AC 2009-1785: GO FOR AEROSPACE! RECRUITING AND MENTORING THE NEXT GENERATION OF AEROSPACE ENGINEERS

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Go For Aerospace!: Recruiting and Mentoring the Next Generation of Aerospace Engineers

Abstract

Recruitment for engineering programs is a real challenge for universities nationwide. To address this problem, Central Connecticut State University (CCSU) has received funding from NASA to conduct an innovative, year-long extracurricular program designed to reach out to high school juniors with high potential in math and science and excite them about careers in aerospace engineering. This new program, "Go For Aerospace!," will provide mentoring and support to these students and encourage them to pursue a degree in engineering. CCSU, with its exceptionally well-qualified engineering faculty, its central location, and its close linkages with local industries and secondary schools throughout Connecticut is ideally suited to launch this effort. The selection process is an extremely important part of the project and is conducted through nomination by math and science teachers in five high-need school districts throughout Connecticut. Based on their recommendations, 30 high-achieving high school juniors are participating this year.

Last fall, a kick-off dinner was held on campus which included a keynote lecture from Captain Daniel C. Burbank, a Coast Guard Aviator and NASA Astronaut. Also in attendance at the kick-off were CCSU's President, Provost and special guests from industry and public education, as well as many of the students' nominating teachers and parents. During the spring semester, students are participating in four full-day field trips, during which they are working with university faculty and students on projects related to mechanical and aerospace engineering, and visiting industrial aerospace facilities to tour research and manufacturing labs and speak with practicing engineers. Another important aspect of these trips is the personal contact that the high school students are having with faculty and undergraduate engineering students throughout the day. The culminating event of the program will be the summer institute where students will spend three days on campus participating in varied activities, such as special seminars and workshops designed to familiarize them with campus life and the college application process. Students will then travel to NASA's Goddard Space Flight Center in Maryland for a five-day visit during which they will learn about state-of-the-art engineering. This experience is intended to inspire students' imagination, ignite their fascination with challenging engineering projects and ultimately develop their genuine interest in engineering careers. A tour of the Smithsonian Institution's National Air and Space Museum in Washington, D.C., will be included as well.

This project is distinctive not only because the aerospace specialization in mechanical engineering at CCSU is unique in Connecticut but also because it outlines a comprehensive plan

for the successful recruitment of prospective engineering students. The selection process is expected to be very effective as it directly involves math and science teachers, a very influential group of mentors. It is also a pro-active approach, which will allow for identification and mentoring of talented students, especially among women and minorities, who might otherwise not pursue a degree in engineering and perhaps not even consider a college education at all. The project will be assessed regularly with regard to both the quality and effectiveness of each stage of the process. Through a follow-up, multi-year study and data collection on the future college choices of participating students we will be able to assess the effectiveness of this approach and also improve the process if necessary.

Introduction

Need for Science, Technology, Engineering and Math (STEM) Talent in the U.S.

Long-term growth in the number of positions in science and engineering has far exceeded that of the general workforce, with more than four times the annual growth rate of all occupations since 1980.[2] The most recent occupational projections from the Bureau of Labor Statistics[3] forecast that total employment in fileds that the National Science Foundation (NSF) classifies as science and engineering will increase at nearly double the overall growth rate for all occupations by 2014, growing by 26% from 2004 to 2014, while employment in all occupations is projected to grow 13% over the same period.[4]

In spite of such promising job prospects, recruitment for science and engineering programs is a real challenge for most universities, nationwide. Unfortunately, math and science are not the subjects of first choice for the majority of American high-school students. According to the recent, congressionally requested report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* "In South Korea, 38% of all undergraduates receive their degrees in natural science or engineering. In France, the figure is 47%, in China, 50%, and in Singapore, 67%. In the United States, the corresponding figure is merely 15%.[5] Clearly, if the United States is to maintain its competitive edge in the global economy, we must increase the pipeline of interested and qualified students prepared to enter STEM careers.

Equally alarming, international comparisons of student mathematics and science performance indicate that U.S. students scored below average among industrialized countries.[4] U.S. 15-year-olds scored ranked 27th out of the 39 countries participating in the 2003 Program for International Student Assessment (PISA) examination, which is designed to assess students' ability to apply scientific and mathematical concepts to real-world problems.[6] Furthermore, the retention rate for engineering students is one of the lowest among all college majors. About one-third of all U.S. students intending to pursue engineering switch majors before graduating.[5] In part, this is due to a demanding and rigorous curriculum, but the fact that some engineering students realize quite late that the program is not the best fit for them also has a negative impact.

Demographic Disparities in Math and Science Achievement

According to the National Science Board's *Science and Engineering Indicators 2008*[4], there are significant racial and ethnic gaps in science and mathematics performance, as evidenced by studies that follow the same groups of students as they progress through school. These studies "reveal performance disparities among demographic subgroups starting when they enter kindergarten … although all subgroups made gains in mathematics and science during elementary school, the rates of growth varied and some of the achievement gaps widened." Similar gaps were observed in rates of immediate college enrollment, with black and Hispanic students, as well as those from low-income and poorly educated families, trailing their white counterparts or those from high-income and well-educated families.[4]

The outlook is also bleak in higher education. Nationwide statistics[7] show that in 2003, 68.3% of engineering degrees were awarded to Caucasians, 14% to Asian-Americans, 5.1% to African-Americans, 5.4% to Hispanic students and 7.2% to others. It is important to note that since 1999 there has been a declining trend in the number of Hispanic and African-American students among all engineering graduates. At the same time, the percentage of Bachelor's engineering degrees awarded to women is around 20%, another indication of the declining trend. For women in Mechanical Engineering and Aerospace Engineering the numbers are only 13.2% and 18.8% respectively.

Effects of Early Experiences on Interest, Retention, and Success

The idea to engage students in early, hands-on experiences as an authentic scientist or engineer is not a new one. However, it is only in recent years that extensive, formal research studies examining the outcome of these opportunities have emerged. According to the 2008 NSF Science and Engineering Indicators, "There is now a growing body of literature that examines the results of such efforts and analyzes them for their effect on at least one of the following outcomes: student attitudes toward science, student research skills, student confidence in his or her ability to become a scientist or engineer, and retention of students within the field."[4] In general, these studies have shown increases in students' interest in and understanding of the research process and the strategies and tools that scientists use to solve problems, as well as a broader sense of career options in the field.[8] A number of studies found that students with a broader range of abilities as well as underrepresented minority students were more likely to stay in or switch to a science or engineering major and to pursue science or engineering graduate education because of an early experience with a working scientist or engineer.[9-13]

Local Aerospace Industry Workforce Needs

CCSU was recently granted licensure to offer a Bachelor of Science degree in Mechanical Engineering, including the opportunity to specialize in aerospace studies, making ours the only university in Connecticut to offer a program in this subject area. Our institution recognized the need for engineering students to remain in the state after graduation to fill local job openings, especially in shortage areas, and thus proposed a program to help meet that need.

The Connecticut Department of Labor compared the number of graduates in the state with the number of annual openings for each occupation. The engineering/science/technology occupations were listed as having the best opportunities for employment. Among these occupations, mechanical engineering and related specializations ranked number one, with 511 annual job openings but only 268 graduates. This indicates that if all graduates sought employment locally, only some 50% of openings would be filled, a condition that is worsened by the known outflow of engineering graduates from the state. According to regional graduate retention data[14], only 27% of graduates intend to stay in the region, while 45% plan to leave after graduation. This makes the shortage of engineers even more severe than typical statistics of openings versus graduates illustrate.

High technology companies form a large and growing sector of Connecticut's economy, incorporating seven of the top ten fastest growing occupations in the state. A large annual gap

between supply and demand in all highly technical fields in the state is anticipated at least through 2012, and it is critically important that engineering students remain in the state to fill job openings. Our state employs 1.7 percent of the engineering workers in the nation, but generates only 0.8 percent of its engineering graduates. Therefore the industry has to recruit from outside Connecticut for these workers.[14] In particular, in our state's engineering arena, there is a strong need for graduates proficient in the area of aerospace engineering as several large and internationally known aerospace companies maintain a significant presence in the state.

To address this problem, CCSU has received funding from NASA to conduct an innovative, year-long extracurricular program designed to reach out to high school juniors with high potential in math and science and excite them about careers in aerospace engineering. This new program, "Go For Aerospace!," will provide mentoring and support to these students and encourage them to pursue a degree in engineering. CCSU, with its exceptionally well-qualified engineering faculty, its central location, and its close linkages with local industries and secondary schools throughout the state is ideally suited to launch this effort.

Program Description

Overview and Objectives

"Go For Aerospace!" (GFA), is a year-round program for high school students and teachers designed to foster students' interest in and readiness for participation in aerospace engineering and related fields. The GFA program has the following specific goals: (1) Expose high school students, especially those from underrepresented groups, to career paths related to aerospace engineering; (2) Conduct research about the effects of the GFA program to enable rigorous assessment of this and other student and teacher outreach projects; and (3) Contribute to the research knowledge base about STEM career preparation through dissemination of information about the program and its resources, and insight gained from the program's development and implementation.

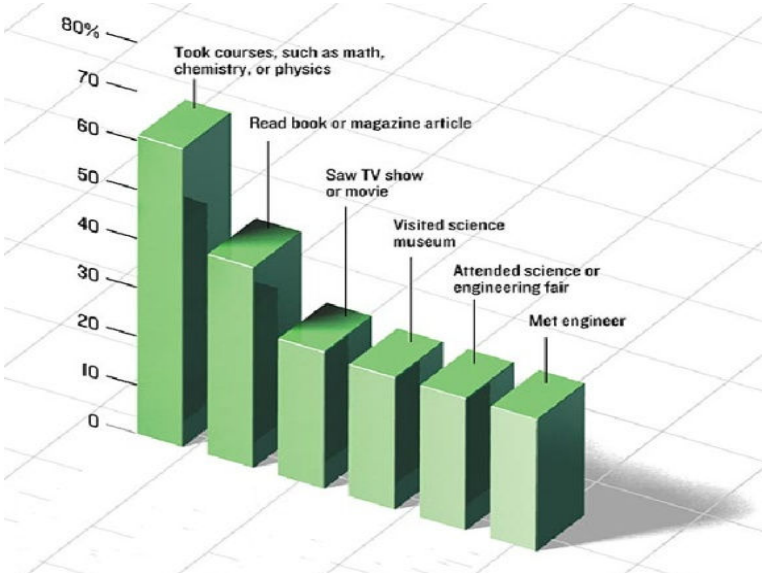

Figure 1. Activities that inspired survey respondents to consider being an engineer/ technology professional.[1] *(Source: The Response Center, a market research firm in Fort Washington, Pa., conducted the survey for IEEE Spectrum and IEEE-USA. An e-mail questionnaire was sent to about 2000 higher-grade and 2000 student IEEE members selected randomly. Data was collected between 3 and 16 December 2003. A total of 830 members responded, including 427 higher-grade and 403 student members, for a 21 percent response rate. More data from the survey is available at www.spectrum.ieee.org.)*

Selection process

The selection process is an extremely important part of the entire project. Results from surveys of technology students (Figure 1) indicate that math and science teachers can have a

significant impact on the decisions of prospective engineers. This important fact informed the strategy that we used to recruit our first cohort of students. We began by first assembling the math and science supervisors from several high-need school districts in order to provide them with an overview of our new program and the desired profile of a qualified student candidate. The district supervisors then passed this information along to their high school math and science teachers, who proceeded to nominate students for the program using application forms we specifically developed for GFA.

Based on their recommendations, 30 high-achieving high school juniors were selected (demographic data provided in Figure 2) and on November 17, 2008, a kick-off dinner was held at on our campus that included a keynote lecture from a Coast Guard Aviator and NASA Astronaut. Also in attendance at the kick-off were the university's President, Provost and special guests from industry and public education, as well as many of the students' nominating teachers and parents. In a recent installment in the Harvard Family Research Project's series of evaluation briefs, "Issues and Opportunities in Out-of-School Time," Lauver et al. list effective outreach to families among the key strategies for getting students into programs and sustaining their participation.[15] This underscores the importance of parent involvement.

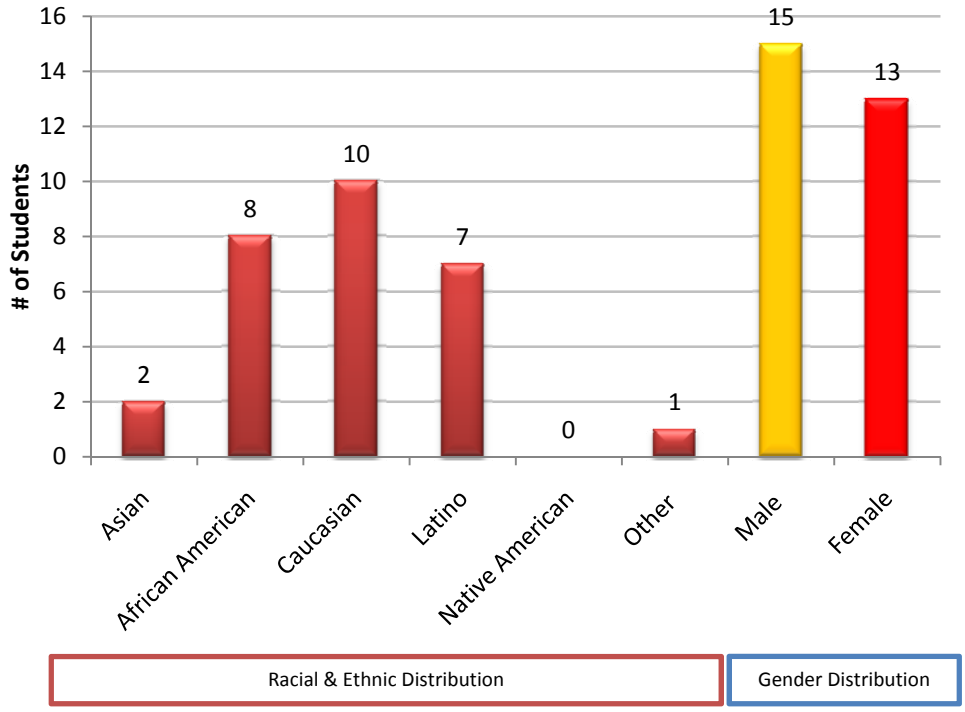

Figure 2. Race/ethnicity and gender distribution of Go For Aerospace! participants.

Orientation Semester

The selected 30 high-school juniors will participate in four spring sessions shown in Figure 3. The aim of this phase of the GFA project is to acquaint the prospective students with the basics and principles of the engineering profession. As mentioned previously, the high drop-out rate

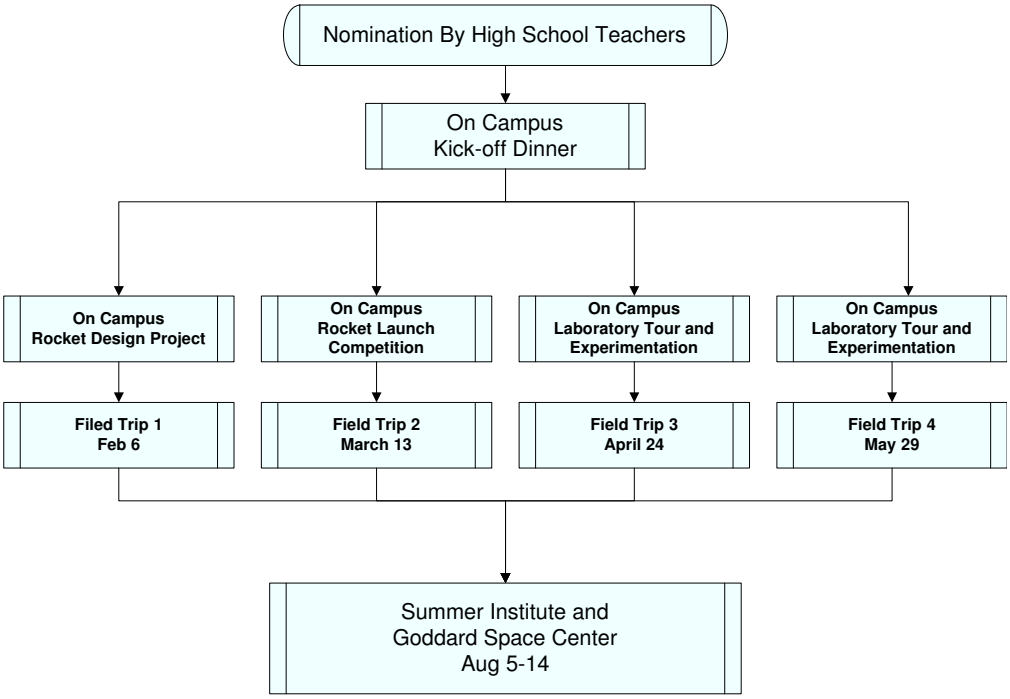

Figure 3. Go For Aerospace! at a glance.

among engineering program applicants is in part a result of high school students' vague understanding of what an engineering curriculum and position entails. Thus, all four of the proposed spring semester sessions will focus on this aspect of students' preparation for an engineering career. One Friday per month between February and May, students will be transported from their respective high schools to our campus, where they will spend the morning working with university faculty and students on projects related to mechanical and aerospace engineering. After lunch on campus, all 30 students will visit industrial aerospace facilities to tour research and manufacturing labs and speak with practicing engineers. Each month the students will visit a different company and these local firms have generously offered to donate their time and talent to accommodate the GFA students. This part of the orientation semester is focused on providing prospective students with an informed understanding of the engineering profession in general, as well as an appreciation of what a typical engineering job in the aerospace industry might involve.

Summer Institute

The culminating event of the program will be its Summer Institute, which will include three days of activities at CCSU designed to familiarize program participants with the college application process and financial aid, and introduce them to campus life in general, including a stay in the dormitories. Students will next travel to NASA's Goddard Space Flight Center in Maryland for a five-day visit during which they will learn about state-of-the-art engineering. We strongly believe that this visit, far from being merely an attractive excursion, will open a new horizon for our students, ignite their imaginations and basically promote their fascination with the

engineering profession as a whole and the aerospace discipline in particular. As a part of the trip, the students will also visit the Smithsonian Institution's National Air and Space Museum in Washington, DC, providing historical perspective for an aerospace career.

Assessment

As described previously, recent studies point toward a growing body of literature that suggest students' attitudes toward science, research skills, confidence in their ability to become scientists and engineers, and retention in these fields can be positively impacted by early exposure to and engagement with scientists and engineers working in the field. The GFA project will add to this pool of knowledge by conducting research aimed at identifying specific learner characteristics, teaching and learning strategies, and environmental factors that may discriminate between students who do and students who do not choose to pursue careers in aerospace engineering and other STEM disciplines. The purpose of this research is to provide information for future interventions aimed at increasing the pipeline of students motivated and qualified to enter STEM-related disciplines.

Methods

The research will employ a quasi-experimental design in which qualitative and quantitative methods will be used to examine the extent to which the proposed extracurricular activities for high school students, especially minorities and women, and professional development for teachers, influence students' propensity to pursue careers in aerospace and other STEM disciplines. Specifically, we seek to better understand (1) which strategies best support student development for productive participation in the STEM workforce of the future, (2) what knowledge, skills, and dispositions do students need in order to participate productively in the changing workforce in STEM, and (3) how can we prepare teachers to help students acquire such knowledge, skills, and dispositions.

To answer these questions, data will be collected from several sources including: (1) The Motivated Strategies for Learning Questionnaire (MSLQ)[16], a self-report instrument designed to assess students' motivational orientations and their use of different learning strategies; (2) student satisfaction surveys; (3) semi-structured interviews with teachers, students, and aerospace industry professionals; (4) student demographics; (5) assessment of student performance on projects and problem-based learning activities; and (6) student enrollment in STEM related courses/programs in their senior year in high school and beyond.

Initial Conclusions and Future Directions

Although the program is in its initial stages, there are already some lessons learned that will enhance our future endeavors. One of the most important features of the kick-off stage of the program was the keynote speaker. He was motivational, inspiring, and made an impact on everybody in attendance. After the address, for example, one student changed his mind from planning to pursue electrical engineering to having a keen interest in aerospace studies. A survey to determine the impact of the keynote address, among other things, will be conducted to aid in

our assessment. It is important to note that outstanding keynote speakers are hard to schedule on short notice, so significant effort and lead-time must be afforded this element.

Inviting parents to the initial event proved advantageous in many respects. During the banquet we recognized the students for their academic achievements which enabled them to have been nominated for this program by their teachers. Through this we hoped to elicit parental endorsement and support for their child's academic and career interests in engineering. Also, meeting with faculty and staff should increase parent comfort levels with CCSU. And finally, we acknowledged the influence of parents on the success of these students and showed appreciation for their interest in the student's career choices.

Securing program buy-in from the regional district math and science supervisors was quite effective in identifying the teachers to recommend the called-for number of students from each local about the Connecticut. Involving the math and physical science teachers in the recommendation stage certainly ensured a diverse cohort of high-potential students capable of undertaking aerospace or other engineering studies. These connections have also proven to be most valuable in the implementation and logistics of the initial stages undertaken to date.

Our activities thus far have already prompted us to consider some follow-up activities. Among those suggested are additional organization of tours of high school students to the university, labs, and facilities; visits to high schools by student professional society officers (ASME) to discuss engineering; establishment of some links between the high school science and math clubs with the professional societies at the university.

The hands-on nature of our planned rocket and laboratory activities at the university should prove to be an excellent way of piquing student interest and excitement about engineering. Coupled with the local aerospace company tours and the trips to Goddard and the Smithsonian, this program is bound to have a memorable and significant impact on our student participants and we anticipate that the compilation and final analysis of the data will support this claim.

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