Strengthen Education in Engineering and Research (STEER) Program

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ABSTRACT: *During summer 2003, California State University, Los Angeles (CSULA) and California State University, Long Beach (CSULB) have established a Research Experiences for Teachers (RET) program sponsored by the National Science Foundation (NSF) and the National Astronautics and Space Administration (NASA). Through this program, entitled Strengthen Education in Engineering and Research (STEER), a group of fifteen teachers have received five-week research training on the two campuses. Four research facilities were utilized: the Multimedia Animation Technology Incorporated in Engineering Systems (MATIES) Laboratory; the Structures, Pointing and Control Engineering (SPACE) Laboratory; the Digital Signal Processing (DSP) Laboratory at CSULA; and the Robotics and Automation Laboratory at CSULB. The research activities comprised of Animation of Space-Based Dynamic Systems and Aircrafts (both conducted at MATIES Laboratory), Development of an Interface Device and Control Algorithms for the SPACE Test-bed (conducted at the SPACE Laboratory), Digital Signal Processing (conducted at the DSP Laboratory), Structural Health Monitoring (conducted at the Long Beach Public Safety Building), and Control of Robots (conducted at the CSULB Robotics and Automation Laboratory). The objective of the STEER program is to increase the participants' research competency, and to motivate them to revise the course curricula at their institutions based on the newly emerging concepts, software, and simulation tools. A series of workshops, and seminars have been conducted for the participants to gain knowledge of transferring engineering and technological innovations to high school and community college classrooms. A website has been established for the STEER program. Significant emphasis of this website has been put on an innovative development of the webfolios that include information of the participants. As a result of this program, the Co-PIs have submitted a proposal to Boeing Corporation and based on the funding level up to hundred teachers will participate in this program over the period of three years.*

1 INTRODUCTION

GOALS AND OBJECTIVES OF STEER

California State University, Los Angeles (CSULA) and the California State University, Long Beach (CSULB) established a Collaborative to sponsor the Strengthening Teachers Education in Engineering and Research (STEER) 2003 summer program. The proximity of these universities separated by only 24 miles, as well as, a strong history of past collaborations a broad coalition of educational and research resources exist within the Multimedia Technology Research Laboratory - a National Science Foundation (NSF) – supported facility; the Structures Pointing And Control Engineering (SPACE) laboratory – a National Aeronautics and Space Administration (NASA) – supported facility at CSULA; the Long Beach Public Safety Building – and the Robotics and Automation Laboratory – at CSULB.

The major learning and programmatic goals of the STEER program were:

- Offer opportunities for fifteen teacher and community college faculty to experience research as practiced at these laboratories located on the CSULA and CSULB campuses.
- Train the participants on the use of software packages that can be utilized for the modeling and animation of large structures, such as space telescopes, aircrafts and robots. Increase the participants competency in topics related to the areas mentioned above and motivate them to revise the course curricula at their institutions based on the new emerging concepts, software and simulation tools.

- Conduct interface seminars between the participants and the CSULA / CSULB professors to gain knowledge of transferring engineering and technological innovations to high school and community college classrooms.
- Enrich the collaboration between the participants and CSULA/CSULB to increase the number of underrepresented minority students who will choose engineering and science as their future study subjects.

The PI for this effort was Professor Helen Ryaciotaki-Boussalis, the Chair of Electrical and Computer Engineering (ECE) Department at CSULA. The Co-PIs were Professors Charles Liu, Jane Dong, Khosrow Rad, Jeffrey Beyon, Professors of ECE at CSULA, and Professor Anastasios Chassiakos, Professor of the School of Engineering at CSULB.

2 RESEARCH ENVIRONMENT

CSULA, five miles from the center of downtown Los Angeles, serves the most diverse population of students of any higher education institution in the country. As an urban institution located in the midst of a highly developed concentration of electronic, manufacturing, and aerospace industries, the university has an historic commitment to and record of service in meeting the educational needs of Los Angeles 'culturally diverse communities. Of its 19,500 students, 46.2% are Latino, 25.8% Asian American/Pacific Islander, 17.6% white, 9.9% African American and 0.5% American Native. One of only two four-year public institutions in California that is a full member of the Hispanic Association of Colleges and Universities (HACU), CSULA is also a federally designated Title III institution and the only Minority Institution (MI) of higher learning in the State of California with an engineering school.

The California State University, Long Beach (CSULB) is a large urban university, located in the port city of Long Beach, CA. In Fall 2002 there were 34,566 students enrolled, making CSULB the largest campus in the CSU system and the second largest in the state of California. Of the 34,566 students, 20,730 were female and 13,836 male. Among the Fall 2002 students, 7,633 were Hispanic, 2,062 African American and 221 were American Indian.

The Multimedia Technology research laboratory at CSULA was established in 2002 and is sponsored by NSF. The objective of this laboratory is to develop multimedia technologies applicable to space-based dynamic systems, to aircrafts and to semiconductor devices. Computer design and analysis software including IDEAS, NASTRAN, Open GL, Visual Studios, and MATLAB are used for design, simulation, animation and visualization. A major goal of the laboratory is to increase the number of CSULA underrepresented minority students who will participate in a structured research-based educational program, preparing them for advanced degrees and engineering careers.

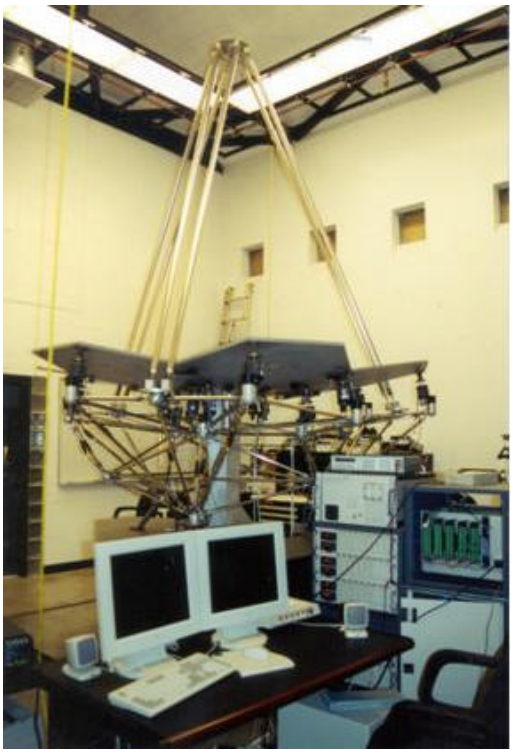

Figure 1 – The SPACE Laboratory

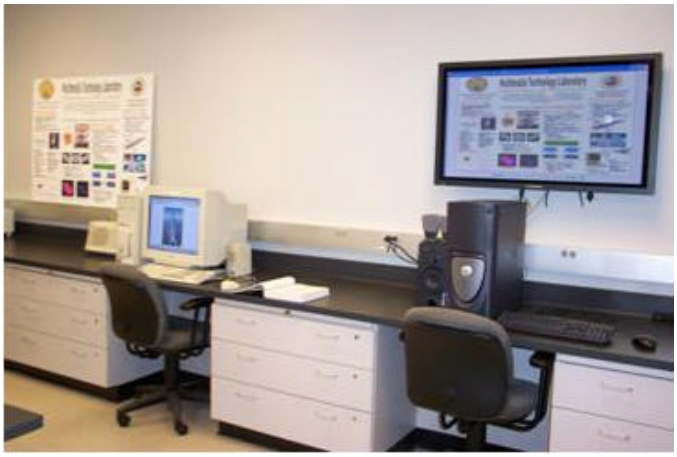

Figure 2 – The MATIES Laboratory

The SPACE at CSULA was established with a $5.3 million NASA Institutional Research Award (IRA) granted in 1992. The objective of the program is to design and build a segmented reflector test-bed. Within this project, state-of-the-art multidisciplinary technologies have been developed that combine controls, structures, electronics, and computers. The project has been conducted under a coalition consisting of four universities, a NASA Center, and five major aerospace companies. The development of the test-bed has been conducted under the supervision of eight dedicated engineering faculty whose renowned expertise encompasses the variety of disciplines inherent in the project. Over hundred talented minority engineering students from the participating universities have been 'involved in the research and development of the test - bed. The project has served as a stepping-stone from which these students have pursued either graduate studies or successful careers in major industries in Southern California. Effective March 1, 2003 this Laboratory is part of a University Research Center (URC) sponsored by NASA for the next five years. The research concentration will be related to the control of space segmented telescopes.

The Signal Processing Laboratory was established in 2002 with funding received from National Instruments. The Laboratory is equipped with 10 stations. In each station, a dynamic signal analyzer board (NI-PCI-4451) with a omni-directional microphone, and an amplifier are embedded. Each analyzer board offers 2 simultaneous-sampling analog input channels with software-configurable on-board anti-aliasing filter with maximum of 204.8 KS/s scanning rate. For more than two channels of simultaneous sampling, multiple NI-PCI-4451's can be synchronized by an external triggering signal. The analyzer's broad dynamic range of 90 dB with 16-bit resolution provides digitized analog samples of superb accuracy and high quality. In each workstation, the state-of- the-art software package, LabVIEW, is available to provide computing capability.

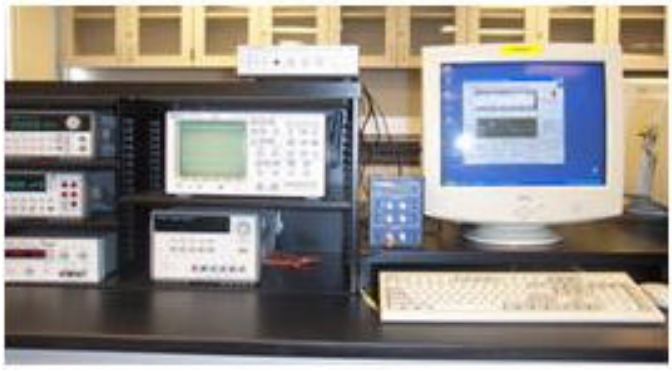

Figure 3 – Signal Processing Laboratory

The Long Beach Public Safety Building Facility is located in downtown Long Beach, CA. and it is currently undergoing a $30 M seismic retrofit. Part of the retrofit project is the instrumentation of the building with sensors and data acquisition systems to monitor the structural response and changes in the structural parameters. The sensors that are currently being installed on the building include: strong motion accelerometers, strain gages, fiber optic strain measurements, acoustic emission sensors, and laser-based displacement measurements.

Figure 4 – Long Beach Public Safety Building

The Robotics and Automation Laboratory at the CSULB College of Engineering is an instructional and research laboratory. The laboratory uses instructional robots such as RHINO five axis robotic manipulators, LEGO Mindstorm robots, and Basic Stamp-based Boe-Bots from Parallax Corp. Robots are programmed in C, C++, Visual Basic and PBasic. The laboratory also uses an ER1 robot by Evolution Robotics with 1MHz P4 processor on-board for autonomous movements and for integration of machine vision with other sensor signals. In addition, students in the laboratory work on designing, manufacturing and testing robots for participation in robot battle competitions. Robotic activities at CSULB are sponsored by the Society of Manufacturing Engineers, Northrop-Grumman Corp., Electronic Data Systems (EDS), local industry, and by the CSULB College of Engineering.

Combined these laboratories offered opportunities for teachers and community college faculty to participate in the following range of research experiences:

- Modeling, Electronic Interface, and Animation of Large Structures;
- Digital Signal Processing;
- Civil Structure Monitoring;
- Design and Manufacturing of Robotic Systems;

Figure 5 – Robotics and Automation Laboratory

In addition, the educational resources of the two universities provided both the teachers and the community college faculty the opportunity to participate in two seminars covering the following topics:

- Overview of "What is Engineering";
- Research Ethics, and Developing a research plan that can form the basis of a proposal;
- "How to communicate the results through a report and poster session";
- Basics of pedagogical approaches to translate the research experience back into their classrooms.

3 NATURE OF TEACHER/COMMUNITY COLLEGE FACULTY ACTIVITIES

Specific research activities under the STEER program are presented in the sequel. Twelve participants have worked with the faculty at CSULA while three of them worked with the faculty at CSULB for a total of fifteen participants.

Each participant was required to be involved with one activity, but yet was required to participate in all workshops sponsored by this program.

3.1 ACTIVITIES

Considering the number of research laboratories available, as well as, the expertise of the CSULA/CSULB professors the following activities have been conducted:

Activity 1: Animation and 3D Visualization of Space-Based Dynamic Systems

One of the research activities of the NSF-sponsored multimedia technologies laboratory is to use animation and 3-D visualization techniques. Such techniques are used to create a computer simulation environment where the dynamic behavior of a space telescope can be visually demonstrated. The Next Generation Space Telescope (NGST), which is based on a segmented reflector technology, is one of NASA's future missions. The technology developed at the SPACE laboratory along with the 3-D visualization and animation capability, which essentially creates a virtual telescope, will be highly relevant to the NGST program. The virtual telescope can be used to evaluate technologies developed for shape control, pointing and tracking. The STEER program offered an excellent opportunity for the teachers and community college professors to learn about the dynamics and basic control methods of a space telescope. In addition, the participants have been trained to use software packages such as Open GL, Visual C++, and the 3D Studio Max. With the knowledge gained, the participants upon return to their campus can enrich the content in courses offered in the areas of physics, mathematics, and astronomy.

Activity 2: Animation and 3-D Visualization of Aircrafts

Another research activity being carried out in the CSULA Multimedia Lab is the development of simulation software packages to model the complex dynamic behavior of flight vehicles. In addition, animation and 3-D visualization techniques are developed allowing the creation of virtual aircraft structures. The participating teachers and community college faculty had the unique opportunity to learn about the dynamics of aircrafts, and get familiar with animation software packages such as 3D Studio Max, Open GL and Visual C++ which facilitate animation. Experience earned in these areas is leveraged

to have a great impact on the high school, as well as, community college mathematics and physics education.

Activity 3: Development of an Interface Device for the SPACE Test bed

The participants participated in the design of an interface device between the controllers and the SPACE test bed. This activity enhances the participants' knowledge in the areas of modeling, system design, and software programming. Software packages such as MATLAB and PSpice are utilized to facilitate the system design. The knowledge gained from this activity assists the participants in the development and modification of existing science courses offered at their institutions.

Activity 4: Control System Design

The participants participated in the design of decentralized controllers that achieve shape control and precision pointing of the SPACE testbed. State-of-the-art software packages such as MATLAB and SIMULINK are utilized to facilitate the design. The knowledge gained from this activity assists the participants in the development and modification of existing science courses offered at their institutions.

Activity 5: Familiarization with Signal Processing Systems

The participants investigated on the overall concept of signal processing systems starting with analog signal conditioning, data acquisition, front-end data processing, signal processing algorithms, and finally conversion of processed data to an analog signal, via hands-on experiments on each topic. Hardware configuration as well as software integration was introduced to participants. The application of Digital Signal Processing to dynamical systems was also demonstrated. Field trips to local industry were scheduled in order to enhance the real-world experience. State-of-the-art software packages such as LabVIEW and MATLAB are utilized to perform the design. Experience earned in this area has a great impact on the high school, as well as, community college mathematics and physics education.

Activity 6: Design and Manufacture of a Robot for Participation in a Robot Battle Competition

This activity was conducted as a continuation of a yearlong project, sponsored by the Society of Manufacturing Engineers (SME), the CSULB, and high tech industry such as Northrop-Grumman, and Electronic Data Systems (EDS). The participants worked on one of the following components:

- Use the robot CH-53 that has already been built at CSULB, and convert it to an autonomous guidance vehicle (AGV). Autonomy is achieved via a vision system through a camera mounted on the front end of the robot. PBasic for Basic Stamp BS2, or Microsoft Visual Basic are software packages utilized to facilitate the design.
- Design and assembly a new robot to be used for off-road competitions. This project involves ruggedizing the robot, the electronics, and the motor drives to be able to withstand the harsh off-road environment.

The knowledge gained from this activity has a great impact on the high school as well as community college mathematics and physics education.

Activity 7: Structural Health Monitoring of the Long Beach Public Safety Building

The participants worked on one or more aspects of sensor characteristics, data acquisition, data processing, and data analysis. Software packages used include LabVIEW and MATLAB to facilitate the data acquisition, processing, and analysis. Experience earned in this area has assisted development and modification of existing science courses offered at high schools and community colleges.

3. 2 TUTORIAL SEMINARS AND WORKSHOPS

Several seminars have been offered to 1) brainstorm the difficulty and challenges to encourage students pursuing engineering and science majors, 2) expose the participants to topics related to the engineering profession, engineering ethics, proposal preparation, report preparation, and basic pedagogical approaches to translate research experiences back into the participants classrooms. Also several workshops have been offered to provide training of Microsoft Office software package, website design, and webfolio design.

The following time schedule for the above-mentioned activities and workshops was implemented:

Week 1:
All participants were introduced to the research activities conducted at the research laboratories at CSULA and CSULB. Specifically, seminars sponsored by the Co-PIs have been offered to provide extensive information of the specific research projects. In addition, the participants had the unique opportunity to get a hands-on experience in the participating laboratories. The graduate assistants assisted the Co-PIs to provide the initial training pertinent to the areas of research at the laboratories. At the end of this week, each participant were assigned to a research laboratory in which they received training during the following weeks. Topics described in Activity 8 were also addressed during this week; two seminars were conducted by the Co-PIs to cover these items.
Weeks 2 through 4:
Each participant has been introduced to the dynamics of the assigned system in each research facility and was trained to the utilized developed software techniques. For example, the participants were trained to get familiar with several software packages such as graphic software (3D Studio), programming package for GUI development (Visual C++), and animation software (OpenGL). By the end of the fourth week, the participants were required to give presentations to the group to demonstrate knowledge obtained and skills developed. Furthermore, they should recommend methodologies to be developed to allow transfer of research experiences to the classroom settings. Such information has been archived in their individual webfolios.
Week 5:
The participants completed their training and started working on the preparation of their final report. The report has been submitted to the corresponding Co-PI and evaluated by the Executive Committee. The Executive Committee upon completion of the report evaluation has provided feedback to the participants for finalizing their presentations.

Further, an Executive Committee composed of the investigators has been formed to facilitate project coordination and task progress monitoring. The Executive Committee held weekly meetings to discuss the progress of the program. The PI, as Chair of the Executive committee, was responsible for ensuring the smooth functioning of the project, task oversight and timely accomplishment, documentation and report delivery by the participants, as well as, accountability for overall program performance.

4 PARTICIPANT RECRUITMENT AND SELECTION

The selection and recruitment criteria of the STEER program are described as the follows:

4. 1 RECRUITMENT CRITERIA:

The Co-PIs have developed recruitment materials which were distributed:

- through the CSULA/CSULB college of engineering outreach offices to the local high schools and community colleges;
- through the MESA and MEP offices in both campuses to the local minority serving high schools and community colleges;
- to the CSULA/CSULB campus newspapers to assist identify teachers who are currently enrolled in classes.

4. 2 SELECTION CRITERIA:

The selection of the participants was based on the following criteria:

- examination of applicant's resume by the Executive Council;
- consideration of applicant's letters of recommendation;
- consideration of applicant's statement of purpose describing the reason of participation to the program, as well as, their commitment to it;
- telephone interviews with the applicants to discuss the program and learn more about the applicant's interests;

- in-person interviews with the group of semi-finalists conducted by the Executive Council;
- the assignment of the participants to a research laboratory was based on their professional backgrounds, research interests, and class assignments.

5 PROJECT EVALUATION AND REPORTING

The assessment process included pre-evaluation and post-evaluation of the program. At the beginning of the program the participants were asked to participate in a survey that focused on the interests and abilities of the participants. The post assessment was focused on the value-added knowledge and skills. Summative assessments were based on the participants' webfolio and visits by the Co-PIs to their sites.

Annual report was submitted to the National Science Foundation (NSF). This report outlined the program activities, as well as the assessment methodology and programmatic data acquired during the training period.

6 RESULTS AND CONCLUSION

The results of the STEER program are summarized below:

- The Co-PIs of this program have developed a web site (www.csulasteer.com) which describes extensively the STEER 2003, summer program;
- Due to this program a great number of minority students accompanied by the STEER participants visited the research laboratories mentioned above. These visits have been beneficial to the students, and there are indications that they have been encouraged to major in Science and Engineering;
- Due to this program, the Co-PIs have visited the STEER participant's sites and interface with their students thus providing more encouragement for their involvement with science and mathematics classes;
- During summer 2003, it came apparent that the program was very beneficial to the participants and they have suggested that the Co-PIs seek funding from federal agencies and local industry to enable continuation of this program. As a result of this suggestion the Co-PIs have submitted a proposal to Boeing Corporation and based on the funding level up to hundred teachers will participate in this program over the period of three years.

The goal of the program to involve minority teachers was also fulfilled. In particular, 43% of the participants were female, 79% were underrepresented minority including females, 36% were African American, 8% were Hispanic, 1% Asian American, and 21% white male.

Figure 6 - STEER Summer 2003 Photos

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