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ABSTRACT

THE DEMAND FOR TECHNICIANS WILL EXPERIENCE A RAPID RATE OF INCREASE--FROM 35,000 JOB OPENINGS A YEAR IN THE EARLY 60'S TO 128,000 A YEAR EXPECTED BETWEEN THE MID-1960'S AND THE MID-1970'S. A PRIMARY STIMULUS FOR THIS INCREASE IS THE VOLUME AND SCOPE OF RESEARCH AND DEVELOPMENT ACTIVITY DIRECTED TOWARD ACHIEVEMENT OF NATIONAL GOALS AND MANPOWER NEEDS. CAREER OPPORTUNITIES FOR TECHNICIANS IN THE 1970'S WILL REFLECT CURRENT TRENDS IN MEDICAL SERVICES AND IN ENGINEERING AND NATURAL SCIENCES. COLLEGES AND UNIVERSITIES AND NON-PROFIT ORGANIZATIONS WILL ALSO PROVIDE A LARGER PROPORTION OF JOB OPENINGS BY 1975. TECHNICAL EDUCATION PROGRAMS ARE CHALLENGED TO IMPROVE THEIR PUBLIC IMAGE BY (1) IMPROVING EXISTING POST-SECONDARY COURSE OFFERINGS, (2) EXPANDING TEACHER EDUCATION PROGRAMS, (3) DEVELOPING NEW PROGRAMS, (4) PROVIDING REMEDIAL SCIENCE-RELATED INSTRUCTION TO THE EDUCATIONALLY DISADVANTAGED, AND (5) CREATING A NATIONAL AWARENESS OF THE QUANTITY AND QUALITY OF TECHNICAL CAREER OPPORTUNITIES. (CH)

Education for Technician Careers and the Nation's Priorities in the 1970's

Working Paper

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INTRODUCTION

Technological progress is the means to a more abundant life for Americans. Our national investment of funds and manpower in new technologies has been rewarded by increased life expectancy, by rapid increases in productivity, and by far-reaching improvements in our standard of living.

A nation experiencing substantial technological advance needs a greater number of technicians to support the increasing supply of scientists and engineers. Yet, in the past, the United States has had one of the world's lowest ratios of technicians to scientists and engineers.(1) As industry, government, and universities come to utilize technicians more effectively, many more career opportunities will become available in the technical occupations. Accordingly, an annual average of 128,000 job openings is expected to develop in this field between the mid-1960's and the mid-1970's. This compares with the 35,000 job openings a year which became available between 1962 and 1966. These are among the most rapid rates of increase anticipated in any occupation.

Science-based industries and technical-service firms continue to show rapid growth. However, the main stimulus for technical manpower demand arises from increasing expenditures for research and development (R&D). Although it is difficult to measure the effect of R&D on economic growth, it is estimated that about half of our economy's recent expansion

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(1) Bowen, Charles R. "Educators Plus Employers: A Team to Meet the Critical Need for Technicians", presented at the National Clinic on Technical Education, Albuquerque, New Mexico, March 27, 1968, pp. 13-15.

is the result of increases in productivity which stem largely from technological and organizational changes.[2]

From the mid-fifties to the mid-sixties, R&D outlays accounted for approximately two-thirds of the employment growth for scientists and engineers in private industry.[3] Growth in expenditures for R&D in the 1970's will probably play an equally important role in raising requirements for technicians to support these scientists and engineers.

It is likely that there will be both continued growth in R&D related to defense and space in the next ten years and a more rapid expansion of research for the civilian economy. In analyzing requirements for scientists, engineers, and technicians for the 1970's, it is also reasonable to anticipate that there will be larger publicly-sponsored programs to translate R&D findings more quickly into technological advances in everyday use. Based on these considerations, it is estimated that requirements for technicians, excluding medical and dental technicians and surveyors, will grow from 900,000 in 1966 to nearly as high as 2 million in 1975.[4]

It is clear that this expected growth implies a need for an expansion and a redirection of emphasis in the vocational programs concerned with educating and training technicians in the 1970's. As a minimum, the vocational education system must attract many more students to the technician training courses -- particularly women and the disadvantaged. This will

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(2) Kendrick, John W., Productivity Trends in the United States, National Bureau of Economic Research, Princeton University Press, 1961, p. 80; Solow, Robert M., "Technical Change and the Aggregate Production Function," The Review of Economics and Statistics, August, 1957, pp. 312-320.

(3) U. S. Department of Labor, Occupational Employment Patterns for 1960 and 1975, p. 17.

(4) Lecht, Leonard A., Manpower Requirements for National Objectives in the 1970's, National Planning Association, 1968, p. 258; and Current Population Survey for 1966 (unpublished).

call for improved pre-service and refresher teacher training programs, and innovative leadership and strong administrative capabilities to shift priorities in vocational education. In this way, greater recognition can be accorded to the impact of technological advance for job opportunities.

R&D PRIORITIES, NATIONAL GOALS, AND MANPOWER NEEDS

The revolution in the role and organization of research since the Second World War has made America acutely research-minded. R&D is now an important means for achieving established national objectives such as defense as well as in suggesting new goals, i.e., space exploration or oceanics. If a high priority continues to be assigned to goals involving large-scale research and development, it is estimated that expenditures for R&D will rise from a little over $20 billion in 1962, or 3.6 per cent of the Gross National Product, to about $50 billion by 1975, or 4.3 per cent of the GNP (in dollars of 1964 purchasing power).(5) Such outlays will ovbiously require great increases in scientific and technical manpower. Research programs of these magnitudes affect employment in many areas because they inevitably reverberate throughout the technology and economy of our nation.

World War II marked the beginning of publicly financed R&D on a large scale designed to promote massive technological change. Today, most public and private research is federally financed.(6) Thus research has

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(5) Lecht, Leonard A., op. cit., p. 56.

(6) Statistical Abstract of the United States, 1968, p. 525.

become more than ever oriented towards achieving goals supported by the Federal government. In recent years, the Department of Defense, NASA, and the Atomic Energy Commission have accounted for approximately seven-eighths of all federal R&D spending. In the 1970's however, this situation could shift substantially toward a greater emphasis on improving the quality of the urban environment, on coping more effectively with unmet economic and social needs, and exploring areas as yet lightly touched by R&D. (7)

Scientific advances in oceanics alone may, in the next decade, come to rival the current effort in exploration of outer space. The nation probably will also insist on seeking more effective solutions for problems of health, welfare, education, housing, and transportation through R&D programs designed to accelerate technological and organizational progress. We can assume, moreover, that the 1970's will also bring expansion in the nation's information storage and retrieval systems and an R&D extension service to make research results available to the private sector.

In view of the major role federal agencies will play as sponsors of research in these fields, the changes in R&D priorities mentioned above will be obtained through changes in federal policy. Important shifts in emphasis on R&D may also take place in areas where private industries finance their own research. In the early 1960's, firms producing paper, foods, textiles and apparel, lumber, metals and petroleum spent one percent or less of their revenues on research. At the same time, firms producing chemicals, machinery, scientific instruments, electrical or communications equipment were channeling

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(7) Lecht, Leonard A., Goals, Priorities and Dollars -- The Next Decade, The Free Press, New York, 1966, pp. 215-23.

three percent or more of their revenues into R&D. Even a modest shift in policies toward greater support of research in the industries which place less stress on R&D would have major impact on technological developments, and concomitantly, on technical manpower requirements.

Job opportunities for technicians depend not only on research priorities, but also on the choice of national goals. If, for example, the nation were to encourage modernizationa and foster expansion of its industrial plant and equipment, 275,000 more technicians would be employed for this purpose in the mid-1970's than in the early 1960's. Over the same period, attaining goals in urban development would enlarge employment for technicians by only 110,000, even though the 1962 expenditures for urban development exceeded those of private plant and equipment. (See Table 1 on page 6).

The choices policy makers will face in the next decade is one of emphasis to be placed on different goals rather than the complete attainment of some goals and the complete neglect of others. The influence of possible changes in priorities may be assessed by comparing the different numbers of technicians required per $1 billion spent in pursuit of specific goals. For example, it is estimated that spending an additional $1 billion for national defense would generate approximately 4,000 new jobs for technicians; a similar expenditure on urban development would create fewer than 2,000 new jobs. These estimates illustrate the fact that we make use of research and development and new technology to a larger extent for defense purposes than in most other areas. The estimates also show that the pursuit of other goals requires, to a greater or lesser extent, the services of people with technical know-how below the professional level.

Table 1

Growth in Employment of Technicians Required for Achieving Selected National Goals: 1962 and 1975[a]

Goal	Employment (in 000) in 1962	Employment (in 000) Projected for 1975	Percent Increase in Employment 1962 to 1975	Projected Employment per $1 billion in 1975[b]
All research and development	178	460	158%	11,700
National defense	112	184	64	4,400
Private plant & equipment	126	380	201	2,500
Transportation	71	168	137	2,300
Urban development	82	192	134	1,800

(a) Technician totals include engineering and national science technicians, draftsmen and industrial designers. They exclude medical and dental technicians and computer programmers, the latter because of lack of data by goal.

(b) Refers to final demand expenditures in 1962 prices.

Source: Lecht, Leonard A., Manpower Requirements for National Objectives in the 1970's, National Planning Association, February 1968, pp. 397, 409, 422, 447, 460; U. S. Department of Labor, Manpower Report of the President, April 1968, Appendix Table E-11, p. 306.

In undertaking to consider the manpower impacts of pursuit of the nation's goals, it is reasonable to assume that by 1975 we may expect the establishment of a high priority for dealing with those problems which technology itself helps to create. For example, science has developed techniques for exploiting offshore oil, but techniques to preserve the nation's beaches from oil-slick pollution remain to be invented. Although use of DDT to eliminate destructive insects has controlled diseases and enlarged our crops, it now poses problems of harmful chemical accumulations in human and animal tissues. Since the manipulation of nature will continue to exacerbate imbalances in nature--imbalances which will require continuous advances on the frontiers of science--growth in career opportunities for technicians to assist research scientists, both in the physical and life sciences, is bound to continue.

CAREER OPPORTUNITIES FOR TECHNICIANS IN THE 1970's

Three sets of considerations in addition to the R&D priorities, national goals, and technological improvements discussed earlier can be expected to influence requirements for technicians in the next decade. The first set involves the traditionally American qualities reflected in our approach to technology -- practicality and team play coupled with a willingness to undertake large-scale enterprises. The second deals with the utilization of technical manpower in research and development and in science-based industries. The third relates to the geographic concentration of research activity.

The most important traditional American characteristic which favorably affects opportunities for technicians is our pragmatic emphasis, our interest in the uses of new knowledge. In the past, most of the nation's massive R&D expenditures have been directed to applied science and to development rather than pure research. In 1966, for example, only a little over one-tenth of the total R&D expenditure was for basic research.[8] In the 1970's, this pragmatic approach to science and technology is likely to continue.

Another feature of the modern scientific scene and one of the most significant developments in postwar technology is the team concept. The rapid growth in research and development since World War II is largely attributable to technical teams working in large laboratories or development centers, rather than to the lone researcher operating on a small

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(8) Statistical Abstract, loc. cit.

budget.[9] Moreover, with the growing emphasis on the application of techniques of operations research to complex systems, the trend is toward collectively planned R&D efforts carried out by teams of senior and junior technical personnel. This approach would be illustrated by a research project aimed at devising a completely modernized and largely automated postal service network.

Developments in systems research, made possible by the growing power of computers, will mean new jobs for junior systems analysts to support the emerging teams of social scientists and mathematicians. Growth in electronic data processing capabilities, incidentally, will continue to create new roles for technicians such as programmers by making them essential members of specialist teams.

Despite the continuing emphasis on the practical aspects of science and the trend toward more complex team efforts, the United States is still far behind the Soviet Union, West Germany, and other countries in effectively utilizing technicians to release scientists and engineers. The ratio in the United States, although rising rapidly, is still below the ratios considered desirable by industry.

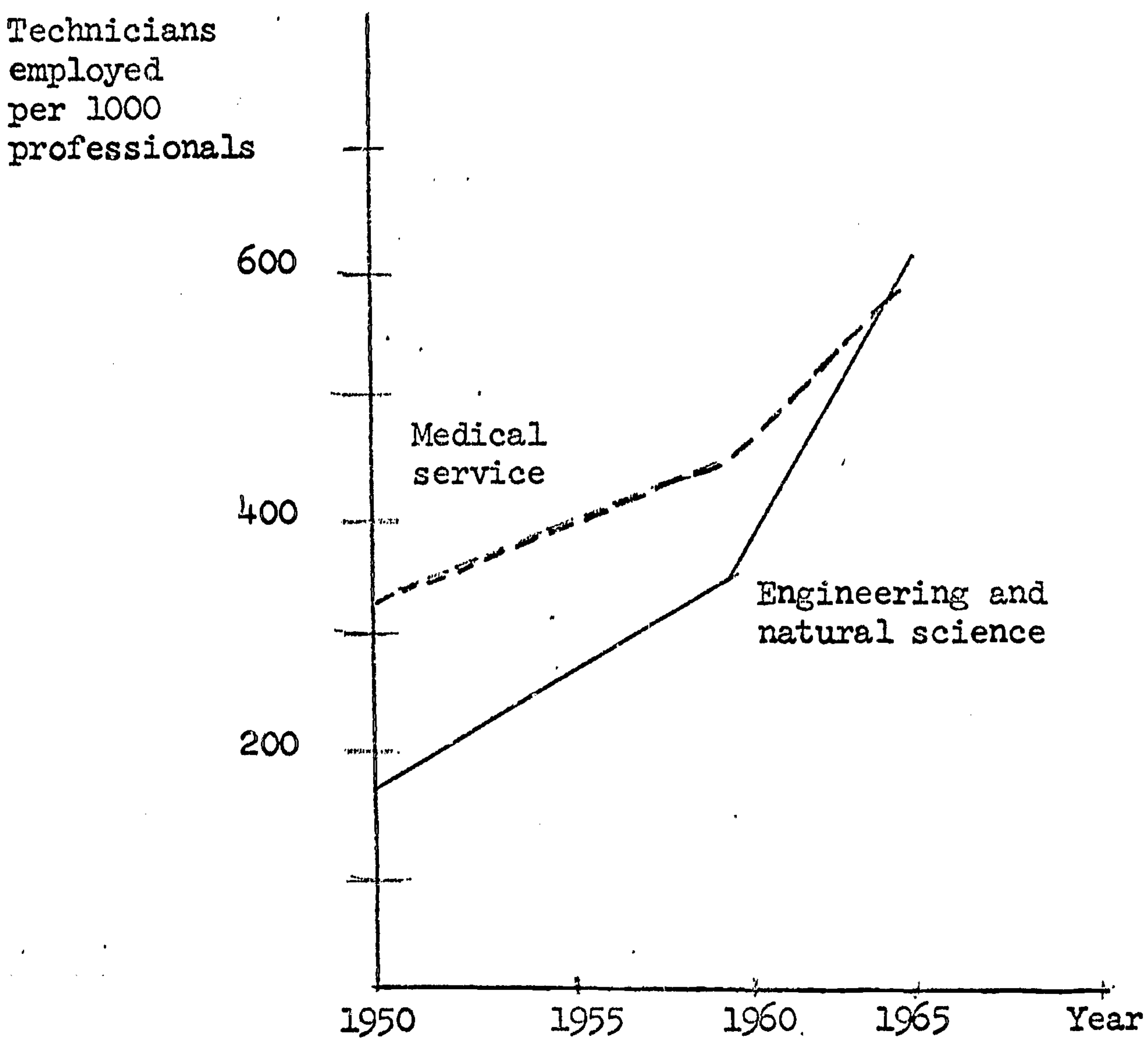
In 1950, there were less than 200 technicians per 1,000 professionals in engineering and natural sciences. By 1966, this ratio had increased to 600. The growth in the ratio of technicians to engineering and natural sciences professionals in the 1950 to 1966 period was more rapid than the

(9) Lecht, Goals, Priorities, op. cit., p. 218.

comparable growth rate in the medical services field, a field characterized by widespread use of technical manpower. The growth in the use of medical and dental technicians was also significant, a rise from 320 per 1,000 physicians in 1950 to 600 in 1966. Yet this represents less than a doubling in medical services compared to a greater than three-fold increase in the technician-professional ratio in engineering and natural sciences. (See Chart I).

Chart I

Trends in Ratios of Technicians to Professionals in Two Fields: 1950 to 1966



Source: See Appendix Table 1.

Although many more engineering and natural science technicians are now employed per 1,000 professionals in these areas than in 1950, there is a strong likelihood that growth in this ratio will continue to increase career opportunities in the technical occupations in the 1970's. For example, the American Society of Engineering reported in its survey of technical institute education in 1967 that industry desired a ratio of almost 2,000 technicians per 1,000 scientists and engineers.[10] Similarly, the experience of other countries underscores the potentials for more widespread utilization of technicians in the United States. About 2,000 technicians are now employed per 1,000 scientists and engineers in West Germany, approximately the ratio preferred by American industry. In the Soviet Union, to cite another illustration, planners are aiming at a ratio of 3,000 to 4,000 technicians for every 1,000 professionals employed in 1970 in industrial, construction, transport, communications, and agricultural occupations.

In any technical work, professional personnel are regularly supplemented by supporting technicians as well as by instrumentation and equipment. Technicians, however, instead of being only a supplement, are often a substitute, and so make it possible to economize in the use of high-level professional manpower, who are often in short supply. Further, properly trained technicians can often perform technical work which otherwise would require expensive instrumentation. Another important factor which affects the need for technicians is the research timetable. Projects rushed toward completion by a sudden influx of money reach a point of diminishing returns.

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(10) Bowen, C. R., "Educators Plus Employers; A Team to Meet the Critical Need for Technicians," op. cit., p. 13.

Thus, a faster job is more likely to be excessively expensive if there is no reserve of trained manpower from which to draw.(11) In the future, when the demand for scientists and engineers will continue to rise, we can reasonably expect higher ratios of technicians to professionals if well-trained graduates of the technician programs are available. Assuming the steps are taken to increase their availability, requirements for technicians, according to the National Planning Association's projections, would grow more rapidly than for the professionals with whom they work. The relevant estimates of percentage growth for the 1966 to 1975 period are 122 per cent for technicians and 82 per cent for scientists and engineers.(12)

Finally, the geographic concentration of research affects the job openings available for technicians in different states and localities. In the 1960's, defense and space-related research and development activities have been concentrated more heavily in some states than in others. The presence of numbers of large universities and scientific laboratories in the Boston area and in southern California, for example, has been an important influence in the location of many technologically-advanced industries, i.e., the electronics industry, made up of large establishments in the same areas. These establishments maintain substantial research teams and they attract sizeable federal research support. Employment opportunities for technicians, accordingly, are greater in these areas than in the ones which are less important as centers of research-oriented industries. The geographic concentration of research will probably be

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(11) Terleckyj, Nestor E., Research and Development: Its Growth and Composition, National Industrial Conference Board, Inc., New York, 1963, pp. 12-15.

(12) Lecht, L., Manpower Requirements for National Goals, op. cit., and Current Population Survey for 1966 (unpublished).

less pronounced in the 1970's than in the 1960's. This anticipation stems partially from congressional concern with reducing geographic imbalances in the distribution of research funds. It also reflects an expected shift in emphasis in R&D priorities to allow for greater support for research and development throughout the nation related to social needs such as education, health, pollution, mass transit, and low-cost housing. As research support becomes more evenly diffused, a growing demand for technicians will also be more evenly spread across the country.

Consideration of the forces affecting the employment of technicians makes it reasonable to anticipate rapid expansion in job opportunities in virtually all specialized fields, although the percentage increases are likely to be considerably larger in some occupational areas than in others. The potentials for growth are illustrated by the projections of average annual job openings in specific technical fields in Table 2. (See page 14 for Table 2). The estimates indicate the breakdown by speciality of the 128,000 average annual job openings expected to materialize in the 1966 to 1975 period if our society were to assign a high priority to goals involving a substantial technological component for their pursuit.

Scientific and engineering technicians of all types accounted for half of all employment in the technical fields represented in Table 2. These are also the technical areas expected to undergo the largest increases in employment and job openings in the 1970's. Among engineering technicians,

Table 2

Estimated Annual Average Job Openings
for Technicians, 1966 to 1975
(in 000)

Occupational Category	Number Employed 1966	Number Employed Projected 1975	Annual Average Job Openings 1966 to 1975[a]
Scientific and engineering technicians	459	1,268	89
Electrical and electronic	136	456	34
Other engineering	207	496	33
Life sciences	16	73	6
Chemical	48	130	9
Physics	10	24	1
Other physcial sciences	3	8	1
Applied mathematics	39	81	5
Draftsmen and designers	346	525	23
Computer programmers	100	220	14
TOTAL[b]	905	2013	128

(a) Refers to job openings generated by replacement demand and for replacement of losses due to deaths and retirements.

(b) Details may not add to total due to rounding.

Source: See Appendix Table 2.

the electrical and electronic fields--such as communications, radar, or fields related to space craft guidance, missiles, and electronic equipment--are likely to undergo the more pronounced rates of growth. This reflects the continuing emphasis on the nation's space exploration and defense goals, as well as the proliferation of electrical and electronic equipment throughout our society.

Agricultural and biological technicians (life sciences in Table 2) have unusually rapid growth prospects, although they are now relatively small in number. Progress in "farming" the oceans and in preserving food through improved packaging may increase the demand for life science technicians to even higher levels in the 1970's. Requirements for sub-professional technical manpower to assist chemists, physicists, and other physical scientists will rise rapidly in the next decade, although the percentage increase for this group is expected to be smaller than for the life science technicians. New scientific techniques such as the use of infra-red photography to determine the location of undeveloped natural resources could raise requirements for physical science technicians above the levels shown in the table.

As may be seen from Table 2, draftsmen and designers are now the largest single specific occupation in the technical manpower field. This group, heavily dominated by draftsmen, accounted for almost four out of ten people employed in technical occupations in 1966. However, since employment growth for draftsmen will probably be held back by automation, less than two out of ten job openings are expected to go to draftsmen and industrial designers in the 1966 to 1975 period.

Employment opportunities for computer programmers in the 1970's will be fewer than for designers and draftsmen but they are expected to grow more rapidly. Computer programming is a fairly new occupation which became significant in the 1950's. In 1959, the introduction of transistorized computers ushered in a period of mass production of miniaturized computers and the accompanying software. This development gave rise to new demands for technicians. As the revolution in data processing continues, it is estimated that, between 1966 and 1975, there will be 14,000 job openings a year for computer programmers. Moreover, by 1975 it is likely that some skill in scientific data processing will be required of almost all technicians to insure adequate communication among all specialists in science and technology.

Employment for technicians in the 1970's will be affected substantially by patterns of occupational growth in the specialities within the field. Job opportunities will also be influenced by the rate at which different sectors of the economy expand in the coming decade. According to a Department of Labor study, the largest percentage increases in employment in these occupations will take place in the services sector. Colleges and universities, and non-profit organizations, frequently R&D organizations, will provide a larger proportion of jobs in the 1970's than in the 1960's. Growth in employment opportunities will also be above average in Federal and local government. On the other hand, industries manufacturing machinery and equipment, including electrical equipment, aircraft, and motor vehicles, and public utilities will be somewhat less important as sources of employment in the technical occupations in the next five or ten years. (See Appendix Table 3).

IMPLICATIONS FOR VOCATIONAL-TECHNICAL EDUCATION

Although job prospects in the next decade will not be equally favorable in all occupational and industrial classifications, on the whole, employment opportunities for well-trained technicians will be excellent. And yet the recruitment of qualified students is a major problem in developing vocational education programs for technicians. In the first place, many high school students study only a minimum of science and mathematics. Second, students often fail to develop the reading, writing and speaking skills which would insure that they would be reasonably successful in technical education programs.(13) High school students who choose the background courses necessary for training as technicians usually aspire to a college degree. And, unfortunately, many Americans tend to denigrate degrees below the baccalaureate. Therefore, encouraging more students to prepare for careers as technicians will involve improving general as well as vocational education, inculcating a greater awareness of opportunities, and changing the status connotations associated with different types of degrees.

The Engineering Manpower Commission reported in 1969 that, after twelve to fourteen years of experience, the average technician received a salary quite close to that of an engineer in the lower half of the salary scale

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(13) Brooking, Walter J., "Student Recruitment and Student Development for Technical Programs," circular issued by U.S. Office of Education, March, 1969, p.1.

for all engineers.[14] Publicizing facts such as these is likely to require a concerted effort to reach parents, students, teachers, and guidance counselors. Recently, for example, the Advertising Council started a nationwide campaign to create greater awareness of the availability of good technical jobs which do not require four years of college. However, these public service campaigns by the mass communications media are supplements, rather than substitutes for the efforts of the school systems themselves to interest more young persons, and young persons from underrepresented groups, in these rewarding careers.

Attracting more qualified students into technical fields will mean focusing to a considerably larger extent than in the past on students from disadvantaged groups and on women. In 1966, to cite an instance, only some 5,000 nonwhites were employed as electrical and electronic technicians. This represented about 4 percent of the total.[15] In the early 1960's, fewer than 10 percent of all employed technicians were women.[16]

Many students, white and nonwhite, in inner city schools lack the educational background in introductory science and the supporting mathematics required to enter the usual postsecondary technician training programs. In our culture, women, too, have obstacles to overcome if they are to be adequately represented in our technician training courses. Prominent among these are the

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(14) Technician Education Yearbook, 1967-1968, Prakken Publications, Inc., Ann Arbor, Michigan, pp. 181-2.

(15) Based on Current Population Survey for 1966 (unpublished).

(16) Technician Manpower: Requirements, Resources, and Training Needs, U.S. Department of Labor, Bulletin No. 1572, 1966, p. 31.

social practices which formerly restricted the work careers of women coupled with the feeling that the technician's work is not feminine.

Recent developments in science and engineering favor increased participation by women in technical fields since they point in the direction of an emphasis on design and research. These are activities which do not involve the type of cultural obstacles women have had to surmount in fields like mechanical engineering. Also, women's supposed knack for detail gives them a favored position among programmer candidates. In Russia, where engineering is not regarded as a male profession, about a third of the engineers are women.(17) The Women's Bureau has reported that no significant formal restriction bars women's access to technical training. Instead, the Bureau's report concluded that the desire to obtain training is frequently restrained by the attitudes of parents, counselors, and educators -- as well as by the women themselves.(18)

In addition to social barriers and lack of an awareness of the opportunities, failure to elect the requisite courses in secondary schools serves to remove many women and persons from disadvantaged groups as prospects for the science-related fields. One way to give such people a second chance is through programs called by various names like "student development", "pretechnical", or "opportunity" courses. All of these

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(17) Mattfield, Jacquelyn A. and Van Aken, Carol G. (eds.) Women and the Scientific Professions, the MIT Symposium on American Women in Science and Engineering, MIT, 1965, p. 174.

(18) U.S. Department of Labor, Careers for Women as Technicians, Women's Bureau Bulletin No. 382, 1961, p. 24.

provide remedial and preparatory education in the sciences and mathematics. Administrators of such programs have stated that when students remove the academic deficiencies as a part of their occupational study programs, the morale of both students and instructors is improved, and the number of students who drop out because of academic failure is greatly reduced.(19)

Preparing more students from disadvantaged and other groups to enter the technician fields presupposes growth in the programs available as well as in enrollments. Unfortunately, we do not as yet have the programs and facilities to train all the technicians needed in the U.S. economy. There are, of course, a number of ways to obtain the necessary training. Among these are technical institutes, endowed or publicly supported, junior or community colleges, divisions of engineering in other colleges and universities, colleges of technology, proprietary schools operated by individuals or corporations, training in the armed forces and in programs sponsored by the Manpower Development and Training Administration, and training in high school. In 1966, 15,000 students were receiving secondary school training as technicians in comprehensive high schools, vocational technical schools, technical high schools, and vocational and trade schools. However, training at the secondary level frequently provides no more than a background, although a number of graduates from high school programs go directly into jobs as technicians (see Appendix Table 4).(20)

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(19) Brooking, W.J., "Student Recruitment", op. cit., p. 2.

(20) U.S. Department of Labor, Technician Manpower, op. cit., p. 35.

At the postsecondary level, there are major discrepancies between the number of technicians needed in various fields and the number graduating from training institutions. For example, as indicated in Table 3, in fiscal year 1967 completions of postsecondary technician programs eligible for federal support in the electrical and electronic engineering fields amounted to about 6,000. Average annual openings for these occupations from the mid-1960's to the mid-1970's are estimated at 34,000, almost six times the completions. For chemical technicians, job openings are twenty times the number of persons who completed training programs in 1967. Program completions for life science technicians, an occupation projected to have one of the highest growth rates in the next decade, were negligible. Even though many life science technicians need a college degree to qualify for entry level jobs, others can enter the field with an associate degree.

Table 3

Estimated Job Openings and Completions of Technical Training Programs, 1966 to 1975
(in 000)

Occupational Category	Average Annual Job Openings- 1966-1975	Completions of Post-Secondary Vocational Education Programs in 1967(a)
Electrical and electronic	34	6
Other engineering and designers	38	5
Life sciences	6	(b)
Chemical	9	(b)
Physics	1	(b)
Other physical sciences	5	4
Applied methematics	1	(b)
Draftsmen	18	2
Computer programming	14	3
TOTAL	128	21

(a) The postsecondary programs are offered in junior and community colleges, four year colleges and universities, postsecondary technical institutes and vocational schools, combination secondary and postsecondary vocational schools and institutes. The figures refer to completions in programs eligible for federal support in fiscal year 1967.

(b) Less than five hundred completions

Source: See Appendix Table 4.

The number of completions listed in the table refers to postsecondary programs in 2 and 4 year colleges, vocational schools and technical institutes. Consequently, in fields like drafting, where high school programs provide enough training for some entry level jobs, the figures understate the supply of newly trained technicians likely to result from these federally-aided programs (see Appendix Table 4). There is also some evidence based on the relationship of the completions in all postsecondary programs training technicians to the completions in the federally funded programs indicating that more technicians may be trained in fields related to the physical sciences than is shown in Table 3 (see Appendix Table 5). Allowing for this additional training, it is apparent, to quote the American Association for the Advancement of Science, that "there is every indication now that a critical shortage of technicians will be as much a matter of national concern as was the shortage of scientists and engineers a few years ago."(21) Both the imperfect statistical measures and the expert opinions point to the importance of a substantial expansion in vocational education programs to serve the needs of students for careers and of the economy for trained and educated manpower.

With the continuing explosion of scientific knowledge and its application in new technology, the vocational-technical education system also faces the challenge of training for occupations which scarely existed a decade ago. Specialists in pollution control are instances. As a result of mounting

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(21) Technical Education--A Growing Challenge in American Higher Education, A Report by the Commission on Science Education of the American Association for the Advancement of Science, 1968, p. 3.

public pressures to counteract the deterioration of the natural environment, a deterioration often caused by ignoring the side effects of technological progress, thousands of new positions for technicians will be created in the 1970's in government regulatory agencies as well as in industry. It has been estimated that by 1975 there will be a need for over 7,000 technicians to control air pollution,(22) and over 33,000 to abate water pollution.(23) In 1967 there were fewer than 11,000 water pollution control technicians.

The vocational-technical system has begun to respond to the challenges implied by the nation's R & D priorities. At one college in Virginia, for example, a nuclear option specialization is being offered to technicians within the framework of an electronic engineering program.(24) Under the National Sea Grant Program, one-year training programs have been started for paraprofessionals in ocean-related technologies.

Yet it is evident that bringing the technical education system up to date will involve far more than occasional innovations coupled with a simple expansion of the existing programs. Recent studies have shown that, on the whole, education for technicians has been untouched by the reforms in science education. Teacher training programs -- both for initial preparation and refresher training -- often lag behind current developments in education and

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(22) Applying Technology to Unmet Needs (Appendix Vol. V., Technology and the American Economy), National Commission on Technology, Automation and Economic Progress, 1966, pp. 144-45.

(23) Manpower and Training Needs in Water Pollution Control, Senate Document #49, 90th Congress, First Session, 1967, Table 1, p. 15.

(24) Kovner, Edgar A., "Training Nuclear Technicians at Old Dominion College," Technician Education Yearbook, 1967-68, Prakken Publications, Inc., Ann Arbor, Michigan, pp. 129-32.

in technology. There is a need for strong leadership to improve program management, to develop better communications with employers, and to modernize the regulations governing the certification of teachers and the licensing of technicians. Greater progress along these lines would facilitate the acceptance of technical education as an integral part of the higher education system. With this progress, students wishing to obtain a four-year college education would find it less difficult to use credits received in technical courses to fulfill the requirements for a bachelor's degree.

There are many proposals receiving consideration for improving the quality and acceptability of technical education. It has been suggested that experimental technical institutes be established as parts of major universities.(25) Some have proposed studies of outstanding cooperative work-study programs and technical education curricula to determine how success was achieved as a basis for planning new programs.(26) While these ideas are worthy of exploration, they are unlikely to provide solutions for local school systems which lack the resources for exemplary programs. Much of the initiative in introducing more experimental programs will require support from federal government sources.

Admittedly, the task of creating a better system of technical education in the 1970's will be a demanding one. However, success in upgrading the technical education programs offers the most promising route for elevating the status of technicians, and, thereby, attracting many more students to these programs.

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(25) Letter by Nathan S. Washton, relating to Abelson's "Toward Better Vocational Education," in Science, 8 November 1968, pp. 619-20.

(26) Technical Education, op. cit., p.19.

PRIORITIES IN VOCATIONAL-TECHNICAL EDUCATION

The priorities proposed for planning in vocational education grow out of the recognition that technical training is a matter of national concern. Enlarging the supply of technicians contributes to economic growth by increasing the effectiveness with which we make use of all of our research resources including scientists and engineers. Since the technician occupations are among the most rapidly growing fields in the economy, they offer many career opportunities for young people who receive the appropriate training.

The scale on which job openings materialize for technicians in the 1970's will depend on a variety of factors. They include the emphasis placed on the nation's R & D priorities as they relate to the pursuit of different national goals, the extent to which scientific advances are translated into technological improvements in industry and in everyday life, and the occupational makeup of the technical teams engaged in research or production. The occupational makeup of the technical workforce is likely to be affected significantly by a continued rise in the ratio of technicians to professional scientists and engineers. This means that American patterns of technical manpower utilization will move closer to the standards desired by industry and to the situation in other nations such as West Germany.

These anticipations point to the need for expanding and modernizing training for technicians in the vocational-technical education system. Planning to attain these objectives will involve assigning a high priority to policies such as the following:

1. Substantially increase course offerings and enrollments, particularly at the postsecondary level, in programs preparing technicians in engineering, life sciences, applied mathematics, physical sciences, and the computer programming fields.

2. Introduce more teacher training programs to orient new and experienced teachers in the technician training courses to recent developments in science and technology such as oceanics, the laser, or micro-miniaturization.

3. Develop programs in technical education for new occupations resulting from technological advances and shifts in R & D priorities such as specialists in pollution control.

4. Sponsor pre-technical, remedial, and opportunity programs to enable more persons from disadvantaged groups and more women to acquire the background in introductory mathematics, science, and English required for training as technicians.

5. Create a national awareness of the availability of attractive career opportunities through public information programs and guidance counseling in the elementary and secondary schools.

Appendix Table 1

Employment for Technicians per
1,000 Employed Engineers, Natural Scientists, Physicians
and Dentists, 1950, 1960 and 1966
(in 000)

	1950	1960	1966*
Engineering and natural science technicians	102	345	805
Engineers and natural scientists	556	1,008	1,310
Technicians per 1000 engineers and natural scientists	108	340	610
Medical and dental technicians	78	139	224
Physicians and dentists	248	317	374
Technicians per 1000 physicians and dentists	310	440	600

*The data collection procedures in 1966 differ from those used for the decennial censuses so that the ratios for this year are not strictly comparable with earlier years.

Source: U.S. Department of Commerce, U.S. Census of the Population: 1950, Occupations by Industry, P-E No. 1C, 1954, Table 2, Detailed Occupation of Employed Persons by Detailed Industry and Sex for the U.S.: 1950, p. 1C-12; U.S. Census of the Population: 1960, Occupation by Industry, Final Report PC (2)-7C, 1963, Table 2, Detailed Occupations of Employed Persons by Detailed Industry and Sex for the U.S.: 1960, pp. 7,8; Current Population Survey for 1966 (unpublished data).

Appendix Table 2

Estimated Employment Growth and Annual Average Job Openings in Technical Fields by Occupation, 1966 to 1975 (in 000)

Occupational Category	Employment in: 1966	Employment in: 1975	Average Annual Job Openings 1966 to 1975 (a): From Employment Growth	Average Annual Job Openings 1966 to 1975 (a): From Replacement Demand	Total
Scientific and Engineering technicians	459	1268			89
Electrical and electronic	136	456	32	2	34
Other engineering (b)	207	496	29	5	33
Life sciences	16	73	6	(c)	6
Chemical	48	130	8	1	9
Physics	10	24	1	(c)	1
Other physical sciences	3	8	1	(c)	1
Applied mathematics	39	81	4	1	5
Draftsmen and designers	346	525	18	5	23
Computer programmers	100	220	12	2	14
TOTAL	905	2013	111	17	128

(a) Replacement demand estimates refer to replacements for attrition losses due only to deaths and retirements.

(b) Calculated as a residual after estimating employment in the other technician categories such as life sciences, chemical and physics technicians.

(c) Less than one thousand.

Source: Appendix 4, U.S. Department of Labor, Technician Manpower Requirements, Resources and Training Needs, Bulletin No. 1512, pp. 11-20, 54; and U.S. Department of Labor, Occupational Outlook Handbook in Brief, Vol.12, No. 2, May 1968, p. 5.

Appendix Table 3

Estimated Employment of Technicians by Industry,
1963 and Projected 1975*
(in percent)

Industry	1963	1975	Change 1963-1975
Mining (including petroleum)	2%	1%	44%
Construction	3	3	79
Manufacturing	46	42	60
Durable	37	33	56
Ordnance and accessories	2	1	17
Lumber and furniture	1	1	40
Stone, clay and glass products	1	1	45
Primary metal products	2	2	48
Fabricated metal products	3	3	67
Machinery, except electrical	7	6	51
Electrical equipment	12	11	66
Aircraft and parts	4	3	36
Motor vehicles and equipment	2	1	13
Other transportation equipment	1	1	60
Professional and scientific instruments	2	2	88
Nondurable	9	8	76
Food and kindred products	1	1	46
Textile mill products and apparel	(a)	(a)	83
Paper and allied products	1	1	72
Chemicals and allied products	4	5	97
Petroleum refining and products of petroleum and coal	1	1	34
Rubber products	1	1	87
Miscellaneous manufacturing	1	1	17
Transportation communication and public utilities	7	5	29
Transportation	1	1	45
Communication	3	2	30
Electric, gas & sanitary services	2	1	26
Services	22	27	115
Miscellaneous business services	4	6	144
Medical and dental laboratories	2	4	252
Nonprofit organizations	1	2	162
Engineering and architectural services	8	8	69
Colleges and universities	1	2	173
All other nonmanufacturing	5	5	79

Appendix Table 3 (continued)

Estimated Employment of Technicians by Industry,
1963 and Projected 1975*
(in percent)

Industry	1963	1975	Change 1963-1975
Government	20	22	93
Federal government	9	8	62
State government	7	9	132
Local government	4	4	97
TOTAL	100	100	77

* Technicians as defined by the Labor Department study, on which these figures are based, include surveyors and medical technicians other than those who assist medical practitioners in the direct care of patients, in the dispensing of drugs and services, or in diagnosis.

(a) Less than one percent

Source: U. S. Department of Labor, Technician Manpower: Requirements Resources and Training Needs, Appendix A_1 - A_3 .

Appendix Table 4

Estimated Job Openings and Training Program Completions for Technicians by Occupation (in 000)

Occupational category	Average Annual Job Openings, 1966-1975(b) Number	Percent	Completions of Programs Eligible for Federal Funds, FY 1967(a) Secondary Number	Percent	Post-secondary Number	Percent
Electrical & electronic	34	27%	4	27%	6	31%
Other engineering and designers	38	30	1	8	5	23
Mechanical				5		13
Electro-mechanical				(c)		(d)
Industrial				1		3
Civil				1		6
Aeronautical				1		1
Life sciences (e)	6	5	(d)	-	(d)	-
Chemical	9	7	(d)	2	(d)	2
Physics	1	1	(c)	-	(d)	-
Other physical sciences	5	4	1	9	4	19
Metallurgical				(d)		1
Instrumentation				1		1
Geological (petroleum & marine)				(c)		(d)
Architectural				6		11
Environmental control				(d)		2
Automotive				(d)		3
Engineering related				2		2
Applied mathematics	1	1	(d)	-	(d)	-
Draftsmen	18	14	7	46	2	12
Computer programming	14	11	1	8	3	13
TOTAL	128	100.0	15	100.0	21	100.0

(a) The institutions eligible for federal funds are comprehensive high schools, junior and community colleges, four year colleges and universities, post-secondary technical institutes and vocational schools, combination secondary and post secondary area vocational schools and institutes.

(b) Job openings equal the sum of employment growth and replacement demand due to normal attrition stemming from death and retirement.

(c) There are no completions reported.

Appendix Table 4 (continued)

(d) Less than five hundred completions or 0.5 per cent.

(e) Medical and dental technicians involved in the diagnosis or care of patients are excluded.

Source: Population Survey, 1966 (unpublished data); Lecht, Leonard A., Manpower Requirements for National Objectives in the 1970's. Feb. 1968, Appendix Table 8, pp. 258-262; Norman Frumkin, Manpower Implications of Alternative Priorities for Coping with Poverty, May 1968. Appendix Table A-15; U. S. Department of Labor, Tomorrow's Manpower Needs, Vol. 1, Bulletin No. 1606, Appendix A, pp. 64-67; U. S. Office of Education, "Technical Education-FY 1967," and "Trades and Industrial Education-FY 1967" (unpublished data).

Appendix Table 5

Training Completions Reported by Colleges
Compared with Those Reported by the Vocational
Education System, 1966-67
(in 000)

Category	Completions of College Programs (a) 2 but less than 4 years	1 but less than 2 years	Total	Completions of Post Secondary Vocational Programs (b)
Electrical and electronic	6	1	7	6
Other engineering and designer	7	2	8	5
Life sciences	2	(c)	2	(c)
Chemical	1	(c)	1	(c)
Other physical sciences	7	1	8	4
Computer programming	1	(c)	1	3

(a) Completions are measured by numbers of diplomas, certificates, and other formal awards granted by two-year or four-year higher educational institutions with organized technical curriculums.

(b) These are completions of postsecondary programs which are offered in junior and community colleges, four year colleges and universities, postsecondary technical institutes and vocational schools, combination secondary and postsecondary vocational schools and institutes.

(c) Less than five hundred completions.

Source: Brinkman, M. Jean, Associate Degrees and Other Formal Awards Below the Baccalaureate, 1965-1966 and 1966-1967, National Center for Educational Statistics, Office of Education, U.S. Department of Health, Education and Welfare, Table 11, p. 15; U.S. Office of Education, "Technical Education FY 1967" and "Trades and Industrial Education, FY 1967" (unpublished data).

Appendix Table 6

Schools Offering Technical Education Programs Receiving Federal Support by Type, FY 1967

	Part-time Programs for Adults	Full-time Programs for Youth	Total
Specialized secondary schools	57	76	133
Technical or vocational schools	141	193	334
Regional or comprehensive high schools	268	293	561
Community or junior colleges	190	301	491
Collegiate level	23	38	61
Combined secondary-post secondary	64	71	135
TOTAL	743	972	1715

Source: U.S. Office of Education, Division of Vocational and Technical Education (unpublished data).