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ABSTRACT

This issue of the newsletter of the American Association for the Advancement of Science is devoted to information about employment opportunities for natural scientists and engineers in the '70s. Problems of supply and demand are considered, with graduate enrollment in natural science fields being considered as an important indicator of the future supply of trained professionals. Students are urged to consider the employment situation in various fields before making a career choice. (PEB)

SCIENCE EDUCATION NEWS

April 1973

Young men and women choosing career fields, colleges and universities responsible for their education, and employers planning to utilize their services all need information by which they might assess the potential supply of new scientists and engineers and the potential demand for these specialists in a period far enough in the future at least to take into account the four-to-ten-year length of the educational pipeline. There are no perfect crystal balls that will give an accurate picture either of supply or demand. We cannot predict with great accuracy whether the number of people trained in technological specialties will match the demand for their services either at the time they complete their formal education or in the years beyond. Inaccuracies occur because of the large number of variables in the supply-demand equation.

On the demand side, accurate forecasts require the ability to predict the health of the general economy and to forecast the priorities that will be assigned by the legislative and executive branches of government to solving national problems (and the funding that will be appropriated for their solution); also, they need to take into account the possibility of technological breakthroughs that may change both the number and the kind of specialists required to solve particular kinds of problems. While it is not difficult to list a number of national problems that await solution, it is very difficult to anticipate which of the problems may be attacked first (or at all) and how much effort will be applied to solving them in a reasonable time. We can, for example, make fairly accurate estimates of the need for scientists and engineers (among others) to clean up our environment to a given level within a given period of time. Without knowing the priority, the level of effort, or the time period that will be assigned to the problem, translating the "need" into "demand," or job opportunities, becomes both more difficult and more subject to error.

Another set of unknown variables faces us when we try to anticipate the supply of scientists and engineers at some point in the future. The career choices that will be made by students are determined by a number of factors and many of them are not easily measurable in advance. Students with both the interest and the aptitude for science or engineering careers may be influenced into or out of these fields by their perceptions of the current job market and or the future job market; by advice from parents, friends, teachers, or employers; or by their experiences in science or engineering courses.

The size of the college age group at any given time can be determined quite accurately through Census Bureau data, and we know historically what proportion of this age group in past years has entered post-high-school education. We have seen this proportion rise fairly steadily over the past several decades, and might be able to anticipate a continuing rise in the proportionate enrollment of the age group until some ceiling is reached. Obviously there will never be 100 percent participation in higher education, since some men and women will lack the ability, some will lack the motivation, some will be unable to manage the costs, and there will be combinations of these reasons for failing to pursue further formal education.

Some manpower authorities believe that we are approaching that ceiling, at least in terms of capability.[1] Other projections indicate that as much as 76 percent of all 18 year olds may be entering college by 1985 (compared to 53 percent in 1970), and that approximately the same proportion as now of those who enter (56 percent of the men and 53 percent of the women) may complete a bachelor's degree in some field.[2]

However, the proportion of male high school graduates entering college in the next school year has dropped

* Adapted by the author for *Science Education News* from a more extensive report to be issued by the Scientific Manpower Commission later in 1973.

[1] Wallace R. Brode, "Approaching Ceilings in the Supply of Scientific Manpower," *Science* 143: 3601 (1964).

[2] Forecasting Enrollments and Degrees, National Science Foundation. Unpublished.

from 44.7 percent in 1969 to 37.6 percent in 1972. The proportion of 18- and 19-year-old-women stayed steady at about 34 percent. Thus the picture may be changing, or we may already have reached the ceiling, pushed up by draft rules that provided deferment to young men in college during much of the Vietnam war. We may also be witnessing the beginning of a period when more students will take a break of two or three years before beginning college.

In forecasting the number of graduates, once we have estimated the proportion of the age group that will enter college, it is important to recognize that science and engineering fields generally must be chosen fairly early if they are to be chosen at all. Even in high school, students choosing the wrong mathematics program can tend to close off opportunities in the technological fields. Rarely are students able to enter engineering programs after the freshman year in college, and science majors also tend to choose their programs early in their college careers. Thus, if too few students in the freshman year elect a program of studies aiming toward science or engineering, the graduating class four years later will not be implemented by "drop-ins" from the social sciences and the humanities.

On the other hand, science and engineering traditionally have been excellent springboards into other fields, and we can expect a fairly steady drop-out rate from these fields both in the undergraduate years and at the beginning of graduate study.

Despite the difficulty of making accurate projections of either supply or demand, such projections are made so that some guidelines will be available to individuals for making informed choices and to planners who may offer or withdraw incentives designed to persuade larger numbers to choose these fields at a particular time.

The very fact that a forecast is made and published will affect the outcome of that forecast. If predictions by responsible people indicate that there will not be sufficient employment for the number of people training for a particular field, some of these students will change their plans and move into another area where opportunities may be better. If shortages are forecast, not only will some students elect to move into the fields indicated, but incentives may be offered in the form of scholarships, higher salaries, or status symbols to encourage the movement of young people toward these areas.

When any of these things happen, the accuracy of the forecasts will be changed. Therefore, it is hard to measure the forecasting error even when the data become available.

The nature of the forecasts that are available shows us clearly that no one has found the perfect way to develop a forecast. Several methods are used. Some forecasts are derived from surveys of informed opinion about the future, while others are built by projecting the trend of past data under certain assumptions to some period in the future. Many forecasts incorporate both these methods. Increasingly computers are used to make forecasts based on models set up under certain assumptions about the future, with the complex variables interacting to produce a picture of what may happen if these particular assumptions are correct.

Forecasts of both supply and demand are made by government agencies and by private groups. Despite their imperfections, these forecasts are needed to allow valid planning for the future by individuals, universities, employers, legislators, and professional groups concerned with the welfare of their members.

Supply

A major source for information about the future supply of new graduates in all fields is the National Center for Educational Statistics (NCES) of the U.S. Office of Education.[3] These projections in turn rely on the data collected annually by USOE on degrees conferred by U. S. universities and on enrollment trends as shown through a number of surveys.

The most recent projections by NCES for bachelor's degrees in the fields of natural science and engineering are shown in table 1.

TABLE 1
EARNED BACHELOR'S DEGREES, SELECTED FIELDS OF STUDY: UNITED STATES, 1960-61 TO 1981-82

Year	Total Degrees	Physical Sciences	Engineering	Mathematics and Statistics	Biological Sciences
1960-61	368,857	15,452	35,698	13,097	15,861
1961-62	387,830	15,851	34,551	14,570	16,694
1962-63	416,421	16,217	33,285	16,078	18,849
1963-64	466,486	17,457	35,013	18,624	22,454
1964-65	501,248	17,859	36,586	19,460	24,872
1965-66	520,248	17,129	35,615	19,977	26,565
1966-67	558,075	17,739	35,952	21,207	28,483
1967-68	631,923	19,380	37,368	23,513	31,429
1968-69	728,167	21,480	41,248	27,209	34,989
1969-70	791,510	21,439	44,479	27,442	37,031
1970-71	839,730	21,412	44,898	24,801	35,743
1971-72	876,000	21,160	45,580	25,370	36,870
			Projected		
1972-73	926,000	21,090	44,560	26,700	38,810
1973-74	958,000	20,770	44,380	27,620	40,380
1974-75	948,000	19,340	36,840	27,100	39,760
1975-76	1,003,000	19,360	33,610	28,670	42,230
1976-77	1,055,000	19,080	35,520	29,910	44,280
1977-78	1,107,000	18,670	37,180	31,140	46,310
1978-79	1,159,000	18,220	38,770	32,410	48,330
1979-80	1,192,000	17,340	39,740	33,080	49,580
1980-81	1,221,000	16,320	40,600	33,660	50,610
1981-82	1,242,000	15.220	41,090	33,940	51,300

SOURCE: *Projections of Educational Statistics to 1981-82,* National Center for Educational Statistics, U.S.O.E. In Press.

It is easy to see that while the total number of degrees expected is rising. the numbers in physical sciences and engineering are falling. The proportionate share of all bachelor's degrees granted that are given in the physical and biological sciences, mathematics, and engineering has fallen from a little over 20 percent of the total in 1954-55 to less than 18 percent in 1969-70, and the projections made by the NCES anticipate that by 1981-82 engineering, mathematics, and natural science degrees will make up only about 12 percent of all the bachelor's degrees granted. The proportions also are falling at both graduate degree levels.

Because of the increasing size of the college population, the actual number of degrees granted in these fields continued to increase each year through 1970-71, and increases are projected each year through 1981-82

[3] *Projections of Educational Statistics to 1981-82,* National Center for Educational Statistics, U.S. Office of Education. In press.

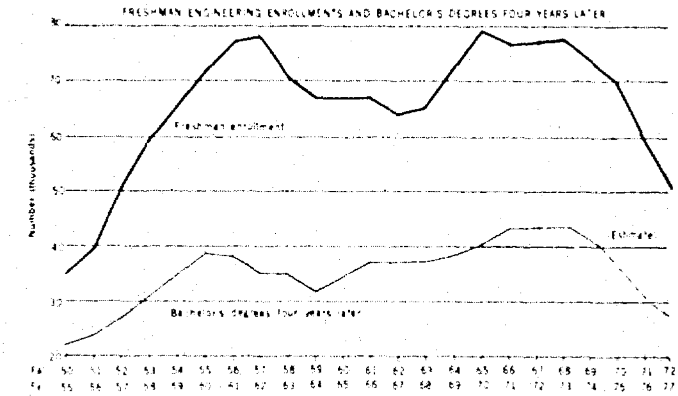
in mathematics and statistics and in the biological sciences. In the physical sciences, however, the number of new baccalaureate graduates began to drop in 1971-72 and is projected to continue to fall through 1981-82.

In engineering, even when bachelor of technology degrees are added to the number of engineering degrees, the total will fall rapidly through 1975-76 before it is expected to start slowly up again. The decrease through 1977 is quite certain to occur, since those classes already are in engineering school, and freshmen engineering enrollment has dropped 30 percent since it peaked in 1967 (table 2). As noted earlier, engineering is

TABLE 2
ENGINEERING ENROLLMENTS

Engineering Students	Fall 1967	Fall 1968	Fall 1969	Fall 1970	Fall 1971	Fall 1972
Freshman year, full-time	77,551	77,484	74,113	71,661	58,566	52,100
Sophomore year, full-time	56,975	55,615	52,972	53,419	47,948	42,272
Junior year, full-time	50,483	50,274	50,039	49,855	48,543	45,874
Senior year, full-time	47,551	50,736	51,738	51,983	51,377	49,895
Fifth year, full-time	4,589	5,133	4,668	4,812	4,391	4,586
Total full-time undegraduates	237,149	239,242	233,530	231,730	210,825	194,727
Part-time undergraduates	NA	20,754	20,984	18,445	18,222	14,149
Master's degree, full-time	34,231	24,469	20,014	23,216	22,105	22,877
Doctor's degree, full-time	15,376	15,768	14,298	14,802	14,100	13,460
Total full-time grad students	49,607	40,237	34,312	38,018	36,505	36,337
Part-time graduate students	NA	27,246	32,645	30,802	27,302	24,940

SOURCE: *Engineering and Technology Enrollments, Fall 1972*. Engineering Manpower Commission of Engineers Joint Council.



Source: Data from Engineering Manpower Commission annual reports of engineering enrollments and engineering degrees.

Figure 1

not a field that students can enter at later levels of their undergraduate years.

When freshman engineering enrollments are plotted against engineering bachelor's degrees four years later, we can see that the number of degrees projected by USOE for 1976 is probably too high (figure 1). Junior class enrollment in the 1972-73 school year is down 5.5 percent from the fall of 1971 and total full-time undergraduate enrollment is down 7.6 percent. Graduate enrollment of full-time students is down 0.5 percent from the previous fall.

In physics the enrollment drop is similar to that in engineering, and the number of

TABLE 3
PHYSICS ENROLLMENTS AND DEGREES IN THE U.S.

Academic Year (July 1 to June 30)	Physics Degrees Granted: Bachelor's	Physics Degrees Granted: Master's	Physics Degrees Granted: Doctorate	Undergraduate Physics Majors Enrolled: Jr. year	Undergraduate Physics Majors Enrolled: Sr. year	Graduate Students Enrolled: Total	Graduate Students Enrolled: 1st year
1962-63	5,452	1,850	858	7,873	6,386	12,265	
1963-64	5,611	1,907	792	7,520	6,676	13,046	4,061
1964-65	5,517	2,045	983	7,132	6,514	13,629	4,167
1965-66	5,037	2,050	948	7,014	6,296	14,876	4,358
1966-67	5,236	2,193	1,233	7,345	6,992	15,504	4,162
1967-68	5,522	2,077	1,325	7,822	6,704	15,305	4,010
1968-69	5,975	2,223	1,355	7,587	7,019	15,475	3,669
1969-70	5,782	2,268	1,545	7,480	6,700	14,372	3,918
1970-71	5,755	2,300	1,530	6,884	6,663	14,327	3,494
1971-72				6,593	6,162	13,276	3,336

SOURCE: American Institute of Physics.

degrees granted began to fall in 1969-70. Table 3, prepared from information gathered by the American Institute of Physics showing student enrollment and degrees in physics, indicates a continuing drop at all degree levels at least through the next several years. AIP estimates that the class of 1976 will include only 5,000 new bachelor's degrees in physics.

In the chemical sciences, a survey by the American Chemical Society in the spring of 1971 found that the number of bachelor's degrees was expected to rise through 1973, but that graduate degrees would start dropping by 1971 or 1972 with Ph.D.'s reaching a level of about 1,500 by 1976 (table 4).

Since a high proportion of bachelor-degree holders in the chemical sciences do not enter the chemical profession, trends in graduate enrollment may be a better measure of the supply of chemical scientists a few years in the future than changes in bachelor's degrees. As a matter of fact, ACS noted a large increase in enrollment in first- and second-year chemistry courses in the fall of 1971 and carried out a survey of selected schools to determine the size and nature of the increase. They found that despite a 2 percent drop in total freshman enrollment in the schools surveyed, enrollment in first-year chemistry courses rose 9 percent from the fall of 1970 to the fall of 1971 while enrollment in organic chemistry rose 14 percent. A follow-up study to learn the reason for the increases found no apparent increase in the number of chemistry majors planning a career in that field, but instead students were indicating an interest in medical careers. There were at least 35,000

TABLE 4
CHEMICAL SCIENCES GRADUATES 1968-1973

Degree	Departments Reporting	Reported graduate production: 1968[a]	1969[a]	1970[a]	1971[b]	1972[b]	1973[b]	Change 1968-70	Change 1971-73
Chemistry									
Bachelors	555	6,153	6,453	6,113	6,275	6,300	6,925	−1%	10%
Masters	160	879	945	977	1,075	1,078	1,126	11	5
Doctors	116	1,021	1,212	1,378	1,512	1,426	1,421	35	−6
Chemical engineering									
Bachelors	82	1,967	2,107	2,140	2,231	2,192	2,344	9	6
Masters	66	653	635	564	787	616	638	−14	−19
Doctors	65	228	293	293	350	349	330	29	−6
Biochemistry									
Bachelors	32	180	203	240	283	320	378	33	−34
Masters	45	90	104	102	97	92	80	13	−18
Doctors	60	227	238	265	316	316	304	17	−4

[a] 1968-70, actual. [b] 1971-73, estimates made by surveyed institutions.

SOURCE: American Chemical Society, Department of Professional Relations and Manpower Studies.

students competing for the 13,000 places in first-year medical school classes in the fall of 1972 according to an estimate by the Association of American Medical Colleges, and interest in medical careers appears to be climbing considerably faster than the number of new spaces that will be available for first-year medical students.

Another option for these chemistry students is in the environmental/public health area where the outlook is somewhat more encouraging. Environmental Protection Agency officials estimate that some 70,000 engineers and 28,000 scientists will be needed by 1975 in the environmental area. At present rates, they say there will not be enough people specifically trained in these fields to meet the demand. Some chemistry majors may be competing for these positions with persons who are trained specifically in the fields of environmental science where more than 100 schools now offer degree programs.

Geoscience student enrollment has generally been rising since 1966 at the undergraduate level, although graduate enrollment over the six-year history of the surveys of enrollment made by the American Geological Institute shows some dips in a generally steady rise. In 1971-72, geology majors increased at all levels; geophysics majors dropped slightly; oceanographers showed substantial increases at the master's and doctoral levels following drops in the previous two years; enrollment was down in graduate degree programs for earth science teachers; and environmental science programs exploded, more than tripling the total number of Ph.D. candidates since 1971. Environmental science programs are the fastest growing of any of the geosciences fields.

In the biological sciences, we have no enrollment surveys, and the degree data, available only through the U.S. Office of Education, are always about two years behind.

The Higher Education Panel of the American Council on Education began in 1970 a survey of enrollment by field of junior year students in order to obtain information about trends in choice of major field in advance of the usual data on baccalaureates granted. Between the fall of 1970 and the fall of 1971, total field enrollment rose 7.6 percent with the largest increases in the health professions, the life sciences, and applied social sciences. The only fields that showed a drop in enrollment between these two years were history (down 5.7 percent), engineering (down 7.3 percent), mathematical sciences (down 0.6 percent), chemistry (down 2.2 percent), and physics (down 8.4 percent). Preliminary, unweighted data for junior year field enrollment in the fall of 1972 show about a 3 percent rise in all fields combined, a slight rise in biological sciences, a very slight drop in physics and chemistry, and a more substantial drop in mathematics. Engineering, of course, continues to drop.

Graduate Enrollment

Enrollment at the graduate level in the natural science fields is a particularly important indication of the future supply of trained professionals. Some projections are available. The NCES projections in the natural sciences are shown in tables 5 and 6.

TABLE 5

EARNED MASTER'S DEGREES, SELECTED FIELDS OF STUDY: UNITED STATES, 1960-61 TO 1981-82

Year	Total	Physical Sciences	Engineering	Mathematics and Statistics	Biological Sciences
1960-61	81,690	3,786	8,214	2,235	2,358
1961-62	88,414	3,913	8,953	2,680	2,642
1962-63	95,470	4,115	9,666	3,320	2,921
1963-64	105,551	4,555	10,857	3,625	3,296
1964-65	117,152	4,906	12,093	4,196	3,600
1965-66	140,548	4,977	13,717	4,769	4,233
1966-67	157,707	5,405	13,986	5,278	4,996
1967-68	176,749	5,499	15,247	5,527	5,506
1968-69	193,756	5,895	15,372	5,713	5,743
1969-70	208,291	5,935	15,723	5,636	5,800
1970-71	230,509	6,367	16,443	5,191	5,728
1971-72[a]	239,000	6,550	16,520	5,390	6,280
		Projected			
1972-73	250,000	6,760	16,560	5,590	6,490
1973-74	260,000	6,950	16,720	5,760	6,700
1974-75	272,000	7,190	16,980	5,970	6,950
1975-76	280,000	7,290	16,890	6,080	7,100
1976-77	292,000	7,500	17,000	6,280	7,340
1977-78	302,000	7,680	17,110	6,440	7,530
1978-79	310,000	7,810	17,090	6,550	7,680
1979-80	320,000	7,990	17,160	6,690	7,870
1980-81	329,000	8,150	17,210	6,820	8,040
1981-82	332,000	8,180	16,950	6,840	8,060

[a] Estimated.

SOURCE: *Projections of Educational Statistics to 1981-82*, NCES of USOE. In Press.

TABLE 6

EARNED DOCTOR'S DEGREES, SELECTED FIELDS OF STUDY: UNITED STATES, 1960-61 TO 1981-82

Year	Total	Physical Sciences	Engineering	Mathematics and Statistics	Biological Sciences
1960-61	10,575	1,991	959	344	1,193
1961-62	11,622	2,122	1,216	396	1,338
1962-63	12,822	2,380	1,385	490	1,455
1963-64	14,490	2,455	1,705	596	1,625
1964-65	16,467	2,829	2,133	682	1,928
1965-66	18,237	3,045	2,315	782	2,097
1966-67	20,617	3,462	2,619	832	2,255
1967-68	23,089	3,593	2,933	947	2,784
1968-68	26,188	3,859	3,391	1,097	3,051
1969-70	29,866	4,312	3,691	1,236	3,289
1970-71	32,107	4,390	3,638	1,199	3,645
1971-72[a]	34,600	4,510	3,830	1,250	3,850
		Projected			
1972-73	37,700	4,570	4,150	1,320	3,970
1973-74	39,900	4,540	4,220	1,440	4,150
1974-75	42,700	4,570	4,480	1,550	4,460
1975-76	44,100	4,500	4,410	1,600	4,640
1976-77	45,800	4,480	4,540	1,670	4,810
1977-78	47,700	4,430	4,690	1,730	4,990
1978-79	48,900	4,410	4,750	1,760	5,080
1979-80	50,500	4,430	4,860	1,800	5,220
1980-81	52,000	4,410	4,950	1,850	5,340
1981-82	53,500	4,410	5,050	1,890	5,450

[a] Estimated.

SOURCE: *Projections of Educational Statistics to 1981-82*, NCES of USOE. In Press.

Natural science and engineering degrees at the master's and doctor's level as well as the bachelor's are expected to make up a smaller and smaller proportion of all graduate degrees granted.

These figures reflect a view commonly held that graduate schools will continue to expand and that increasingly large numbers of Ph.D.'s will be trained, in many cases in numbers far in excess of any foreseeable need of society or likelihood of their being able to find appropriate employment.

This is not in accordance with results found by the Council of Graduate Schools in the United States (CGSUS) in a survey in the spring of 1972. Deans of the graduate schools comprising the Council were asked to make their best individual projections on how many doctorates their universities would confer in the academic year 1975-76. This year was chosen because students who will receive their degrees in that year were currently enrolled. Total doctorate production for that year based on this survey is projected to increase by just a little more than 5 percent above the actual production of Ph.D.'s in 1969-70, leading to an estimated total of no more than 31,500 in all fields together. The comparable figure from NCES is 44,100.

CGSUS went further to state that the 1980-81 projection of Ph.D. production by the National Center for Educational Statistics which was 68,700 doctorates (reduced to 52,000 in the latest series of NCES projections) is far in excess of the number anticipated by the Council. CGSUS stated that "on the basis of our best information, an essentially steady or quite possibly declining rate of doctorate production may characterize the last two thirds of the decade in the 1970s rather than the sharp increases others have projected."

The lower projection of the Council of Graduate Schools tends to be supported by an assessment of the National Board on Graduate Education which points out that individual universities reacted to reports of over-supply of Ph.D.'s by cutting back on doctoral programs and "the numerous decentralized decisions currently being made to reduce support of graduate education may have the unintended effect of severely damaging the nation's capacity to provide the quality and diversity of graduate education that we believe to be a continuing national need."[4]

In the areas of the natural sciences and engineering, the number of new Ph.D.'s that may be expected in the latter half of the '70s certainly does not appear to be expanding. As the potential Ph.D.'s of the late '70s and early '80s enter college as freshmen, a decreasing percentage are indicating a probable major in a physical science or engineering field, although interest in life sciences and the health sciences is increasing (table 7).

In summary, while there is some variation in the figures, most projections of future additions of U.S. graduates to the supply of natural scientists and engineers indicate a decreasing proportion and in some instances a literally decreasing number of new graduates through the '70s.

Demand

The Department of Labor makes continuous projections of demand both for use in its *Occupational Outlook Handbook* and in other reports. The latest figures from DOL project a demand for 45,000 engineering graduates per year to 1980.[5] Reference to figure 1 shows that there is little possibility that this need will be filled by new graduates of U.S. universities. As in the

TABLE 7

PERCENT OF FULL-TIME FRESHMEN ENTERING COLLEGE WHOSE PROBABLE MAJOR WAS IN A SCIENCE OR ENGINEERING FIELD, BY SEX, FALL 1966 AND FALL 1972

	Total		Men		Women	
Probable Major	1966	1972	1966	1972	1966	1972
Total, all fields	100.0	100.0	100.0	100.0	100.0	100.0
Total, science and engineering fields	33.6	32.0	43.7	41.1	21.8	22.0
Physical sciences	3.3	1.9	5.0	3.0	1.2	.8
Engineering	9.8	6.9	17.9	12.7	.3	.4
Mathematics and statistics	4.5	2.2	4.6	2.2	4.5	2.2
Life-sciences[a]	5.6	7.1	7.6	10.0	3.2	3.8
Social sciences	8.2	7.8	5.2	4.9	11.7	11.1
Other technical fields[b]	2.2	6.1	3.4	8.3	.9	3.7
Health professions[c]	5.3	10.6	1.5	3.4	9.8	18.7
All other fields[d]	61.1	57.4	54.8	55.5	68.4	59.3

[a] Includes agriculture, forestry, and biological sciences.
[b] Includes computer science, electronics, industrial arts, and other technical fields.
[c] Includes health technology, nursing, pharmacy, and therapy; excludes premedical.
[d] Includes arts and humanities, education, business, prelaw, premedical, and other nontechnical fields.

SOURCE: American Council on Education longitudinal research program.

past when there were shortages of U.S. engineering graduates, the demand will generally be filled by increasing numbers of foreign engineers and by the increasing use of engineers without degrees.

Demand for mathematicians is expected to be somewhat below the supply at present growth rates, but these projections were made before the growth rate started to drop.

DOL projects a requirement for geoscientists that is expected to be in approximate balance with supply to 1980. To meet the projected demand for chemists, DOL says the supply should average almost 65 percent above 1968 levels (see table 4), which does not appear to be happening. Physicists also are expected to be in short supply by the middle of the decade, although DOL projects a substantial oversupply of life scientists in the making (table 8).

TABLE 8

OCCUPATIONAL EMPLOYMENT, 1968, AND PROJECTED REQUIREMENTS, 1980, FOR COLLEGE GRADUATES

Occupation	Estimated 1968 Employment	Projected 1980 Requirements	Percent Change	Supply Estimated to Be
Chemists	130,000	200,000	65.7	Significantly below requirements
Counselors	71,000	107,000	49.8	
Dietitians	30,000	42,100	40.3	
Dentists	100,000	130,000	31.7	
Physicians	295,000	450,000	53.1	
Physicists	45,000	75,000	63.9	
Engineers	1,100,000	1,500,000	40.2	Slightly short of requirements
Geologists and geophysicists	30,000	36,000	20.6	
Optometrists	17,000	21,000	23.5	
Architects	34,000	50,000	47.1	In balance with requirements
Lawyers	270,000	335,000	22.7	
Pharmacists	121,000	130,000	7.0	Slightly above requirements
Mathematicians	70,000	110,000	60.5	
Life scientists	168,000	238,000	40.8	Significantly above requirements
Teachers, elementary and secondary	2,170,000	2,340,000	7.8	

SOURCE: *College Educated Workers, 1968-1980*, Bulletin 1676, United States Department of Labor.

[4] *Graduate Education: Purposes, Problems and Potential*, Report of the National Board on Graduate Education, November 1972, p. 2.

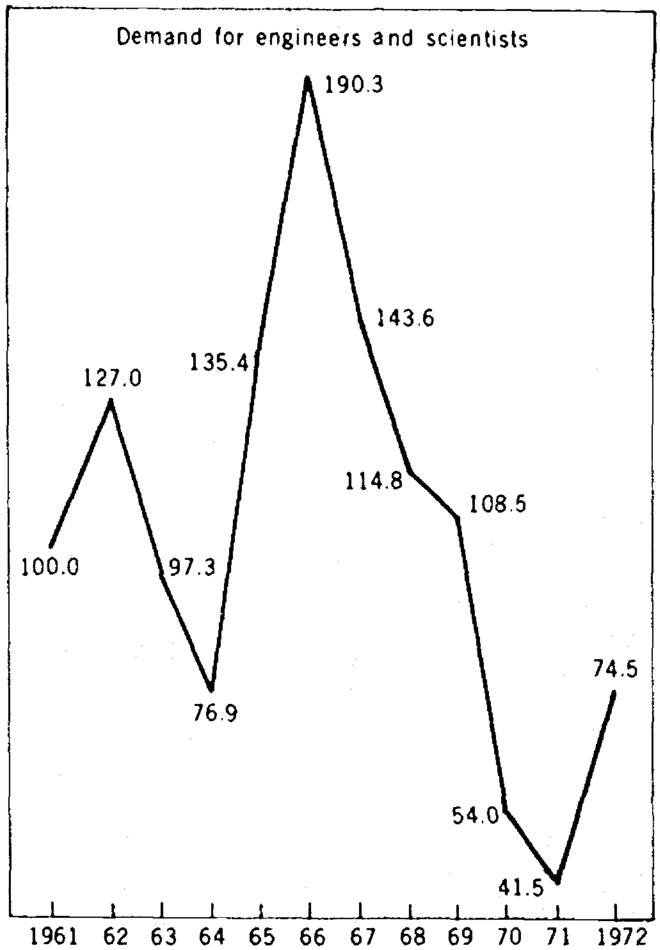
[5] *Occupational Outlook Handbook*, 1972-73 edition, Bureau of Labor Statistics; and *Occupational Manpower and Training Needs*, Bulletin 1701, Bureau of Labor Statistics.

The National Science Foundation also has published projections to 1980 of science and engineering doctorate supply and utilization.[4] The latest of these reports, published in 1971, projects an oversupply of doctorates in engineering, a balance in supply and demand for doctorates in the physical sciences, a substantial oversupply in the social sciences, and a less extreme oversupply in the life sciences of about 9 percent. In mathematics, NSF projects a 10 percent oversupply at the doctorate level. These figures are being revised to take into account the dropping enrollments for advanced degrees in many of these fields.

Projections of short-range demand are made on an annual basis by measuring the recruitment activity among new graduates each year. The major continuing reports of this activity are those conducted by Frank Endicott of Northwestern University and by the College Placement Council which publishes quarterly reports on beginning offers by business and industry to new graduates. While employment opportunities for new graduates dipped fairly sharply in 1970 and 1971 as the economy dropped across the board, 1972 graduates found a slight upturn in opportunities; and beginning offers to the graduates of 1973 are up sharply in the science and engineering fields. The latest CPC report[5] shows a 16 percent increase in demand for new graduates this year with increases of 27 percent in the demand for engineering majors at the bachelor's level and an increase of about 17 percent for students in the sciences, mathematics, and other technical disciplines.

Dr. Endicott found that 75 percent of the companies he interviewed expect 1973 to be a better business year than 1972 and that the hiring of new graduates will be up 19 percent at the bachelor's level and 20 percent at the master's, with the demand for engineers up 47 percent at the bachelor's level and 20 percent at the master's.[6]

Another indicator of current demand is the Engineer/Scientist Demand Index maintained by the advertising firm of Deutsch, Shea and Evans, Incorporated. This index measures the volume of classified advertising for scientists and engineers and has been maintained since 1960. After falling steadily from 1966 to 1972, the index rose in 1972 and is expected to continue to climb through 1973 (figure 2).



Source: Deutsch, Shea and Evans.

Figure 2

Given this much fragmentary and sometimes contradictory information, how can students choosing a career field make a rational assessment of the opportunities that may be available in any of a number of semi-related fields in which the student has an interest?

The employment situation in various fields at the time a choice of careers is being made is certainly one factor that most students consider. However, some of them fail to realize that their choice of career field cannot affect or be affected by the employment market of that present moment, and that employment opportunities in the longer range future are of more relevance. Probably one major reason for the abrupt decline in engineering enrollments was the large number of articles in the public press relating to unemployed engineers, both those laid off in aerospace and those who lost jobs across a broad spectrum of industry in a faltering economy.

Unemployment among professional workers of all types has been high in comparison to the figures of three or four years ago. The Labor Department reported a 3.3 percent unemployment rate for professional and technical workers in March 1971, which fell to about 2 percent at the end of 1972. This latter figure represents about 200,000 unemployed workers of whom perhaps a fifth are scientists and engineers, some without degrees. Unemployment rates among women professionals have been consistently higher than among men in all fields. For example, women chemists

[4] *1969 and 1980 Science and Engineering Doctorate Supply and Utilization*, NSF 71-20, National Science Foundation, May 1971.

[5] *A Study of 1972-73 Beginning Offers by Business and Industry*, Report No. 2, March 1973, College Placement Council.

[6] Frank S. Endicott. *Trends in Employment of College and University Graduates in Business and Industry 1973*, Northwestern University.

reported a 7.3 percent unemployment rate as of March 1, 1972 compared to 2.4 percent for men.

Without minimizing in any way the personal or national loss represented by these unemployed professionals, we should remember that the situation among professionals in science and engineering has been no worse than for professionals in many other fields, and indeed in some instances it has been much better. The same thing has been true for employment difficulties among new graduates. Employment statistics from all available sources indicate that those students majoring in nontechnological subjects have had considerably more difficulty over the past two years in finding suitable employment, and particularly employment related to their major field, than have new scientists and engineers. Nonetheless, because any difficulty at all in finding employment within these technological fields has been unusual, the emphasis in many of the stories in the news media about the educated unemployed has been on unemployment among scientists and engineers, both those just entering the profession and those who were already in our technological manpower pool.

It is characteristic of our news media to consider only the unusual as reportable news. Because a high proportion of the humanities and social science majors do not generally find employment in their field of specialization, there have been fewer stories.

It seems likely that some students have been turning away from careers in science and engineering for the paradoxical reason that they have acquired an increased interest in the environment and have learned enough about some of the technological bases for the past degradation of that environment to conclude that technology itself must be the villain. If this has indeed caused them to turn away from science, they have probably failed to recognize both that the benefits of technology already put to work to improve men's lives have far outweighed the damages and that improvement in the environmental situation can come about only through the application of more technology accompanied by careful assessment of potential harm as well as probable benefit. Many applications of technology both solve problems which we would not wish to reintroduce and produce new problems which we have not yet solved. This will probably always be so.

Much of our effort over the past decade has been devoted to our national defense—so much that there has been little chance to channel the tremendous potential of science and engineering toward our national social goals. That effort cannot wait much longer.

We must, for example, find acceptable ways to produce more energy. The problem cannot be solved simply by doing without those electrically operated gadgets that make our lives more comfortable such as our electric blankets and our air conditioners. Almost every environmental task including control of our biggest water pollutant, human wastes, demands huge amounts of electrical energy. But power cannot be created with present technology without adding more pollution. To attain the goal of adequate energy without pollution requires knowledge which we do not yet have and the application of that knowledge through new technology which does not yet exist. Controlled hydrogen fusion promises unlimited, inexpensive, nonpolluting energy—but this is still perhaps 30 years away. Coal gasification, fuel cell research, magneto-hydrodynamics, geothermal and solar energy are potentially promising. But they too are still in the future. The problem will not be solved sooner if many of our best potential students reject careers in science and engineering.

Engineering is the bridge between the new knowledge found by science and society itself. While the twentieth century has seen thousands of new products and services emerge through the application of engineering to the physical sciences and mathematics, increasingly engineering will also be applied to social and biological sciences to provide society with a new kind of assistance in solving its increasingly complex problems. Technology is the principal tool that our civilization has fashioned to alleviate the harsh condition of man in his world. If that world is to be better tomorrow than it was yesterday, we will need more and better science-based technology rather than less.

Young men and women considering careers in the sciences and in engineering should also be aware of the problems involved with such careers. One of the most critical of these, reexposed and reemphasized by the dislocations of the past two years is their interdependence with government programs. The job market for technological manpower is highly dependent upon decisions made by the federal government. In the past, the government generally has been unwilling to plan far ahead but has been willing to support crash programs to produce qualified manpower on demand for such large programs as the space effort, and to support

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salary levels for this kind of specialized manpower at a rate well above that given to other specialists with similar educational time requirements. While this trade-off policy has obviously worked by providing needed manpower to accomplish a particular objective such as landing a man on the moon, it also produces new problems when no other priority program has been established to utilize that trained manpower when the first project is completed. For adequate individual planning, it is vital that we establish priorities among such national goals as a cleaner earth, a more adequate transportation system, livable cities, abundant power, and better health care. Until this happens, job security for the scientist or engineer (and indeed for those in other fields as well) cannot be guaranteed.

Forecasting government decisions for funding of priority programs that will require large numbers of scientists and engineers is extremely difficult. While the needs for specialized personnel in these and in other disciplines to solve such problems can be readily perceived, those needs are not translated into job demand until funding is made available. Thus, there is and will continue to be for the foreseeable future an element of risk in planning for a career in almost any field. Nonetheless, it seems obvious that we are not likely to train more scientists and engineers than we need, or even more than we can use in the long run, provided we encourage those students who possess the triple requirement of an aptitude for science and engineering, the interest to pursue it, and the ability to master the technology already created. Potential students with these three requisites also must understand that the nature of science and engineering will require them to continue to study throughout their lifetimes if they are not to become technologically obsolescent.

There undoubtedly will be periods in the next decade or two when the general economy will falter and employment opportunities will shift. Students beginning college today may change the direction of their specialized interests two or three times over their working lifetime—either because the needs for their specialties change or because their personal interests lead them in new directions.

Opportunities for tomorrow's scientists and engineers will certainly include some job openings for the kinds of specialists that we have always needed, trained in such traditional fields as the engineering specialties, physics or chemistry. However, increasingly the new engineer and the new scientist will need to understand things beyond the technology involved in a problem. Some of tomorrow's scientists and engineers must be what Columbia's Dr. Simon Ramo has called the "poly-socio-econo-politico-technologist," who must understand much more about the implications of his work than was required of him in the past. Many science and engineering curricula will be and already are cross-disciplinary, geared toward problem solving that involves legal, sociological, and political implications along with economic and technological ones.

Today's enrollment patterns and the needs for scientists and engineers to solve problems already perceived make most science and engineering fields highly promising for the student with the interest and the ability to complete the rigorous training programs that the fields demand. However, if major changes come about in the perceived demand either through scientific and technological breakthroughs or because of changes in national goals, those students who have entered into a technological major are not at a disadvantage. An undergraduate major in science or engineering has traditionally been an excellent springboard into the world of business administration, the social sciences and even the humanities. On the other hand, technological fields are very difficult to enter at a late stage in the undergraduate years or at the graduate level when the previous preparation has been in other areas.

Science and technology are not the only tools that will be required to solve the major problems faced by the nation. However, these problems cannot be solved without a continuing infusion of capable, interested, and dedicated young people well trained in science and engineering.—BETTY VETTER, *Executive Director, Scientific Manpower Commission, 1776 Massachusetts Avenue, N.W., Washington, D.C. 20036.*

The Scientific Manpower Commission, established in 1953, has become a Participating Organization of AAAS with offices adjacent to those of the AAAS education staff. This issue of *Science Education News*, written by SMC's knowledgeable Executive Director, is the first of what the education staff hopes will be many benefits to the education efforts of both AAAS and SMC in their new relationship.

—J.R.M.

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