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Contributions to Educational Structures that Promote Undergraduate Research

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Abstract. The opportunities for community college and traditionally underrepresented minority students to participate in research experiences are typically rare. Further, what research experiences that are available often underutilizes the students' potential and do not have follow-up programs. The Physics Outreach Program (POP) working in conjunction with the Jet Propulsion Laboratory is designed to reach out to this segment of the student population and encourage them to consider careers in physics and astronomy. The program is special in that it creates a "vertical" consortium or pipeline of schools whereby students graduating from one participating institution will then transfer to another. This helps to insure that participating students will experience continuity and, with the assistance of JPL equipment and staff, a quality of instruction that they would otherwise not be able to afford.

Key words. educational outreach, undergraduate research, community college research, underrepresented minority student research

I. Program Overview

The Physics Outreach Program (POP) is a consortium of local Los Angeles universities, community colleges, high schools and NASA's Jet Propulsion Laboratory (JPL) [1]. Its primary purpose is to encourage students, especially underrepresented minorities, to consider physics and astronomy as career choices. A secondary purpose is the establishment of a direct mechanism for transfer of research methodology from JPL to the local participating science education departments and the strengthening of the cooperative ties between those departments. Last] y, the formal results of the research have direct application to the mission design of current or proposed flight projects at JPL.

To achieve its primary purpose the POP program has adopted a "pipeline" or vertical organizational structure. The idea here is that students would go to, and be supported from, high school to community college, to state college and then finally to graduate school. If all goes well some of those students could end up as contributing professionals at research institutions.

Communication among faculty along such a structure can strongly promote improvements in curricula, educational delivery and laboratory experiences at the entry level institutions. Faculty at such institutions can then more strongly justify requests for course and laboratory upgrades with school administrators with the argument that they are required to maintain the level of quality expected of the transferring institution and JPL. This type of structure could serve as one possible model to improve science education nationally in conjunction with NASA field centers and their affiliated local universities.

Under ideal circumstances potential physics and astronomy students would enter the program at participating high schools, typically at the beginning of their junior year. For their participation, they would receive financial support at a level consistent with entry level high school employment. This would in turn obligate them to stay in school, maintain a B average in their science classes, participate with the college students in field training exercises and generally expose them to the potential of the program. The financial support is crucial to establish the commitment of the program *for* the student and to be able to demand a higher level of responsibility *from* the student that would in general not be required in the high school environment.

The program is committed to communicate to the student that they have stable and positive choices in life, and that they can join a nurturing community and environment that understands and appreciates their desire to do science. Such an environment is important to all young science students but especially to minority students who traditionally lack exposure to a science community.

At the end of their high school participation students should have established their desire to a career in the sciences or that science is a direction they wish to pursue. And although their choice may not necessarily be in physics and astronomy that they are planning to enroll in the standard science/engineering courses. Additionally, they should have received enough instruction and training with JPL procedures, protocol and equipment so as to be productive when they enter into the next phase in the collegiate program.

From high school, again under ideal circumstances, students would transfer to a local community college or in special cases directly to a participating state university. The community college transfer choice has the advantage of offering the student a more gradual incorporation into collegiate life and a tremendous cost savings. Students would receive the same stipend that they would have received at the state university so as not to discourage them from attending a community college solely on the basis of discrepancies in financial support. Such savings could potentially be used for graduate school. Additionally, the community college is sufficiently close in most cases so as to allow the student to remain living at home so as to achieve further saving and allow more time for emotional growth. Further, academic deficiencies that may be present can also be addressed.

At the end of the community college experience the student should: have all lower division science requirements completed, have sufficient experience with JPL equipment to have been checked out on all telescopes and to conduct observational investigations without direct supervision, and have declared as their major physics or astronomy.

From the community college, yet again under ideal circumstances, transfer to a participating state college would occur. Students would complete their baccalaureate degrees in physics or astronomy, write a paper to be published as their senior thesis and apply to graduate school.

II. Program Experience

As mentioned before the above overview represents the ideal case. The experiences of the past two summers are distilled in this section.

The previous overview assumes that the program was year-round. Unfortunately funding was available only for the summer research component for the summers of 1995 and 1996. The participating schools were Pasadena Unified School District GeoSpace Academy (sponsored by JPL and known simply as Space Academy), Pasadena City College (PCC), Los Angeles City College (LACC) and California State University, Los Angeles (CSLA). All of the above schools are minority serving institutions.

Since part of the funding for the program came from the Galileo, Cassini and the Mars Pathfinder flight projects offices respectively, research direction came from scientists on these projects. All work was done at JPL's Table Mountain Observatory (TMO) which is about a two hour drive (in good traffic conditions!) from downtown Los Angeles. The telescopes that were used are both of Cassegrain configuration with 1.2 meters and .6 meters of aperture. CCD's used for the observations were both thermoelectrically and LN2 cooled. Data reductions were done on Sun work stations using IRAF (Image Reduction and Analysis Facility) or on 486 based PC's using generic image processing software.

The summer of 1995 was the pilot year of the program, with just PCC and CSLA conducting active research. The following is a brief summary of those efforts.

The PCC team concentrated on faculty/infrastructure development and observationally, at the request of the Cassini project [2], timed the occultations between the moons of Mimas and Enceladus. Two methodologies were employed. One was to construct the combined light curve of both moons and deduce the time when the curve first dropped as the time of first contact. The other was to plot the separation between the moons as a function of time and then to extrapolate to the time when that separation was zero as the time of maximum occultation. 1995 was a rare triple ring plane crossing for Saturn and hence an especially good time to do occultation timings. These observations were part of an international effort to do such timings and the data was used to upgrade the ephemerides of these moons to improve the navigational capabilities of the Cassini spacecraft when it orbits Saturn.

The CSLA group worked on three projects [3], [4],[5]: general scans of the atmosphere of Jupiter to look for remnants of the Shoemaker-Levy 9 impact to support observations of Galileo in orbit about Jupiter, data reductions of previous observations of Mars to characterize the impact of dust storms on potential landing sites, creation of an educational movie which shows the motions of the moons of Saturn, and integration of an infrared spectrometer on the 1.2 meter telescope.

In 1996, during the bad weather season, work started on two instrumentation projects: installation and testing of the conditioners for decreasing instrumental noise on the 1.2 meter telescope CCD camera, and installation and testing of LN2 cooled near infrared imaging spectrometer. The later project also included design of an optical and mechanical system for the simultaneous imaging in the visual and near IR.

For the summer of 1996 students from the Space Academy and LACC joined the program. The research directions were observations of comet Hale-Bopp, the rings and atmosphere of Saturn, continued development of the infrared spectrometer and astrometry of Jupiter's outer moons.

III. Future Developments

Additional community colleges are planned to join the program in 1997. They are East Los Angeles Community College (ELAC) and South West Community College (SWCC). Both are minority serving institutions which have a cluster of minority high schools sending students to them. Since not all students will elect (unfortunately!) to continue in physics and astronomy these additional schools will assist in recruitment and retention efforts, The hope is to create a critical mass sufficient to have students ultimately complete their baccalaureate at CSLA and gain the recognition of prospective Ph.D. granting institutions as a place for them to find well qualified students with research experience.

In the Pasadena area, the Pasadena Unified School District along with the California Institute of Technology has implemented a "pre-academy" at the junior high level as a primer for the existing space academy. This also complements the Caltech SEED program to develop science education at the elementary school level. Thus through public education in Pasadena, students can in the sciences, go from grammar school to graduate school. This again illustrates the advantage of the "pipeline" structure.

The majority of the funding for the current program was provided by NASA's office of Equal Opportunity, Code E. The success of the program can hopefully be continued to a permanent year round program through finding from the National Science Foundation modeled after the successful program currently in place at the University of Wyoming. Continuity and consistency are key for the POP program, or any program like it, to achieve the goal of increasing the number of students, especially underrepresented minority students, receiving Ph.D.'s in physics and astronomy.

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