AIAA 90-3611 Space Grant College and Fellowship Program: Efforts to Ease the Shortage of Scientists and Engineers

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SPACE GRANT COLLEGE AND FELLOWSHIP PROGRAM EFFORTS TO EASE THE SHORTAGE OF SCIENTISTS AND ENGINEERS

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Abstract

The declining pool of graduates, the lack of rigorous preparation in science and mathematics, and the declining interest in science and engineering careers at the precollege level promises a shortage of technically educated personnel at the college level for industry, government, and the universities in the next several decades. The educational process, which starts out with a large number of students at the elementary level, but with an ever smaller number preparing for science and engineering at each more advanced educational level, is in a state of crisis. These pipeline issues, so called because the educational process is likened to a series of ever smaller constrictions in a pipe, are the subject of a major NASA initiative called the NASA Space Grant and Fellowship Program which is designed to attack the problem. An outline of the problem and a short review of some of the current Space Grant programs is presented.

Introduction

The forecasts of a scientific and engineering manpower shortage, due to a decrease in the number of college age students in the next two decades, a low level of preparation in science and mathematics among high school graduates, plus an apparent decrease in interest in science and engineering as a career, has NASA worried. These forecasts are especially pessimistic about increased participation by minority and women students. NASA has decided to support several universities in developing programs at the elementary, middle/junior high school, high school, and college levels to reach out to attract and prepare more and better students for science, engineering, and technology related fields of study.

Briefly, in the words of NASA, the purpose of the program is (1) to increase the understanding, assessment and development, and utilization of space resources, (2) to encourage cooperative programs among universities, industry, and federal, state, and local governments, (3) to encourage interdisciplinary training, research, and public service programs, (4) to promote a strong science, mathematics, and technology educational base from elementary through university levels, and (5) to recruit and train professionals, especially women and underrepresented minorities, for careers in science, technology, and allied fields. What is being done to respond primarily to items (4) and (5) is the subject of the following remarks.

Information about the current and future Space Grant College and Fellowship Programs can be obtain from the University Programs Branch, Educational Affairs Division, NASA Headquarters, Code XEU, Wahington D.C. 20546

The Pool of College Age Students

Data presented in the Interim Report of the Task Force on Women, Minorities, and the Handicapped in Science and Technology, September, 1988, entitled "Changing America: The New Face of Science and Engineering", outline the problem and its causes. To quote from the report:

> The percentage of young Americans preparing for careers in science and engineering has been declining steadily. Our most experienced scientists and engineers, recruited after Sputnik, will be retiring in the 1990s. Meanwhile, by the year 2000 the number of jobs requiring college degrees will increase dramatically. The educational pipeline - from prekindergarten through the Ph.D. - is failing to produce the scientifically literate and mathematically capable workers needed to meet future demand.

In a series of charts and figures the evidence is set forth that a real crises is pending.

1. Between 1980 and 2000 the number of 18-24 year olds in the U. S. population will decline by 19 percent while the overall population increases by 18 percent.

2. Of the new workers entering the labor force by the year 2000, only 15 percent will be white men (the traditional source of scientific and engineering manpower), and of the rest will be white women, members of minority groups, and immigrants (the groups traditionally most likely not to enter science and engineering fields).

3. The scores of American twelfth grade students in mathematics and science achievement tests is among the lowest among industrialized countries.

4. Interest among freshmen in science and engineering is down dramatically (one quarter to one third or more depending on field) in the last decade.

5. Decline in interest in engineering and science of Americans carries through to graduate school where participation of foreign nationals has increased dramatically.

6. A shortfall of science and engineering graduates needed to serve industry may reach several hundred thousand by 2010.

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In another report, prepared by the Western Interstate Commission for Higher Education, The College Board, and Teachers Insurance and Annuity Association, entitled "High School Graduates: Projections by Sates, 1986 to 2004, the problem of the projected student supply is reported by region and by state. This report shows that

1. Between 1988 and 1994 there will be a 12 percent drop in the number of high school graduates nationwide; by 2004 there will be 6 percent increase over 1988.

2. There will be dramatic differences between regions with the West (WE) and South/South Central (SO) showing increases and the Northeast (NE) and North Central (NC) showing declines between 1988 and 2004.

3. There will be dramatic differences between states within regions. A few states will show large gains but many will show declines.

Figure 1 shows the trend in high school graduates nationwide. Figure 2 shows the dramatic differences among different regions of the country.

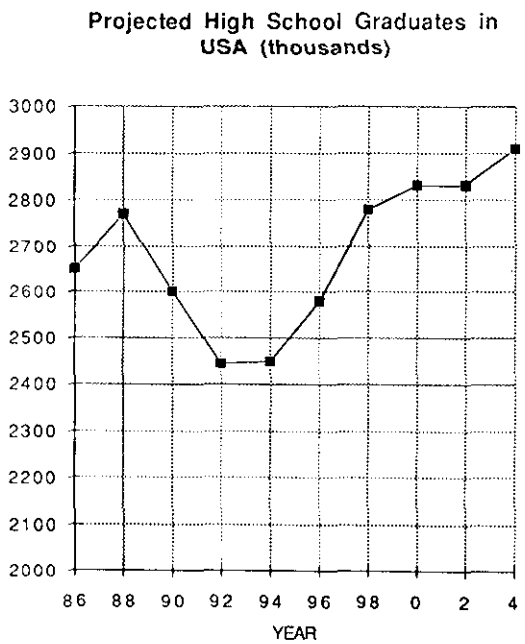

Figure 1. High School Graduates Nationwide

Preparation for College

Much more worrisome than the size of the total pool of high school graduates is the lack of preparation in basic subjects. Many very bright potential students for science and engineering are woefully unprepared to go on to college in these fields. Many have not taken appropriate science and mathematics courses in high school; others have taken them but not learned them well; while others have taken them and not found them interesting.

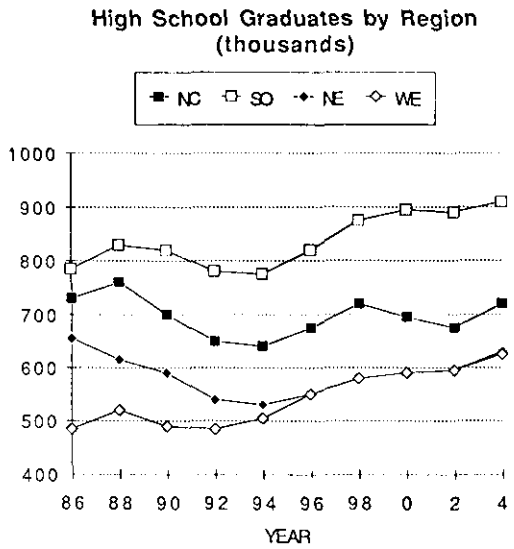

Figure 2. High School Graduates by Region

Many social, cultural and economic factors have led to a decline in the quality and quantity of K-12 education, especially in science, mathematics, and written and oral expression. This decline is very evident in inner cities with large minority enrollments, but is increasingly evident throughout primary and secondary education. Some of those factors are

1. Poor teaching. Low teacher expectations.

2. Poor facilities and learning environment.

3. Short school days, short school year, no homework.

4. Lack of discipline. Drugs.

5. Poor work ethic; low self esteem; absenteeism; negative peer pressure.

6. Lack of parental and community support.

Until there is substantial reform in secondary education, the pool of prepared students will remain very low.

Declining Interest is Science and Engineering

Of equal concern is the lack of interest by potential students for careers in science and engineering. There are many reasons.

1. Social, cultural, and economic factors that keep many students away from science and engineering careers.

   a. Perception of science, mathematics, and engineering as too difficult for most students.
   b. Perception of science, mathematics, and engineering as dull subjects.
   c. Higher work loads and longer degree programs compared to liberal arts.
   d. Perception of science, mathematics, and engineering as not people oriented - in contrast to careers in law, medicine, social work, etc.
   e. Perception of negative impact of science and technology on environment.

f. Close association of science, mathematics, and engineering with war related activities.
g. Perception of low pay compared to law, medicine, entertainment, etc. Growing opportunities in the service sector of the economy.
h. High cost of higher education.

2. Additional social, cultural, economic factors that keep women away from science and engineering careers.

   a. Widespread belief that science and engineering are not for girls. Competing careers that are traditionally female - nursing, teaching, library science, etc.- and, therefore, safe for a girl to pursue.
   b. Tracking of girls out of physics, higher mathematics, etc.; belief that girls can not do as well as boys in these subjects.
   c. No role models; belief that women are not accepted in industrial employment (except as secretaries).
   d. Marriage and child raising alternative.

3. Additional social, cultural, and economic factors that keep minorities away from science and engineering careers.

   a. No role models; perception of past discrimination in industry.
   b. Tracking of minority students out of physics, higher mathematics, etc., because they are thought less likely to go to college - a self fulfilling prophecy.
   c. Likely first generation to go to college; therefore, less academic and career guidance and counseling from home.
   d. Misleading concepts of alternatives: sports, entertainment, etc.
   e. Low family financial support expectations.
   f. More likely to be in one of the weaker high schools with poorer preparation.

The Lack of Attraction of Graduate Education

Among those who do complete undergraduate education in science and engineering, many do not find graduate education to be sufficiently attractive. Among the reasons are

1. Attractive job offers. Most firms deliberately try hardest to hire at the BS level those students who have the most potential for graduate study.

2. Low pay differential for higher degrees.

3. Perception that turning to management, which does not require higher technical degrees, is the only way to ensure promotion. Many turn to advanced degrees in business, law, etc.

4. High cost of graduate education. Limited financial aid (when compared to job offers and earning potential). Debts from undergraduate years.

5. Academic burn out from high undergraduate work loads.

What Can Be Done

To stimulate some discussion, here are some suggestions in broad general categories of what might be done.

1. Push for reform in primary and secondary education.

2. Inform potential college students of the opportunities and rewards that abound in science and engineering careers.

3. Break down stereotypical views of science and engineering.

4. Breakdown stereotypical views of the opportunities for women and minorities.

5. Make science and engineering undergraduate education more attractive.

6. More clearly articulate the need for graduate education.

7. Make science and engineering careers more attractive.

Discussion Among the Space Grant Directors

The at the first annual meeting of the Space Grant Program Directors last January there was a workshop devoted to this issue. The initial discussion was concerned with the end of the pipeline, the graduate program, and the issue of foreign versus US graduate students. It was agreed that foreign students are a valuable and welcome addition to our graduate schools but there was belief that a more generous supply of US students would be desirable. We should not depend so heavily on importing students and, for that matter, importing employees at the post graduate degree level. The discussion then shifted down to the undergraduate level. The need to counsel, encourage, support, etc., more of the better undergraduate students to continue in graduate school was emphasized.

Will there be enough educated scientists and engineers in the next two decades? No one challenged the need for more scientists and engineers but the need for those educated in aerospace disciplines will depend on world events and national policy. The large number of retirements coming in the next decade in the aerospace industries was mentioned as a factor.

At this point in the discussion the issue of quality versus quantity was introduced. Within the group there seemed to be more concern about quality than quantity. It was noted that at the last downturn in quantity - late 60's and early 70's - the downturn in quantity was accompanied by a sharp drop in quality. The belief was widely shared that efforts to prevent a quality loss this time around should be given priority, and, perhaps, the quantity problem was not as serious as some believe.

At the secondary school level, the lack of counseling or other means to let students know what engineering and science careers are all about, was expressed as a major concern. The discussion shifted quickly, however, to the middle school level where this is most painfully apparent. The need for good guidance at that level was considered essential because this is where the students are making the decisions that will keep them available or rule them out of science and engineering careers. It was noted that girls and minority students are still tracked out courses of study essential for college preparation whether by choice or poor advice.

At the primary school level the teacher interested or enthusiastic about science was considered desirable. The quest for quality starts here. And without the quality throughout primary and secondary education we are limited in what we can do about the quantity and quality of future scientists and engineers.

Conclusions of the Program Directors.

In the concluding discussion there was substantial agreement on the following:

1. There is a need for more scientists and engineers, but since we cannot do much about the birth rate of the 1970's and 80's, we shall have to act so that those high school graduates who are potential candidates are well prepared and interested in pursuing such careers.

2. Our best opportunity at the primary school level is to work with teachers. These teachers must have a better understanding and appreciation of science and mathematics as it relates to future the development of the students. They must make the student both more proficient and more interested in these subjects.

3. The middle school students are most critical. We must develop programs which help improve instruction, which help students make proper choices of courses, and which ensure that they learn these subjects. We must not only work with teachers but we must intervene directly with the students to provide role models, counseling, and encouragement.

4. We must develop programs at the high school level to reinforce and continue the efforts made at the middle school level.

5. Undergraduate college students must be encouraged to continue in graduate school in greater numbers. We can continue to pursue, but not depend so strongly on, imported graduate students.

6. We are concerned with the quantity of students in science and engineering but are even more concerned about quality. Those efforts made to increase the number of students in science and engineering should also have the purpose of improving the quality of the students, the quality of their preparation, and the quality of programs they enter.

Current Space Grant College Programs.

The 21 original Space Grant Consortia are responding with programs in a wide variety of ways.

Programs for pre college students

Fifteen consortia have specific plans for programs for pre college students, often adding to or modifying and existing program to give more aerospace emphasis. These include sponsoring science fairs, campus visits, field trips, space camps, extended summer programs on campus, student competitions with aerospace themes, summer research opportunities, developing curriculum modules for mathematics and science courses, adopt-a-school programs, hands-on laboratory development, traveling displays, TV programs, and speakers bureaus. Most of these programs are at the middle and high school levels. Some experimental programs are being tried at the elementary level.

Programs for pre college teachers

Thirteen consortia have programs for pre college teachers which include teacher preparation on aerospace themes, curriculum development, summer research experiences, summer workshops on campus, seminar series, and informational materials.

Programs for college undergraduates

Nineteen have specific programs for college undergraduates, including flight experiments, space academies, coop programs, research, scholarships, workshops, curriculum development, new specialist courses, new degree programs, laboratory development, seminars, library development, multi-disciplinary course development, dual degree programs with 4 year liberal arts colleges, field trips, freshman courses in aerospace, develop courses for non science majors, and upgrade laboratories.

Programs for graduate students

Six have specific programs for graduate education (in addition to the use of the Fellowship money). This includes developing a new graduate institute, augmentation of graduate courses and programs, combined BS-MS degrees, coop programs, and inter institutional degree programs.

Programs for minorities and women

Seven have programs with very special emphasis on minorities and women (although all others had programs which would reach out to minorities and women). These included identifying promising minority and women students early and follow up, summer work and research programs, summer