AC 2012-2990: INITIATION OF AN UNDERGRADUATE RESEARCH PROGRAM

Dr. Dan G. Dimitriu, San Antonio College

Dan G. Dimitriu has been practicing engineering since 1970 and taught engineering courses concurrently for more than 20 years at various institutions. In 2001, he joined San Antonio College full-time as the Coordinator of its Engineering program. He has been involved with several engineering societies and became a member of the Two-year College Division of ASEE in 2002. His research interests are in alternative fuels, fuel cells, plastics, and engineering education.

Mr. Jerry O'Connor, San Antonio College

Jerry O'Connor has been teaching physics (and occasionally engineering and math) courses since 1980. He is currently Department Chairperson and has persistently advocated for the integration of findings from physics and engineering education research with education practice.

Initiation of an Undergraduate Research Program

at a Community College

Abstract

Our two year college is home to the first (and only to date) MESA Center in Texas. MESA is a comprehensive academic support program that originated in California in 1970. MESA stands for math, engineering and science achievement, and the program is designed to help students excel in math, science, technology, and engineering courses and graduate with STEM-based degrees. The MESA Center is also home for several student organizations on our campus, including MAES, SACNAS, and SWE. Over the last two years we have partnered with a nearby university to direct a NASA sponsored undergraduate research program. The program (CIPAIR) provides opportunities for undergraduate students to participate in ongoing research projects off-campus, as well as to conduct new research projects on campus under the guidance and supervision of a faculty member.

The MESA Center served as a focal point for promoting these opportunities and for dissemination of project results. The on-campus research projects were developed by student teams based on equipment and instrumentation that was available and/or obtained by loan or donation. Three teams worked independently on projects involving solar panel efficiency, hydroponics, and energy production by a rider on a stationary exercise bicycle. The projects concluded with team reports and presentations in the MESA center to an audience of students, staff, faculty, and NASA representatives.

Undergraduate research programs at four-year institutions have been widely reported to increase retention, and our results indicate that two-year institutions can also initiate successful programs. This paper will present in detail the initiation of a summer undergraduate research program at our community college, offer recommendations, and outline future plans.

Reason for the Project

Overall engineering employment is expected to grow by 11 percent over the 2008–18 decade and traditionally engineers have been concentrated in slower growing or declining manufacturing industries. It is projected that they will continue to be needed to design, build, test, and improve manufactured products but, at the same time, increasing employment of engineers in service industries such as engineering, research and development, and consulting should generate most of the employment growth [1]. The 2007 United States Census forecast a need for 1.75 million engineers by 2010, a 20 percent increase from the (then) current number of practicing engineers. However, in 2005 the National Science Board reported that less than half of the undergraduates intending to major in science, technology, engineering, or math (STEM) fields actually complete a STEM degree within 5 years, and that underrepresented minorities drop out of these majors at a higher rate than other groups [2].

The National Science Foundation's 2005 Survey of Graduate Students and Post-doctorates in Science and Engineering[3] found that among STEM graduate students in the U.S. who were U.S. citizens or permanent residents, only 7.5% were African American and only 6.9% were Hispanic, although these groups account for 13% and 14% of the U.S. population, respectively.

At the ten institutions listed in the September 2007 issue of Hispanic Business Magazine as the "best engineering schools for Hispanics," Hispanics earned only 6.2% of the postgraduate degrees in engineering. The New York Times reported in May of 2011 that Japan is now short more than half a million engineers, which means that they will be competing with U.S. industries for engineering graduates.

Project Goals

As a minority serving institution, our College has a stated mission to attract and engage minorities on a path toward higher education. A high level of achievement in Science, Technology, Engineering, and Mathematics (STEM) education is essential if the U.S. is to maintain a leading role in aeronautics, space science, and technology. Based on the given realities, our College agreed to partner with the local four-year public University to work with NASA to develop a project that would improve STEM education at our institutions and attract minority students to the STEM fields and retain them through graduation. The major goals proposed for this project were:

Goal 1: To attract Hispanic and other minority students into scientific and technological careers related to NASA's mission, and retain them through the baccalaureate.
Goal 2: To improve the content and delivery of science and engineering education provided by San Antonio College, a minority-serving institution.

It is commonly acknowledged that engaging students in authentic hands-on and interactive educational activities is essential to facilitate and enhance learning in the STEM fields. It has become clear over the past two decades that undergraduate research experiences have consistent positive correlations with student persistence and achievement. [4], [5], [6], [7]

Although it would seem advantageous to introduce undergraduate students to research projects and problem solving activities as early as possible, for engineering students a potential problem is to find meaningful research projects that are representative of engineering problems in general, and that can be analyzed within the students' scope of expertise. In order to be effective, the projects must be interesting and appealing to students in order to ensure engagement and sufficient attention to details. Specific learning objectives for this project were:

- Students will be able conduct meaningful undergraduate research and gather data that will help reinforce principles and concepts learned in STEM courses.
- Students will be able to use word-processing, spreadsheet, and presentation software to write and present reports on their research projects.
- Students will have a deeper understanding of engineering activities in general and specific requirements of research activities in particular.
- Students will be able to engage in productive work with fellow students.

Program Description

In 2010 our College partnered with our local four-year public University to submit and jointly manage a CIPAIR NASA grant to improve the engineering curricula at both institutions by creating new NASA inspired courses and/or improving existing courses by infusing them with NASA related materials. An important part of the program was the development of an undergraduate research plan that would help students relate their NASA sponsored research with STEM course content and classroom activities. This partnership was intended to utilize the dominant transfer path for engineering students from our two-year college to complete their bachelor degree.

An intense advertising campaign was initiated in the early spring of 2010 to recruit qualified students and the results exceeded our expectations by a substantial margin. The number of students expressing an interest to participate in the program exceeded the capacity of the original grant budget, and since the undergraduate research plans for each institution were developed independently we were able to implement a plan for our College that included two different tracks. In one track students would participate in NASA managed projects at the Johnson Space Center in Houston. These students had to have a GPA $\geq$ 3.5, be US citizens, and follow NASA's strict acceptance procedures. Students that did not qualify for a NASA project or could not leave town for personal reasons were provided the opportunity to participate in the second track which would involve students in undergraduate research projects conducted on our College campus under supervision of a faculty member.

After the selection process was completed, four students and one faculty member were each accepted by NASA for a ten week internship period at the Johnson Space Center, and ten students were accepted to do undergraduate research at San Antonio College under the supervision of two faculty members.

Each of the students selected as interns at Johnson Space Center was assigned to a different team. One student studied solar panels efficiency as part of the Crew and Thermal Systems Division of the Engineering Directorate; another student provided support for a new water systems inventory project; a third student was assigned to the Advanced Planning Office and participated in a project of defining, managing, and implementing a software database tool; the fourth student was assigned to the ISS Risk Management Office and participated in research to study the risk to the Cupola module from manmade orbital debris that could affect space shuttle operations and safety of the ISS crew. All four students received excellent performance reviews and two were recommended for outstanding student intern award recognition; one of them was one of the five NASA interns that received the 2010 Outstanding Intern Award that summer.

For the projects conducted on our college campus, the ten students formed three teams based on topics of common interest and each team submitted a research proposal. One team of three students elected to study the efficiency of photovoltaic solar panels under different conditions. They contacted a local solar energy consortium and demonstration project and were able to solicit a donation of three different panels to conduct their the research. The students designed and constructed directionally adjustable support frames, installed the panels, and completed their research agenda during the summer break. Another team of three students selected a subject that might be helpful to future lunar farming: hydroponics. They designed and built the racks, containers, and irrigation system in a nearby greenhouse recently constructed for the Biology department. The students planted several types of vegetables and monitored their evolution with

respect to different feeding formulas and the growing conditions. A third team of four students designed and built a stationary bicycle exercise machine to monitor the energy output of riders in three different pedaling positions.

After the fall 2010 school semester started, in conjunction with a site visit from the NASA Program Manager, a two day public event was held at the San Antonio College MESA Center during which the students presented the results of their research experiences to fellow students, faculty, and attending NASA officials. Local press and radio stations also reported on the event in the local media.

Conclusions

In the NASA End of Experience Survey all participating students unanimously expressed satisfaction with the program, the positive experiences they had with the research, what they learned, and the desire to persist in their current STEM studies. The overall results from the first year of the NASA CIPAIR undergraduate research experience were so uniformly and exceptionally positive that the program funding formula will be reviewed and adjusted in order to accommodate more students in the second year of the grant.

References

1. Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2010-11 Edition*, Engineers, on the Internet at http://www.bls.gov/oco/ocos027.htm
2. NCPPHE (National Center for Public Policy and Higher Education), 2008*: Measuring Up 2006: State-by-State Report Card for Higher Education.* Washington, D.C.
3. NSF's 2005 Survey of Graduate Students and Post-doctorates in Science and Engineering, National Center for Science and Engineering Statistics (NCSES) [formerly the Division of Science Resources Statistics (SRS)], http://www.nsf.gov/statistics/nsf07321/
4. "Developing Undergraduate Research and Inquiry", Alan Jenkins and Mick Healey, June **2009**, The Higher Education Academy (The Higher Education Academy, Innovation Way, York Science Park, Heslington, York, YO10 5BR, United Kingdom) (http://www.heacademy.ac.uk/assets/York/documents/resources/publications/DevelopingUndergraduate_Final.pdf)
5. Forging a 21st Century Model for Undergraduate Research. Bioscience, Jan2011, Vol. 61 Issue 1, p18-18, 1p; DOI: 10.1525/bio.2011.61.1.6; (AN 57643521) http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=57643521&site=ehost-live
6. "Assessing the Impact of Undergraduate-Research Experiences on Students: An Overview of Current Literature" Mary Crowe and David Brakke, *CUR Quarterly*, **2008**, *28*(4) 43-50.
7. "THE PIPELINE: Benefits of Undergraduate Research Experiences" Susan H. Russell, Mary P. Hancock, James McCulloug, *Science*, **2007**, *316* (5824), 548-549.