of modern embedded systems design. A series of example-driven hands-on tutorials have been developed and verified by sophomore community college summer interns from Cañada College, and are currently being used for the class. A course project realizing a complex embedded system in teams of 2 to 3 students is an integral part of this course. The results show that using this platform not only generates excitement and motivation in students, but also enhances their learning and teaches them skills of modern embedded systems design.

Similar course revisions and enhancements using course materials and content developed by community college interns have been implemented for other Cañada College and San Francisco State University engineering courses including Statics, Structural Analysis, Mechanical and Structural Vibrations, Electronics, and Digital Systems Design.

2.3 Summer Research Internship Program

The benefits of internship and research opportunities for undergraduate students have long been recognized. Independent research increases student engagement in their education. Successful research experiences among undergraduate students often lead them to seek even greater challenges that elevate their educational experience to higher levels.[27] The unexpected problems that arise in doing research "force the students to troubleshoot for solutions, which catapult students in undergraduate research past cookbook-style experiments with step-by-step instructions and outcomes."[28] Among community college students, research experiences often lead to strengthened oral and written communication skills, enhanced self-confidence, and enhanced problem solving and critical thinking skills.[29] The National Science Foundation recognizes the importance of providing research and internship opportunities to undergraduate students, and supports such efforts through its Research Experiences for Undergraduates program. This year for instance, NSF expects to provide over $60M of support to about 18,000 REU sites for various areas of STEM research.[30] Although a substantial amount of funding support, these research opportunities mostly benefit students from four-year institutions, with very few community college students being selected, especially in engineering. This is primarily a consequence of an engineering curriculum wherein students generally do not take any majors classes related to their specific field of engineering until their junior year.

In 2010, a focus group of engineering students at Cañada College identified barriers to a successful internship program for community college engineering students. For most 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 them with exposure 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.[31] Since most summer research internship positions are full-time, community college students are often faced with the difficult choice between accepting a summer internship position or taking summer courses to ensure their timely transfer.

One of the major objectives of the COMETS program is to develop a research internship program that is specifically designed for community college engineering students. The ten-week NASA CIPAIR 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 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. The original grant proposal has funding for three full-time positions, and six half-time positions. As a result of collaborating with Cañada College MESA program, additional funding was secured for three additional half-time students, for a total of 12 internship positions, three full-time and nine half-time. Three research groups were formed, four students each for Civil Engineering, Computer Engineering and Electrical Engineering. Table 4 summarizes the demographics of the community college students who participated in the 2011 summer research internship program.

Demographics	# of Students	Percentage
Gender		
Male	10	83.3%
Female	2	16.7%
Total	12	100.0%
Ethnicity		
American Indian	0	0.0%
Asian or Pacific Islander	2	16.7%
Black	0	0.0%
Hispanic	9	75.0%
Other	0	0.0%
White	1	8.3%
Total	12	100.0%

Table 4. Demographics of 2011 Summer Research Internship Program participants.

The research project topics for the 2011 research program were selected by the supervising San Francisco State University faculty, and student interns were divided into three research groups, with each group consisting of one full-time intern and three half-time interns, and mentored by a graduate student selected by the supervising faculty. The 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 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 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 internship program was successful in achieving its goals of developing students' skills needed for academic success. Table 5 shows a summary of student perception of how much they have learned from participating in the internship program, as determined from a post-program survey. Note that for each of the categories, the average response is between "Quite a bit" and "A lot."

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

Table 5. Summary of student responses to the post-program survey measuring the perceived benefit of participating in the research internship program.

Table 6 summarizes the results of post-program student survey designed to measure perception of over-all usefulness of the research internship program. Results show that the research internship program was successful in its 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. Overall, students were satisfied with the program, and would recommend it to a friend. More details of student responses to the post-program survey including their perception of the usefulness of and satisfaction with specific program activities are given in Appendix A.

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

Table 6. Summary of student satisfaction with the summer research internship program.

2.4 Community College Students in Capstone Design Courses

Although studies have shown that engineering students from community colleges perform as well as native four-year students in terms of grade point average and completion rates,[32] one common phenomenon that is widely observed among transfer students is transfer shock, which refers to "the tendency of students transferring from one institution of higher education to another to experience a temporary dip in grade point average during the first or second semester at the new institution."[33] In order to enhance success in their academic adjustment at the four-year institution, students must begin seeking assistance and information about admissions, academics, and social and academic expectations while still in the two-year institution.[34]

To enhance the preparation of Cañada College students for a smooth transition to their four-year transfer institution, reduce the effects of transfer shock, and enhance their academic success, the COMETS program provides opportunities to participate in a year-long senior capstone design course at San Francisco State University. Every fall semester for each year of the grant, four Cañada College sophomore students are selected to participate in SFSU's senior design capstone courses. For two semesters these selected community college students are completely immersed in an enriching experience of being a part of the entire design project from its inception to its completion and presentation at SFSU's Annual College Showcase. This year-end showcase event is widely attended by faculty, students and professionals, and is an effective way of promoting STEM careers.

For the 2010-2011 academic year, four Cañada College sophomore students, one each from the areas of civil, mechanical, electrical, and computer engineering were selected and participated in weekly project team meetings from October 2010 to May 2011 at San Francisco State University. The civil engineering student participated in the design and construction of a timber bridge. The mechanical engineering student participated in a project on Materials and Manufacturing. Both the computer engineering and the electrical engineering participated in projects on Microelectronics. At the completion of the projects at the end of spring semester 2011, each of the participating students earned 3 units of Independent Study at Cañada College. A culminating presentation was given by each of the participants to students in the Introduction to Engineering class at Cañada College. Supervising engineering faculty at SFSU reported outstanding performance of the students in these courses, recommending a grade of A for each of the participating community college student. Students reported overwhelmingly positive evaluations of the benefits of the program in increasing student preparation for transfer. A summary student evaluations of their experience in participating in SFSU upper-division engineering courses is given in Appendix B.

2.5 Outreach Activities

To promote awareness of the COMETS project and NASA missions and goals, a number of outreach activities were organized during the first year of COMETS. On October 18, 2010, a three-hour workshop on robotics using LEGO Mindstorms was given to a group of 20 middle and high school female students who are a part of the Girls Engaged in Math and Science (GEMS) group. On April 28, 2011, COMETS students who participated in senior design capstone projects at San Francisco State University presented their work to Introduction to Engineering students. On April 30, 2011, CIPAIR students coordinated with the Cañada College Robotics Club to organize the NASA CIPAIR Robotics Outreach Day, which introduced basics of robotics using the Boe-Bot Kit manufactured by Parallax. Forty six Cañada College and Skyline College students, and three faculty members attended the event.

On July 19 and 20, 2011, students participating in the NASA CIPAIR Summer Research Internship Program presented their work and facilitated workshops related to their research to the participants of the 2011 Summer Engineering Institute (SEI) program funded by the US Department of Education through the Minority Science and Engineering Improvement Program. SEI participants consist of 26 high school seniors and incoming college freshmen from all over the state. The outreach activities have been well received by participating faculty and students.

3. Conclusion and Future Plans

The first year of implementation of the COMETS project has been successful in carrying out all the planned activities as scheduled. The project has resulted in a number of curricular enhancements in foundational math and engineering courses developed collaboratively by four math faculty and five engineering faculty, as well as curriculum developed by students as part of their summer research activities. Further curricular enhancements are planned for math, engineering, and computer science by incorporating NASA-related content as in-class demonstrations, projects and hands-on exercises.

The Summer Research Internship program 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 post presentation at the 2011 Society of Hispanic Professional Engineers National Conference. As a result of their research experience, all of the participants are now considering to pursue graduate degrees in engineering. Students who participated in the upper-division courses at SFSU expressed that the program has helped in solidifying their choice of major, and has increased their confidence in succeeding in a four-year engineering program.

The success of the collaboration between Cañada College and San Francisco State has prompted the two institutions to seek further funding to strengthen the partnership to better promote STEM education and improve the programs and services offered at both institutions. In October 2011, Cañada College was awarded a $6M Hispanic-Serving Institution Science, Technology, Engineering and Mathematics (HSI STEM) grant by the US Department of Education. The five-year program entitled California Alliance for the Long-term Strengthening of Transfer Engineering Programs (CALSTEP) will build on the success of the collaboration with SFSU previously established through the Summer Engineering Institute and the COMETS project. This new collaborative project utilizes a multi-focused approach to increasing the interest, participation, retention, and success of students from traditionally underrepresented groups in STEM. It promotes an understanding and appreciation of STEM careers through innovative outreach activities for middle school, high school, and community college students. It addresses the main barriers to the retention and success of underprepared students through a combination of intensive preparation for college-level work, multiple entry points and accelerated pathways for students into STEM education, and previously proven academic support strategies. The project will impact not only students in the participating institutions but students all over the State by addressing the recent decline of community college engineering programs in California brought about by the increasing diversification of four-year lower-division engineering curriculum and exacerbated by budget cuts, which threaten this critically important engineering education pipeline. It will do so through innovative initiatives like the Summer Engineering Teaching Institute that will assist engineering programs in improving teaching effectiveness and efficiency using technology, and through the Joint Engineering Programs that will promote collaboration among community college engineering programs all over the State to better serve their students. Together with the Model Transfer Curricula that will be developed by the program, the statewide collaborative programs that will be created through CALSTEP can serve as a model for improving STEM education in public institutions of higher education in other states.

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Appendix A

Summary of Student Responses to 2011 NASA CIPAIR Internship Post-Program Survey

Question: How useful were each of the following activities during your internship?
Response Scale: 1 – Not at all useful; 2 – A little; 3 – Some; 4 – Quite a bit; 5 – A lot.

Activity	Average Rating
Opening Day on June 6^{th}	4.67
Faculty Adviser Description of Project	4.25
Library Orientation Session	2.67
Meetings with Graduate Student	4.00
Meetings with Faculty Adviser	3.75
Weekly Progress Reports	3.75
Mid-Program Presentations (July 22nd)	4.75
Trip to NASA Ames	4.08
Poster Session (Aug 12)	4.83
Final Presentations (Aug 12)	4.92

Question: How satisfied are you with each of the following?
Response Scale: 1 – Very Dissatisfied; 2 – Dissatisfied; 3 – Neutral; 4 – Satisfied; 5 – Very Satisfied.

Activity	Average Rating
Opening Day	4.67
The project/topic you worked on	4.33
The results of your project	3.67
Your final poster	4.08
Your final presentation	3.83
How much you learned from the program	4.75
Your group mates	3.83
Your graduate student mentor	3.83
Your faculty adviser	4.00
The Summer Internship Program as a whole	4.58

Question: As a result of your participation in the program, how much did you learn about each of the following?
Response Scale: 1 – Nothing; 2 – A little; 3 – Some; 4 – Quite a bit; 5 – A lot.

Activity	Average Rating
Performing research	4.67
Designing/performing an experiment	4.67
Creating a work plan	4.5
Working as a part of a team	4.75
Writing a technical report	4.5
Creating a poster presentation	4.67
Making an oral presentation	4.67
Performing research	4.67

Question: Tell us how much you agree with each of the following statements.
Response Scale: 1 – Strongly Disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; 5 – Strongly Agree.

Activity	Average Rating
The internship program was useful.	4.8
I believe that I have the academic background and skills needed for the project.	4.17
The program has helped me prepare for transfer.	4.33
The program has helped me solidify my choice of major.	4.58
The program has helped me solidify my choice of transfer university.	3.75
As a result of the program, I am more likely to consider graduate school.	4.67
As a result of the program, I am more likely to apply for other internships.	5
As a result of the program, I am more likely to consider SFSU as my transfer institutions, or recommend it to others.	3.08
I am satisfied with the NASA CIPAIR Internship Program.	4.67
I would recommend this internship program to a friend.	4.83

Appendix B
CIPAIR Senior Design Course
Student Evaluations of the Program
Spring 2011

Tell us how much you 4 with the following statements. Response Scale: 5 – Strongly Agree, 4 – Agree, 3 – Neutral, 2 – Disagree, 1 – Strongly Disagree	CE	ME	EE	CpE	Ave
My participation in the SFSU class/project was useful.	5	5	5	5	5
I believe that I have the academic background and skills needed for the class/project.	5	5	5	5	5
The project/class I did is relevant to my major.	5	5	5	5	5
My participation in the project/class has helped me prepare for transfer to a four-year school.	5	5	5	4	4.75
I am confident that I have the academic background and skills needed to be successful in a four-year institution	5	5	5	5	5
My participation in the project/class has helped solidify my choice of major.	5	5	5	5	5
My participation in the project/class has helped solidify my choice of transfer university.	3	5	5	5	4.5
As a result of participating in the project/class, I am more likely to consider SFSU as my transfer institutions, or recommend it to others.	3	3	3	5	3.5
I have supportive relationship with the SFSU instructor for the class/project I did.	3	3	4	5	3.75
I have supportive relationships with graduate student assistants at SFSU.	5	5	3	5	4.5
I have supportive relationships with other students at SFSU.	4	4	3	4	3.75
I would recommend this program (Participation in a SFSU class or project) to other students at Canada.	5	5	5	5	5
I am satisfied with the Canada College/SFSU NASA CIPAIR program.	5	5	5	5	5

Briefly describe the project or class that you worked on at SFSU.

- It was a senior design project, in which we worked on building a bridge strong enough to hold the weight of a sport car. We worked on this project for 2 semesters. In the first one i was able to attend to the lecture (lab), and do some work, but in the second one it was all bout working on the project, mostly during the weekends.

- I participated in the ENGR 364 Materials and Manufacturing lab at SFSU on Tuesdays from 2:15-5PM.
- I participated in the SFSU project by taking an upper division class in Digital Circuits. In this course my partner and I learned how to design and implement simple iterative and sequential digital circuits on paper and in a laboratory utilizing a digital trainer.
- The classes I took at SFSU were ENGR 356 and 357.Every week on Thursdays I attended the class Basic computer Architecture (ENGR 356) and ENGR 357 the laboratory portion of the 356 class which focuses on Circuit construction and troubleshooting techniques. In the 356 class I we learned about combinational and sequential circuits as well as digital functional units. We also went over Karnaugh maps and Boolean algebra to apply our understanding to the laboratory portion of the class

What do you like most about the SFSU class/project in which you participated?

- It was a very good learning experience, in which i was able to complete some tasks under a lot of pressure.
- I enjoyed the emphasis on geometric dimensioning and tolerances. This area is important to me as a Mechanical Engineering student, but is also one of the detail intensive areas I enjoy in ME. It illustrates the "puzzle" aspect of design. Each dimension and tolerance is related to all others in the whole. One cannot adjust a single dimension without impacting another dimension/tolerance in the overall design. It requires both critical thinking skills, and demands an innovative approach to problem solving.
- I liked the idea of being more prepared for upper division study at a four year university. The material I was exposed to has helped better prepare me for what is to come.
- What I liked the most about the class that we participated in was that I will be better prepared for a similar computer architecture class that I plan on taking at SJSU. Since taking this class I have been more motivated in getting my degree because most of the labs that we did in ENGR 357 were extremely interesting because it was easy to see where these circuits are used in real life.

Give at least one suggestion for improvement of the CIPAIR Program?

- If somehow we can have more support from the instructors at SFSU, that would be really helpful.
- I am most positive that the faculty supporting CIPAIR is already cognizant of my recommendations. Nothing is ever perfect the first time around--essentially there is always room for improvement. As many of you already know, open communication between all levels of participants in the program is an area for improvement. This is a kind and gentle suggestion. I greatly enjoyed my time in the CIPAIR program. By sharing information about the program with all engineering professors at SFSU, it may enable further support for the program: even if these professors are not participating. The corporate world would refer to this as "buy in". It doesn't mean that the CIPAIR leaders should relinquish control to outsiders. Rather, it suggests they create a buzz, perhaps a community around the program to ensure its future success.
- The CIPAIR program could provide participants with an option to participate in a Senior design project or an upper division course as I have done.

- I recommend that instead of taking the same class for two semesters, there should be two different classes. I also recommend taking the 356 concurrently with the 357 class because the lectures really helped a lot before the labs.

Please give any comments or suggestions you have on the CIPAIR Program.

- It was a really good program. At least for me it fulfilled all my expectations.
- Thank you very much for creating this opportunity. I feel honored to have participated in the inaugural year. My time at SFSU has taught me many valuable skills which I have already put to use to further succeed as an engineering student. CIPAIR has helped me become a better team player and leader. Additionally, it provided me with invaluable experience in the internship application process. Again, I am extremely grateful to all involved. I understand what a tremendous time and energy commitment this has been. Thank you for your efforts.
- In my eyes this program turned out to be a success for it helped me gain much more insight into my major. The program also helped solidify my decision in wanting to become an electrical engineer.
- Thank you so much for letting me be a part of this CIPAIR Program, I really enjoyed taking these classes.