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Engaging Underrepresented Community College Students in Interdisciplinary Learning and Research

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Abstract

As the challenges facing the world become more multifaceted, the solutions are often rooted in multiple disciplines. It gives educators a tough challenge: how to bring interdisciplinary learning and research to undergraduate students, especially underrepresented students. Funded by 2011 NASA CIPAIR (Curriculum Improvements and Partnership Award for the Integration of Research) award, four underrepresented minority (*i.e.*, 3 Hispanic and 1 female) students from Cañada College participate in a ten-week research of designing an electronic monitoring system for biomedical application. First, the students conduct literature research on the requirements that are unique for biomedical monitoring, such as ultra-low power consumption, small form factor and high reliability. Second, the students engage in designing a datalogger to monitor the mechanical pressure that is exerted by a pair of rare-earth magnets. The pair of magnets is used to cure pectus excavatum (hallowed chest). The *ex-vivo* magnet pulls the sternum that is strapped by an *in-vivo* magnet outwards to realign with the ribcage. The students design the schematic and create the manufacturing-ready layout using Cadence Allegro. Lastly, the students optimize the design by choosing the appropriate memory size based on the data sample-size, the sample-rate and the battery capacity, and creative layout style to minimize the overall form factor of the data-logger package. Thus, these four students are exposed to interdisciplinary learning and research by applying electrical engineering into biomedical applications. In addition to learning the electronics design and clinical research, the students create tutorials to help other students to design electronics for biomedical applications. The NASA CIPAIR has promoted interdisciplinary learning and research to underrepresented community college students.

Introduction

Medical devices have a great potential in future medicine. They can widely used in the areas of diagnostics, drug delivery, assisted-prostheses and minimum invasive surgeries. The implanted EKG is demonstrated for accurately monitoring the heart activities [1]. The MEMS pump is used to deliver drug to a localized region without going into the circulation [2]. The CMOS imager is used as an artificial retina [3]. They are also used to carry out the minimum invasive surgeries [4, 5]. Medical devices become key components in improving the healthcare quality.

The boom of the biomedical engineering research is evidenced by many newly established research centers and institutes in many prominent research universities [6], however, it poses a serious challenge to today's educators on how we prepare our future graduates for this interdisciplinary field. In today's engineering program, the training is still focused on the basic math, physics and engineering principles. The training of the medical staff is primarily focused on the biology and life sciences. The correlation between these two fields is weak in term of their theoretical backgrounds, therefore, there is very little overlap in curriculums of most four-year bachelor degree programs. As a result, the collaboration between the medicine and the engineering is not often seen traditionally.

To foster the interdisciplinary learning and research, engineering students are employed to work on the biomedical research related project. "Learning through Doing" has been one of the effective approaches to motivate the students. In the summer of 2011, four community college students from Cañada College joined the Bioelectronics Lab in San Francisco State University. These students designed an electronic monitoring apparatus for a minimum invasive surgical procedure to treat the petus excavatum [4, 5]. In this paper, we will present a collaborative program funded by the **N**ational **A**eronautics and **S**pace **A**dministration (NASA) to integrate students into San Francisco State University bioelectronics research to promote interdisciplinary learning and research.

COMETS Project Between SFSU and Cañada College

Community colleges serve as the gateway to higher education for large numbers of students in the U.S., especially Hispanic and low-income students. Figure 1(a) illustrates the importance of the community college pathway among California engineering graduates. For the year 2008, approximately 33.0% of all UC and CSU engineering graduates in 2008 transferred from a community college (individually, 23.4% of UC and 41.1% of CSU graduates). The community college pathway therefore represents a sizeable portion of the engineering pipeline in California. For many students, particularly those from underrepresented groups, this pathway to an engineering career may be the only practical way for them to access higher education.

However, 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. Figure 1(b) shows that among all non-engineering bachelor's degree recipients in 2008, 46.5% of all UC and CSU graduates were transfer students (individually, 30.1% of UC and 55.8% of CSU graduates). In other words, there is a relatively smaller representation of community college transfers among engineering graduates when compared to other majors. An urgent need therefore exists for improving the successful transfer of engineering students in California community colleges to four-year universities. The NASA CiPair program between SFSU and Cañada College targets to address some of the barriers to the successful transfer of community college engineering students to a four-year institution including inadequate preparation for college-level courses, especially in mathematics, 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.

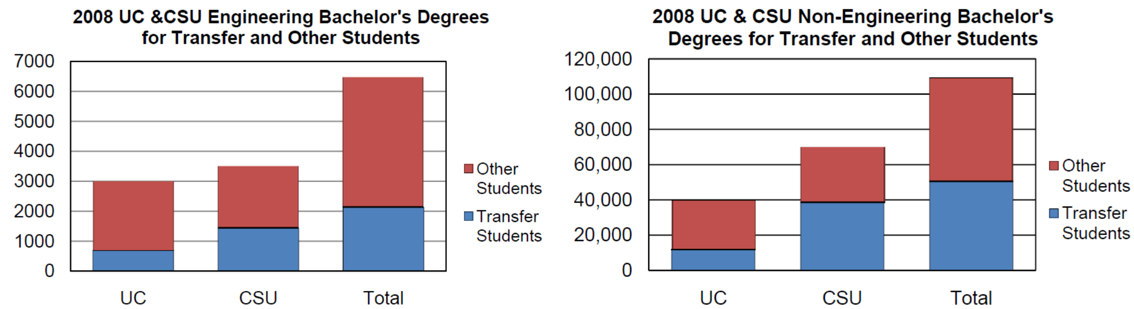

Figure 1. UC and CSU engineering graduates for 2008 showing transfer students from community colleges compared to students who did not transfer from a community college. Data are from California Postsecondary Education Commission [3]

Cañada College is a member of the California Community College System, and is one of three colleges in the San Mateo County Community College District. It is one of only two federally-designated Hispanic Serving Institutions in the San Francisco Bay Area. During the 2008-2009 academic year, the College enrolled 10,865 unique students. The student body is genuinely multi-cultural with Hispanic students as the largest single group at 41.4%; white students comprise 31.7%, Asians 7.2%, Filipinos 3.7%, African-Americans 3.4%, Pacific Islanders 1.7%, American Indian/Alaska Natives 0.4%, other 10.6%. San Francisco State University, is a large, regional, comprehensive university, part of the California State University System. In fall 2009, 30,469 students enrolled at SFSU: 25,001 undergraduates and 5,468 graduate students. Students pursue 115 undergraduate majors, 97 master's degree programs, 27 credential programs, and 37 undergraduate and graduate certificate programs. According to the fall 2009 Undergraduate Student Profile, although white students form the largest racial/ethnic group of undergraduates at 32.8%, 24.9% are Asian, 19.9 % are Hispanic, 9.4% are Filipino, 6.0% are African American, 0.9% are Pacific Islander, 0.5% are American Indian or Alaska Native, and 5.6% are "other." Women are 59.7% of the student body.

The objectives of the COMETS project are: (1) to improve student engagement and success in foundational math courses and core engineering courses; (2) to provide ten participants each summer with research experiences in NASA Ames, which they would not otherwise have in their usual academic environment; (3) to provide current community college students a year-long engineering design experience early in their academic career by participating in capstone design courses for graduating seniors; (4) to strengthen existing faculty relationship with NASA Ames, and establish new collaborative relationships among two-year and four-year engineering faculty, and NASA Ames Research Center; (5) to increase the number of academically prepared community college students transferring to four-year institutions as engineering majors; (6) to improve academic success of engineering students from underrepresented groups by providing academic support and mentoring; and (7) to increase the number of minority students pursuing advanced degrees in STEM fields.

Students Project Description

Pectus Excavatum or "sunken-chest", is due to the overgrowth of the coastal cartilage, which is believed to attach ribs to the sternum. The overgrowth of the coastal cartilage pushes the sternum inwards thereby giving a "caved in" appearance, as shown in Fig. 2(a). To cure the pectus excavatum, one rare-earth magnet is implanted inside the chest. Once an external rare-earth magnet is placed close to the implanted magnet, the magnetic attraction force is able to pull the implanted magnet and the chest outward, as depicted in Fig. 2(b) [4, 5]. After applying a constant force on the chest bone over a period of several months, the chest will be corrected into a normal form.

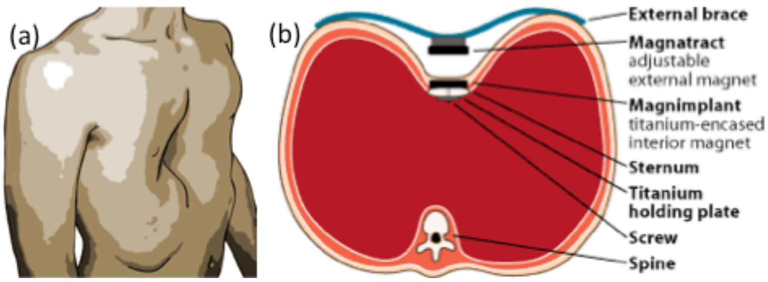

Figure 2: (a) pectus excavatum (b) the magnetic mini mover procedure

To study the efficacy of this newly proposed procedure, a datalogger is needed to record the mechanic pressure generated by the magnets. A pressure sensitive resistor is used to measure the pressure between the external magnet and the external brace. To record the measured pressure, a datalogger is needed. The datalogger is to measure the resistance of the pressure sensor, condition the measured signal, digitize it by an analog-to-digital inside a microcontroller, and store the digitized information. The datalogger includes a pressure sensor, an operational amplifier, a micro-controller and a SD memory.

The students are expected to accomplish the following tasks:

1) Understand the background of the datalogger project; Go over the analog circuit design principles in developing the datalogger.
2) Get familiar with the user interface and the functions of Cadence OrCAD PCB Designer suit 16.3; Learn how to use simulation to solve electrical circuit problems.
3) Collect data sheets of each component, read data sheet and how to make appropriate footprints.
4) Perform design rule check (DRC) of their schematics; Generate a bill of material; Generate a netlist for PCB editor;
5) Finalize the design of 2-layer and 6-layer PCB and generate the Gerber file for fabrication;

Project Outcomes

Students successfully complete the schematic design of the datalogger. With the help from a graduate student, students from Cañada College are able to design a low-power datalogger to monitor the mechanical pressure generated by the magnetic mini mover, as depicted in Fig. 3.

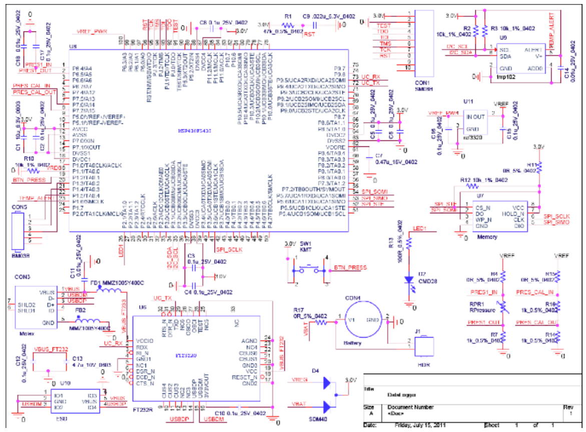

Figure 3: the schematic of the datalogger

Students have devotes > 60% of effort to design the layout of a printed circuit board (PCB) to facilitate the designed schematic. To cut down the size, a six-layers PCB technology is used. The overall diameter of the PCB is 1.5 inch, as shown in Fig. 4

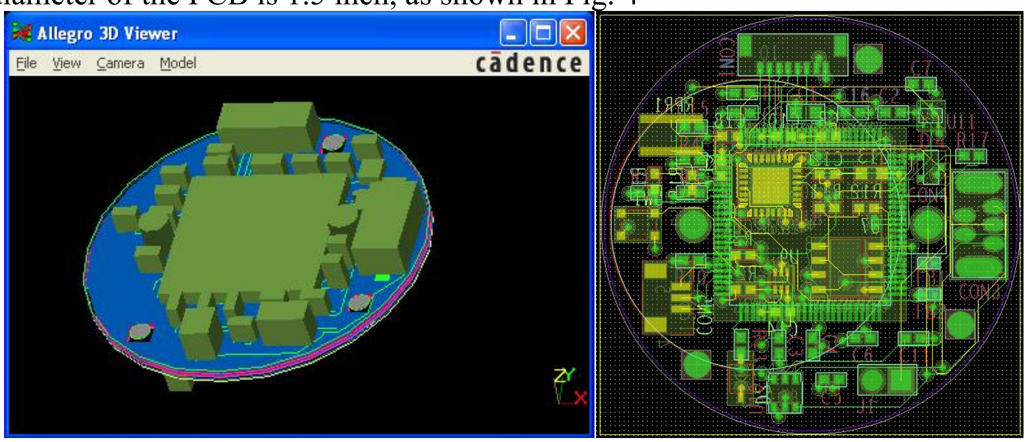

Figure 4: The 3D and layout of the datalogger.

Project Assessment and Future Improvement

To obtain a quantitative assessment of the project and further improve the project in the future, an exit survey was conducted for all twelve students participating the CiPair program. Students were asked to rate their level of agreement with each question in a five point scale: 1 – Not at all useful; 2 – A little; 3 – Some; 4 – Quite a bit; 5 – A lot. The tables below present the students' response to the survey questions. The survey was conducted anonymously to help student express their opinions honestly.

Question**:** How useful were each of the following activities during your internship?

Activity	Average Rating
Opening Day on June 6th	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?

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?

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.

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

The general response to the program is quite positive. The program successfully introduces the engineering research to college students and motivates them to learn more about the engineering.

The students do appreciate the experience in interdisciplinary research, however, they do not show overwhelm enthusiasm on the need for the interdisciplinary learning. The primary reason is that the students are deeply immersed in the project itself and overlook the project's interdisciplinary nature. In the future, the program will have to include the biomedical ethics training so that the students can have more direct communications with medical staffs and opportunities to visit the medical facilities and personals.

Summary and Conclusion

The CiPair program successfully motivates college students to learn engineering by exposing them to the real world engineering research and development. Students have positive feedback on the interdisciplinary learning and research experience. Direct exposure to the biomedical research is desired to further encourage students into the interdisciplinary learning.

Acknowledgement

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