2018 ASEE ANNUAL CONFERENCE & EXPOSITION
JUNE 24–27, 2018
SALT PALACE CONVENTION CENTER
SALT LAKE CITY, UT

Paper ID #21370

Collaborative Interdisciplinary Research Through Projects From Concept To Completion

Prof. Shahnam Mirzaei, California State University, Northridge

Dr. Shahnam Mirzaei is an assistant professor in the Department of Electrical and Computer Engineering at the California State University, Northridge. He has received his Ph.D. from University of California, Santa Barbara (UCSB) in the area of Electrical and Computer Engineering at 2010, His M.Sc. from California State University, Northridge, and his B.Sc. from University of Tehran. Dr. Mirzaei has worked as an application engineer for six years from 2000 to 2005 with focus on problem solving and resolving design issues with regards to Xilinx FPGAs and SoCs. After receiving his Ph.D., he has worked as an R&D engineer in the area of signal processing for three years from 2010 to 2013. Dr. Mirzaei started his academic job as an assistant professor at California State University, Northridge at 2013. His research interests fall into the realm of reconfigurable hardware, signal and image processing, and embedded systems. In recent years, he has focused on developing techniques for hardware acceleration of software algorithms and implementing signal processing applications on on reconfigurable hardware. Dr. Mirzaei has been the recipient of Electrical and Computer Engineering Department Fellowship Award in Spring 2010 from University of California, Santa Barbara, Radar Systems Spot Award Achievement Certificate in recognition of superior individual effort for developing signal processing algorithms, in February 2011 from Exelis (currently known as Harris Corp.), Inc. and 59th Annual National Engineers Outstanding Engineering Achievement Merit Award in Universal City, California in February 2014. He has collaborated actively with researchers in several other disciplines of, particularly computer architecture, reconfigurable hardware, and signal and image processing. He has been a member of Technical Program Committee for International Conference on ReConFigurable Computing and FPGAs in 2013 and IEEE Journal of Transactions on VLSI Systems in 2016.

Ana Cristina Cadavid, California State University Northridge
Dr. Vicki A Pedone, California State University Northridge
Dr. Werner Horn,
Harvey Rich

Collaborative Interdisciplinary Research through Projects from Concept to Completion

Shahnam Mirzaei[1], Ph.D., Ana C. Cadavid[2], Ph.D., Vicki A. Pedone[3], Ph.D., Werner Horn[4], Ph.D.

California State University, Northridge CA 91330, USA

[1]smirzaei@csun.edu, [2]ana.cadavid@csun.edu, [3]vicki.pedone@csun.edu, [4]werner.horn@csun.edu

Abstract. Retention is a major problem for engineering majors, including Electrical and Computer Engineering students. Multiple factors contribute to retention issues, such as poor teaching and advising, the difficulty of the engineering curriculum, and lack of motivation resulting from poor connections to the engineering community. Statistics indicate a large drop in the continuation rate between the first and third years among Science, Technology, Engineering, Math (STEM) students. As students encounter increasing course difficulty in the early stages of their programs, they often lack motivation to persist because they have weak connections to their majors and potential careers in STEM. The Summer Interdisciplinary Team Experience (SITE), part of the National Science Foundation Science Talent Expansion Program aimed at increasing the number of bachelor degrees awarded in STEM fields, focused on students finishing sophomore-level courses in engineering, math, and physical sciences. The primary goal of SITE was to create a STEM community through participation in small research projects that students worked collaboratively on from concept to completion. In this 3-week summer program, students in interdisciplinary teams of ten worked closely with faculty mentors to develop solutions to socially relevant STEM problems. The projects emphasized hands-on activities and interdisciplinary team-based learning and decision making in order to keep students motivated and interested throughout the project. Faculty mentors first introduced the team to the project concept, then helped them develop the skills and knowledge needed to implement solutions. At the end of the 3-week period, each team made a formal presentation that discussed goals, methodologies, challenges and results. The presentations were accompanied by a live demonstration of the final product. Qualitative assessment based on participants' answers to exit questionnaires show that the program accomplished its goal to increase motivation to complete the STEM major. Although our program was not limited to Under Represented

Minority (URM) students, the participation of URM students far exceeds their representations in most of the participating STEM majors. Survey results show that participation in SITE was particularly beneficial for URM students.

1. Introduction

In 2010 the National Science Foundation (NSF), awarded our institute (not mentioned due to blind review policy) a grant to support the activities of the project "STEPS (Students Targeting Engineering and Physical Science). The overarching goal of STEPS is to increase the number of bachelor's degrees earned in STEM (Science, Technology, Engineering, and Mathematics) majors, which we define as all of the majors in the College of Engineering and Computer Science (CECS) and the College of Science and Mathematics (CSM). Our activities target majors in computer science, engineering, mathematics and the physical sciences because bachelor's degrees conferred in these fields declined by 18.6% between 1985 and 2000 [1]. In 2009 at the time of the project design, statistical data from our institute (not mentioned due to blind review policy) showed that only 20% of the STEM first-time freshmen (FTF) graduated in STEM fields within seven years; and only 43% of the STEM first-time transfers (FTT) graduated in STEM fields within five years. Furthermore, the continuation rate for STEM FTF was 77% after one year, but only 42% after two years.

The activities of STEPS at our institute (not mentioned due to blind review policy) focus on decreasing these attrition rates. To achieve this, we have implemented Summer Interdisciplinary Teams Experience (SITE) for students transitioning to the junior year. As indicated by the statistics, there is a high degree of attrition in the transition between sophomore- and junior-level coursework. These students may lose motivation to stay in STEM because course difficulty increases and connections to their majors and potential careers are still weak. SITE targets this student population in a 3-week-long interdisciplinary team project that highlights problem solving and hands-on activities. The framework for SITE is based on established best practices for student success. There is ample evidence that research experiences for undergraduate students are important in enhancing learning, interest, and persistence in STEM fields [2]. Other studies also indicate that summer research experiences have a strong positive effect on subsequent entry to Ph.D. STEM programs [3]. In particular, research activities have been found to be important for retention of under-represented minorities (URM) and disadvantaged economic groups [4, 5, 6]. Other studies demonstrate the benefits of close mentoring of students [7, 8], and that this mentoring is especially important to URM students [9, 10]. Team size in SITE is limited to 10 students in order to create strong bonds between students and between students and faculty mentors. This is typically the first time these students have had the opportunity to work in a small-group environment closely with a faculty mentor because class sizes in freshmen and sophomore courses are usually large.

Statistics from the Office of Institutional Resources (IR) at our institute (not mentioned due to blind review policy) indicate that in the years 2000-2005 about 30% of students in CECS were from traditionally underserved groups (American Indian/Alaskan Native, African American, Native Hawaiian/Pacific Islander, Latina/o). During the grant period of the STEPS project from 2011 until 2016, the percentage of underserved students in CECS has been ~35%. Although SITE activities were not specifically designed for URM students, the aforementioned educational research shows the significant positive impact of research experiences on this student population so that we expect that SITE will contribute to narrowing the opportunity gap.

The rest of the paper is organized as follows: Section 2 covers the components of the SITE program. Section 3 lists the SITE projects. The demographics of the student participants and assessment of the results will be discussed in Section 4, and finally we conclude the paper in Section 5.

2. The Summer Interdisciplinary Teams Experience (SITE)

2.1 Background

The components of SITE were developed using emerging best practices in STEM education and the strengths of our own institution. In 2004 the Committee on Facilitating Interdisciplinary Research, convened by the National Academy of Sciences, presented a report on facilitating interdisciplinary research based on surveys, focus groups, and interviews, as well as a thorough review of the literature [11]. The report presents evidence-based consensus on the study's statement of task by an authoring committee of experts. They found that undergraduate students showed "great enthusiasm for interdisciplinary and problem-driven questions, including those of societal relevance." They also provided a list of recommendations at different levels of the educational process from the development of interdisciplinary courses and programs to interdisciplinary Research Experiences for Undergraduates (REU). The report on "The Logic of Interdisciplinary Studies" [12], based on an extensive compilation of studies until the time of publication, summarized a variety of benefits to the students who partook in interdisciplinary activities. They found that participants had an increased ability to think critically, creatively, and more cooperatively with better understanding and retention of material, and the development of the capacity to find interconnections among fields compared to non-participants.

2.2 SITE Structure

SITE offers students opportunities to participate in research projects that have an interdisciplinary perspective and are related to sustainability issues of interest to the campus and the community at large. Our institute (not mentioned due to blind review policy) has had a strong commitment to sustainability issues on the institutional level and

by individual faculty in their research. In 2009 the Institute for Sustainability was established to foster research and curriculum on diverse impacts of economics, science and technology, and social equity on sustainability. Its mission is to "promote, facilitate, and develop educational, research, and university and community programs related to sustainability." The Institute is committed to serving our campus community by increasing interdisciplinary and cross-functional communication, and supporting and aiding in the development and application of sustainability practices within the university and community. In past years the Institute has partnered with the local community and industry on projects related to solar cell technology, transportation, campus food gardens, increasing recycling, and water conservation. Some of the SITE projects were inspired by these themes. Among all SITE projects, four projects directly and 10 project indirectly address the sustainability issues (The list of the projects can be seen in Table 2).

SITE is a 3-week-long program open to majors in computer science (CS), engineering (ENG), mathematics (MATH) and physical sciences (SCI, Biochemistry and Chemistry, Geological Sciences, and Physics and Astronomy). The program focuses on these majors because the number of graduates in these fields is low compared to those in other majors such as Biology. The goals of SITE are to increase students' critical thinking, teamwork skills, and motivation to eventually increase the retention rate and obtain a bachelor's degree in their fields. The experience of using their STEM knowledge to solve a problem that has socioeconomic and/or ecological/resource relevance affirms the importance of STEM careers and inspires them to graduate in these majors.

In the fall semester preceding an upcoming SITE program, our institute (not mentioned due to blind review policy) faculty submit proposals for team projects. The selection of four final projects by the STEPS' principal investigators (PIs) is based on the relevance of the topic to the goals of SITE and the potential for engaging students with challenging hands-on activities. The scale and scope of projects must be appropriate to the 3-week time frame and follow an arc from presentation of the problem and information and tools needed to solve it, to development and testing of ideas/devices, to the final presentation of possible solutions. Each project under SITE program is led by a faculty member from the CECS. There are also projects within SITE program that are led by other faculty in CSM (College of Science and Mathematics). To provide multiple perspectives on the relevance of the problem and the technical and scientific knowledge needed to solve it, visiting lecturers from other fields lead lectures and/or activities during the program in coordination with the team leader. Field trips are also used where appropriate. Graduate or advanced undergraduate students assist the team leader with the preparation and execution of the hands-on activities.

Each year, about 40-42 students are selected from a competitive application process, open to continuing students and incoming transfer students. To be eligible, students must have completed at least one semester of calculus, one laboratory science course, and one additional course in their majors. The first priority is given to the target population of students transitioning between the sophomore-level and junior-level coursework. The

second priority is given to freshmen transitioning to sophomores and early-stage sophomores. Once the candidates are chosen, selection aims to optimize the diversity of the cohort within the groups according to major, ethnicity, gender, and GPA. Applicant GPAs range between 2.0 and 3.9, with an average around 3.0. The STEPS team organizes the students in teams of 10 (and in some cases up to 12 when grouping in 10 was not possible) students ensuring that a diverse range of majors and student abilities are represented in all teams. Table 1 shows the student participation through the life of the project.

Table 1. SITE student participation

	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Number of applicants	41	69	69	57	104	84	424
Number of participants	30	40	43	42	41	40	236
Participants from CECS	N/A	33	36	35	34	32	170
Participants from CSM	N/A	7	7	7	7	8	36
Projects from CECS	2	2	2	3	4	4	17
Projects from CSM	1	1	2	0	0	0	4
Joint projects from CECS & CSM	0	1	0	1	0	0	2

During the three weeks of the program the teams meet 5 days a week, 9 am-3 pm with a one-hour break. To initiate team bonding, the orientation meeting includes a "roller-coaster-physics" activity (shown in Figure 1) where students and faculty mentors work collaboratively to maximize the number of loops that a ball bearing can successfully complete as it descends unaided through polyethylene tubing.

Figure 1. Roller-coaster-physics activity exercised at orientation meeting

Throughout the 3 weeks, the projects emphasize hands-on activities, the development of critical thinking and teamwork skills, and close connections to the faculty mentors. All SITE members gather for brown-bag lunches on the first two Fridays to share progress on their projects, including how problems were overcome and plans for the following week.

At the conclusion of SITE, each team makes a professional presentation describing their solution to the real-world problem that required integration of knowledge from the different disciplines. In attendance are the SITE participants, the faculty mentors, the STEP PIs, members of the Internal and External Advisory Boards of the STEP program, and other faculty and administrators. The event culminates with a celebratory luncheon in which each student is individually presented with a certificate of completion of the program, a stipend check, and a t-shirt. During subsequent years, SITE graduates receive announcements of REU and summer internship programs; and the STEP PIs and the faculty mentors provide letters of recommendation for the applications.

Students who complete the summer experience with no unexcused absences receive a $1,000 stipend for their participation in the program. They are also given early registration, an important benefit to sophomores who have the last registration dates in the university. Project leaders are paid $9,000. The visiting lecturers including faculty from other institutions, experts from industry, or university technical staff, were given a $500 stipend for a full day of instruction. Each team leader is allowed $2,000 to hire student assistants and $2,000 for equipment and supplies. All expenses are covered by the NSF grant. The average cost per student is roughly about $2300.00.

3. SITE Projects

Below is the list of projects pursued from 2011 to 2016, followed by short descriptions. We had three projects for the first year and four projects for the following years. Among all projects, 56% of the projects were assigned by the faculty from Electrical and Computer Engineering (ECE).

Summer 2011
Global Positioning Satellite (GPS) Instruments and Plate Tectonics (ECE) Earthquakes from plate tectonic movements threaten many major cities in the United States and worldwide. Various research methodologies for plate movements and earthquakes have led to efforts to forecasting these catastrophic events. Global Positioning Satellite (GPS) instruments are an integral component in the study of Earth movements and earthquakes. This summer experience engaged students in the interdisciplinary study of earthquake forecasting.
Constructing an Earthquake Seismometer Earthquakes threaten several major population centers in the United States and around the world. Research into seismic events has led to efforts to predict these seeming random events. Seismometers remain the vital instrument in the study of earthquakes. This summer experience engaged students in the design, construction, and testing of functioning seismometers**.**

Solar Energy vs. Wind Energy Competition (ECE) Increasing sources of non-fossil fuel energy is a national and state priority. In California, utilities are mandated by 2020 to generate 33% of their total generation using clean and renewable energy. Currently, the most popular and cost effective of these are solar and wind energy. This summer experience included a friendly competition in electricity generation between a solar team and a wind team.

Summer 2012
Electric Bicycle Design for a More Sustainable Campus (ECE) University campuses have experienced a dramatic growth in car traffic, parking demands and the size of student population. Bicycle usage on campuses not only addresses many of the problems associated with such a growth, but also contributes to a healthy life. In this project students studied, built and tested an electric bicycle. They also investigated possible impacts of the implementation of an "electric bicycle program" on campus.
Sustainably-powered, Non-polluting Water Purification System Clean water is a basic human need, and in the United States we only think about its availability in times of drought. However during a prolonged power outage or major natural disaster, getting enough drinking water will be critical. In this project students developed a sustainably-powered non-polluting water purification system deployable in primitive conditions and emergency situations.
Construction of an Earthquake Seismometer and Early Warning System Earthquakes threaten many large population centers in the United States and around the world. Early warnings of major seismic events are critical to emergency responders, utilities, and those in charge of other critical infrastructure. In this project students designed and constructed a functioning seismometer and developed a software interface that provided an early warning system.
Natural Hazards and Resources of the San Gorgonio Pass Region Every infrastructural lifeline of southern California—from freeways to cross-continental gas lines to 550 kV power lines, aqueducts, and the railroad—threads through San Gorgonio Pass. The Pass is also one of the nation's deepest mountain passes and, with stable wind flows that average 15-20 mph, home to one of the nation's largest and ever expanding wind-energy farms. This SITE project explored ways that engineering, science and mathematics can help understand the seismic hazard at San Gorgonio Pass and mitigate damage and improve resource management and design**.**

Summer 2013
Harvesting Energy from Human Movement to Charge Hand-held Electronic Devices Harvesting energy from human motion/movements is being widely studied as one of the viable sources of sustainable and renewable energy, in order to supplement the energy extracted from other conventional and non-conventional sources. In this project students focused on harvesting electrical energy from human motion/movements. They performed system analyses of the proposed design and used off the shelf components to produce a prototype.
Construction of an Optical Polarimeter for Sky Measurements The polarization of sky light is produced due to the scattering of unpolarized sunlight by clouds, atmospheric molecules and aerosols, and other local pollutants. Measurement of skylight polarization, using both ground- and space-based techniques, is a powerful technique for remote sensing to monitor a variety of atmospheric constituents. In this project students learned about polarization of light and constructed and operated an Optical Polarimeter.
Measuring Aerosols Locally and Understanding Climate Globally In this project students learned about the greenhouse effect, and used Educational Global Climate Model software to run numerical experiments and make climate predictions 100 years into the future. They investigated the uncertainties due to the air components. In parallel they constructed sun photometers and used them to measure how aerosols in the air affect solar radiation, studying how their results are related to climate change.
Green Design for campus Buildings Green Design is a movement in the architectural and engineering disciplines to design and construct buildings incorporating the local environment and taking advantage of natural resources in order to minimize the impact on local, regional, and the global environment. In this project the students systematically studied the existing conditions of the Oviatt library and developed an optimized renovation model to increase the level of efficiency.

Summer 2014
Implementation of Spectral Imaging Using Fourier Transforms on Reconfigurable Hardware (ECE) Large data sets are products in numerous fields of science and engineering. In this project students learned how to extract information from large datasets from a variety of fields and from simulated noisy datasets. They applied both software and hardware techniques, the latter using a FPGA board in which codes are implemented directly on a microchip.

Impact of Solar and Wind Generation in the Environment and in Sustainability from the Electrical Engineering Point of View (ECE) In this project students learned about the principles of solar and wind generation. They learned how to install and use a set of solar panels and to calculate the electric load of a typical residency in California. Students develop a strong understanding of the importance of renewable energy and its effect on the system (smart grid) especially its impact on the environment.
Future Modern Electric Grid: Generation, Transmission and Distribution (ECE) In this project, students learned how electric energy is generated, transmitted, and distributed to the consumers through an electric power system. They became acquainted with topics such as power generation, power transmission, energy efficiency, energy conservation, and energy monitoring. They also learned the modern concept of "smart grid" as compared to traditional electric power grids.
How Sustainable are the Green Buildings? The Performing Art Center was designed to be energy efficient with LEED (Leadership and Energy in Environmental Design) "Gold" certification. In this project students assessed how this building is performing, evaluated how much sustainability it offers in its current condition, and finally developed an optimized renovation model to increase the level of efficiency.

Summer 2015
California Drought - What Can Californians Do? In this project students learned about the drought problem in California, including the short-term and long-term impacts. They learned how they can prepare for the ongoing drought, including basic facts about water reclamation and reuse. Several hands-on water-saving activities were implemented.
DC (Direct Current) Home (ECE) United States annually consumes an average of 7 Tera watts-hour (TWh) of energy, 1.68 TWh of which is lost in general, with 0.655 TWh being lost specifically in distribution lines. A 10% reduction in distribution losses would save 5.7 billion dollars; and more importantly, 42 million tons of carbon monoxide would not be emitted. One way to accomplish this goal is to integrate solar power, LED lighting and batteries and home electronics into one single system. In this project students learned how to use solar panel energy directly to power LED lighting and home electronics.
Autonomous Collaborative Exploration: An Attempt to Learn Robot-Environment Interaction (ECE) Robots are becoming an intrinsic component of daily life. Intelligent robots can autonomously plan and execute instructions to accomplish a task and adapt to uncertain environments. This project takes a hands-on approach to introducing the basic concepts in robotics science, using LEGO Mindstorms autonomous robots as a

hardware platform. Students developed a hands-on knowledge of robotics science and became familiar with research trends and applications in the field.
Photovoltaic (PV) Power Generation (ECE) PV is rapidly growing and it is expected that CA will have 33% of its power generated from solar panels by 2020. The campus has several PV installations providing energy to different facilities. In this project students were exposed to the basics of PV power generation and to the maximum power point tracking (MPPT) concept. They developed in house systems using off-the-shelf components to monitor the output voltage and current generated by the PV panels for different solar insolation levels.

Summer 2016
Green Energy (ECE) Today mobile devices remain connected 24/7 and therefore there is an increasing demand for electricity for battery chargers. Unfortunately the battery technology has not grown at a comparable pace and there is a need to charge the batteries frequently. When traveling, charging electronics devices can be an issue. A solution to the problem can be provided by a mechanical charger which extracts the energy from some reliable renewable source. The goal for the "Green Energy" SITE project is the design and development of a mechanical charger using wind and solar energy for use with any mobile devices.
Smart Home Energy Management System (ECE) In this project, a small scale smart home with energy management capabilities will be built and demonstrated. Basic principles of power and energy saving as well as energy efficiency within the smart home will be introduced. We will show how intelligent monitoring and control of home appliances will help reduce the energy cost and improve efficiency of the home. A smart controller will be programmed and assembled which gives the home owner the opportunity to monitor the electricity consumption in real time, in order calculate the home energy/power consumption and the future electricity bill. The home owner will be able to monitor the power consumption on a real time base and the power/energy curves after a certain time period. The power saving data of the smart home energy management will be demonstrated to ensure efficiency improvement and electricity bill savings.
Electric Speed Drives in Transportation (ECE) Electric car sales increased by 50% during 2015, which surpassed the car market sales by ten times. Hybrid electric cars still is a large business. The components industry is booming very fast with components such as batteries, supercapacitors, in wheel-systems, transmission and electric motors, and power electronics. There is a tendency to use electric speed drives with capacities from 5 to 15 KW for specific vehicles, such as golf carts, cargo vehicles, lifting vehicles and small shuttle buses. Permanent magnet synchronous motors (PMSM) and Induction Motors (IM) are the motors of choice for drives. To put it in perspective of education, job market, and state of the art technology, in year 2013, 63 billion dollars were spent in electric

motors alone and it is projected that 302 billion dollars will be spent by the year 2023. This is very important in terms of CO2 pollution and the environment as a whole. This project will introduce students into the speed-drive technologies being utilized for electric transportation with a look into the CO2 consequences.
Where Art Meets Science – Evolution of Imaging through Light and Color (ECE) This project takes on hands-on approach to introducing the digital image processing concepts through examples and applications. The topics included in this project are digital imaging science, image visual perception, image enhancement, histogram processing, image filtering, image restoration, image segmentation, and digital photography techniques. Furthermore, the evolutionary path from light sensitive photographic film to modern digital imaging will be reviewed. Most of the photography techniques and principles will be covered in this course. No background is needed in photography or image processing. Advanced scientific concepts will be avoided. By the conclusion of this project, students will have a hands-on knowledge of image processing techniques, research trends, and applications in the science of digital imaging. Writing and implementing image processing applications and algorithms using Matlab high level language to extract and analyze data from images, improving mathematical and analytical skills of data, altogether will significantly improve the resumes of participants. As a bonus, students will obtain a good understanding of the art of digital photography. Prospective industries include image forensics, astronomy, artificial intelligence, biomedical science, aerospace, video/audio engineering, photography, radar engineering, and so on.

The left image on Figure 2 shows the students when they finished the 3-week project on spectral imaging and the right image on Figure 2 shows the students working on line tracker robot project.

Figure 2. Left: Spectral imaging on reconfigurable project, Right: Robot environment interaction project

4. SITE Evaluations

There were 6 SITE programs during the summers of 2011 through 2016. The last one was not originally planned but it was made possible through an extension of the grant. During the first year we had three projects and for all other years we had four, for a total of 23 projects. A total of 230 students from 9 different departments participated. Figure 3 shows the demographics distribution of all students.

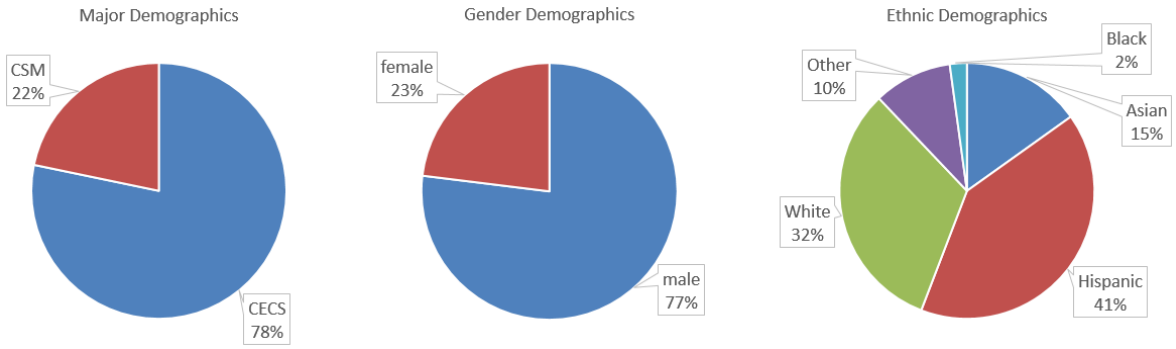

Figure 3. Left: Major demographics, Center: Gender demographics, Right: Ethnic demographics

We had Institutional Review Board approval to conduct and report the assessment on our program. To assess the effects of SITE we are using three tools:

1) Exit questionnaires administered on the last day of SITE (Attached in the Appendix.)
2) Individual interviews conducted about five months after completing SITE
3) Data from IR (Institutional Research)

After the questionnaire evaluation of SITE 2011 (31 students), we found that the exit questionnaire needed improvement to elicit thorough information about the impact of the program on the educational and career plans of the students. The improved questionnaire was then used in all subsequent SITE programs. The statistics presented in Table 2 include all 230 students for questions 2,4,7,8 and 9. For the other questions only the responses for the cohorts 2012-2016 are included. Results parsed according to ethnicity and gender are included.
Responses to all questions indicate that students highly valued their SITE experience, which has increased or maintained their interest in completing their STEM major, their academic-skill levels, and their interest in pursuing faculty research and/or industry internships. We found that for most questions URM students had comparable or slightly more positive responses to those of the whole group. Here we report on the questions in which there were differences in the responses according to ethnicity and gender. 82 % of URM students compared to 78% of all students reported that participation in SITE increased their commitment to complete a STEM major, and 81% of URM students compared to 77% of all students indicated that the program gave them better

understanding of how they will use their STEM skills and knowledge in their future careers. This is specifically can be of interest as this program did not target URM students. These favorable increases are compatible with studies that indicate that URM students are particularly receptive to programs offering research experiences. In the case of gender, 83% of female students compared 74 % male students found the program gave them better understanding of how they will use their STEM skills and knowledge in their future careers. In most of the cases, male and female students had comparable results. However this was one of the few cases that the difference between the two genders was significant. Also 74% female versus 70 % male reported that participating in the project increased confidence in their academic skills. Interestingly the analysis also found that 89% males as compared to 83% females found that the team project made them more positive toward working in groups.

Table 2. Results of Exit Questionnaires

	Questions	Strongly Agree or Agree (%)		Strongly Agree or Agree (%)	
		All	URM	M	F
1	Project met or exceeded initial expectations	81.7	82.5	80.7	84.6
2	Team project made me more positive toward working in groups	87.4	88.7	89.2	82.7
3	Team problem solving with other majors was helpful	89.1	91.8	88.6	90.4
4	Better understanding of how to use skills and knowledge in their career	76.5	81.4	74.4	82.7
5	More interested in working with faculty in faculty mentored research	90.0	90.7	89.2	92.3
6	More interested in industry internship	93.0	95.9	93.8	90.4
7	As result of project more likely to stay in major	95.5	95.4	95.5	95.2
8	As result of project more likely to switch majors within CS, ENG, MATH, SCI	4.0	4.6	3.9	4.8
9	As result of project more likely to switch majors out of CS, ENG, MATH, SCI	0.5	0.0	0.6	0.0
10	Participating in project increased confidence in academic skills	70.9	72.4	69.7	73.8
11	Participating in project maintained confidence in academic skills	29.1	27.6	22.4	21.4
12	Participating in project increased desire to obtain a degree in STEM	77.5	81.6	77.6	78.6
13	Participating in project maintained desire to obtain a degree in STEM	22.5	18.4	22.4	22.2
14	Finding SITE project intellectually simulating	73.9	74.1	74.1	78.6

Quantifying all aspects of student impact is an important task that remains as future work for this experiment but we have seen quite a few positive effects on students. As an

example, JC, a Hispanic student, joined the Department of Geological Sciences in Fall 2010 as a transfer student with a 2.6 GPA. He participated in the first SITE program in June 2011. Becoming aware of the opportunity as a graduate of SITE, and motivated by the summer experience, JC attended in August 2011 the launch of the spacecraft of the Juno mission to Jupiter. While having to overcome the challenges typical of our students to support their education, JC kept on track and graduated in Fall 2012 with a 3.0 GPA. He went on to the MS program in which has completed his thesis and graduated with a 3.6 GPA. In the follow-up interviews, the students consistently praised SITE for:

- Working in teams
- Working with students of different backgrounds
- Exposure to other fields
- Meeting faculty on a close basis
- Working on projects with real applications
- Integrating material learned in courses to solving complex problems
- Opportunity to think about careers in industry
- Good for the resume

At this early stage in their educational careers, SITE represented one of the first times that many of these students were able to engage in and reflect upon these important aspects of STEM training.

The following highlights some markers of positive impact on students:

- 22% of students report that participation in SITE maintained their desire to obtain a degree in STEM.
- 77% of students report that participation in SITE increased their desire to obtain a degree in STEM.
- 87% are more positive toward actively working in groups.
- 90% reported an increased interest in participating in faculty research and 93% in pursuing an industry internship.

5. Conclusion and Future Work

SITE is a component of the comprehensive STEPS program, which has the goal of increasing the number of bachelor's degrees conferred in CECS and CSM. It targets students transitioning between sophomore- and junior-level coursework and offers them a 3-week summer research experience designed to increase critical thinking, teamwork skills, and motivation to graduate in their STEM majors. The activities in SITE emphasize close interactions with the faculty mentors and interdisciplinary work in projects relevant to sustainability. Importantly, 78% of the SITE students are from CECS, and 43 % of participants are URM students. The percentage of URM in SITE is similar to the overall population, but significantly higher than the 35% in CECS. It is a clear

indication of the interest of URM students in this type of program. As the grant ends, in order to quantify the impact of SITE on closing the opportunity gap, we plan on using data from IR to track GPA, retention, and graduation rates in order to compare SITE URM students to the rest of the population of SITE participants. The same analysis will be performed for the female students because their representation is low in the Engineering fields. Results from questionnaires already show that the program favorably impacts the academic skills and attitudes of the participants toward their STEM majors and STEM careers. URM participants in particular strongly value this early-career research experience.

References

[1] National Science Board, 2003, The Science and Engineering Workforce: Realizing America's Potential: National Science Foundation, NSB 03-69, 92 p.

[2] Boyer Commission on Educating Undergraduates in the Research University. State University of New York: Stoney Brook; 1998.

[3] Pender, M., Marcotte, D.E., Sto, M.R. & Maton, K.I. 2010, The STEM Pipeline: The Role of Summer Research Experience in Minority Students' Ph.D. Aspirations., Educ. Policy Anal. Arch., 18(30)

[4] Slovacek, S.P., Tucker, S. and Whittinghill, J., 2008, Modeling Minority Opportunity Programs: Key Interventions and Success Indicators: Journal of Education and Human Development: vol. 2, issue 1, 14 p., http://www.scientificjournals.org/journals2008/articles/1329.pdf

[5] Taningco, M.T.V., Mathew, A.B., and Pachon, H.P., 2008, STEM Professions: Opportunities and Challenges for Latinos in science, technology, engineering, and mathematics: Tomas Rivera Policy Institute, http://www.ibm.com/ibm/ibmgives/downloads/STEM_Lit_04-16-08.pdf , accessed August 2009

[6] Lopatto, D. 2007, Undergraduate Research Experiences Support Science Career Decisions and Active Learning, The American Society of Cell Biology

[7] DuBois, D.L., Holloway, B.E., Valentine, J.C. & Cooper, H. 2002, Am J Community Psychol., 30(2), 157

[8] Campbell, T.A. & Campbell, D.E. 1997, Res. High Educ., 38(6), 727

[9] Summers, M. F. & Hrabowski, F.A. 2006, Science, 311, 1870

[10] Gurin, P., Dey, E.L., Hurtado, S. & Gurin, G. 2002, Harv. Educ. Rev., 72(3), 330

[11] http://www.nap.edu/catalog/11153.html

[12] Mathison, S., & Freeman, M. 1997, "The Logic of Interdisciplinary Studies" National Research Center on English Learning & Achievement, Albany, NY; (http://www.albany.edu/cela/reports/mathisonlogic12004.pdf)

Appendix
Final Assessment Questionnaire

Now that the SITE projects are complete, we would like to ask you a few questions about your experience. Please take your time to answer as honestly as you can and to add addition comments where requested.

As indicated in the questionnaire at the beginning of the project, the results from this questionnaire will be kept strictly confidential. All association with your individual names will be erased at the end of the research. Again, none of the results will be released with your names to instructors. We thank you for participating in this final evaluation of the SITE project.

For questions 1 through 8, please place an answer on the line next to the question or statement about the summer SITE project, from 1 to 5 as follows:

1. Strongly Disgree	2. Disagree	3. Neither Agree nor Disagree	4. Agree	5. Strongly Agree

_____1. I feel that the project met or exceeded my initial expectations.

_____2. I found the team-based problem solving required by the project made me more positive toward actively working in groups.

_____3. I found the team-based problem solving with students from other majors helpful to understanding and solving the class project.

_____4. I have a better understanding of how I will use the skills and knowledge of my major in a professional career.

_____5. The project made me more interested in working with faculty in faculty mentored research.

_____6. As a result of this project I am more interested in doing an industry internship, if given the opportunity.

_____7. I feel that I the project was completed to my satisfaction.

Please elaborate and indicate why you feel this way or why not?

_____
_____
_____
_____
_____
_____
_____
_____

For questions 9 through 12, please use the response categories listed within each question.

_____8. As a result of the project I am more likely to:

A. continue in my current major

B. switch to another major within the sciences, computer science, engineering, or mathematics

C. switch to another major out of the sciences, computer science, engineering, or mathematics.

_____9. Participating in this project _____ my confidence in my academic skills.

A. increased B. maintained C. decreased

_____10. Participating in the project has _____ my desire to obtain my bachelor's degree in a science, math, computer science, or engineering major.

A. increased B. maintained C. decreased

_____11. Approximately what percent of the Summer SITE program did I find intellectually stimulating?

A. 10% B. 25% C. 50% D. 75% E. 90%

Please elaborate on the parts that you found most intellectually stimulating and why.

_____
_____
_____

_____
_____
_____
____

Please elaborate on the parts that you found least intellectually stimulating and why

_____
_____
_____
_____
_____
_____
_____

12. What changes/additions to the Summer SITE program would you like to see?

_____
_____
_____
_____
_____
_____
_____
_____
_____

13. If you think the group aspect of the project could be improved, what parts could be improved and why?

_____
_____
_____
_____
_____
_____

The following questions are for overall data analysis purposes only and will not be used for any other purposes, nor released to anyone as individual information.

_____14 . I consider myself to be:

1. Latino/a or Hispanic 2. Black 3. White 4. Asian

5. Other, please specify_____

_____15. I am: 1. male 2. female

16. My declared major is: _____

Please take a moment to write any *additional* comments about the project and instructors that you feel would be helpful, for example was there too much work, was the work too easy, could you have used more weeks, should there have been homework, etc? Thanks for your help and participation in this survey.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____