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By-Foncannon, Howard F.
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This conference sought to analyze the major problems of science in technical education, formulate possible solutions, and stimulate action by higher education, government, the scientific community, foundations, and private industry. This part of the study concerns only physical science and engineering technicians, most of whom attend junior or technical colleges. Staff studies show that the education of technicians has benefited little from the science education reforms enjoyed by scientists and engineers. General problems considered at the conference were (1) the need for technicians, (2) the institutions, students, and teachers, and (3) the programs offered. The staff prepared working papers on each problem and agreed on certain recommendations: (1) establish the unique identity of technical education, (2) inform a wider public, (3) clarify articulation with universities and high schools, (4) devise a satisfactory vertical structure for technical courses, (5) encourage supporting legislation, (6) refine techniques to study supply and demand, (7) continue study of regulatory agencies, (8) examine motivations of high school students, (9) reduce the attrition rate, (10) help teachers keep up to date (math, science, technology), (11) improve pre-service teacher training, (12) anticipate, rather than accommodate, technological change, (13) explore work-study programs, (14) publicize successful curricula, (15) continually evaluate program objectives and relevancy, (16) develop teaching aids, (17) welcome new teaching methods. (HH)

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

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Foreword

The Commission on Science Education of the American Association for the Advancement of Science is conducting a study of science in vocational and technical education. The principal purposes of the study are to analyze and evaluate the major problems in technical education, to formulate possible courses of action toward their alleviation, and to stimulate action toward their solution by governmental agencies, higher education, the scientific community, private foundations, and private industry.

This is the report of the first phase of the study, which has been concerned with the education of technicians for technical occupations related to the physical sciences and engineering. Much of this education takes place in junior and community colleges and technical institutes.

The Task Force of the Commission which is conducting the study consists of Burton H. Colvin, Head, Mathematics Research Laboratory, Boeing Scientific Research Laboratories, *Chairman;* William T. Kabisch, Assistant Executive Officer, American Association for the Advancement of Science; William C. Kelly, Director, Office of Scientific Personnel, National Research Council; and Vincent J. Schaefer, Director, Atmospheric Sciences Research Center, State University of New York, Albany. Howard F. Foncannon has served as Staff Secretary of the Task Force.

The Task Force is indebted to all of the individuals in junior and community colleges and technical institutes, universities, professional associations, federal and state governmental agencies, and industry who provided information and materials, advised, and helped in many other ways. The Task Force wishes to express its appreciation to each one of them.

The Task Force has a special obligation to the following persons who provided essential advice in the initial stages of the study, assisted in the preparations for the conference, served as discussion group leaders at the conference, reviewed the draft report, and continued to advise the Task Force subsequent to the conference: Stanley M. Brodsky, Chairman, Division of Technology, New York City Community College of Applied Arts and Sciences; Walter J. Brooking, Program Officer, Secondary Education and Post Secondary Education—Technical Education, Division of Vocational and Technical Education, U. S. Office of Education; W. Leighton Collins, Executive Secretary, American Society for Engineering Education; Meredith P. Crawford, Director, Human Resources Research Office, George Washington University; Jerry S. Dobrovolny, Chairman, Department of General Engineering, University of Illinois; Lewis R. Fibel, Specialist on Occupational Education, American Association of Junior Colleges; Norman C. Harris, Professor of Technical Education, Center for the Study of Higher Education, University of Michigan; Eckhart A. Jacobsen, Department of Industry and Technology, Northern Illinois University; Frank R. Kille, Special Assistant to the Commissioner for Science and Technology, State Department of Education, New York; J. P. Lisack, Director, Office of Manpower Studies, School of Technology, Purdue University; Gordon McCloskey, Director, Vocational-Technical Education Research and Development Program, Washington State University; Lyle W. Phillips, Director, Division of Undergraduate Education in Science, National Science Foundation; Maurice W. Roney, Director, School of Industrial Engineering, Oklahoma State University; Neal H. Rosenthal, Chief, Branch of Occupational Outlook and Specialized Personnel, Division of Manpower and Occupational Outlook, Bureau of Labor Statistics, U. S. Department of Labor; Arnold A. Strassenburg, Professor of Physics, State University of New York at Stony Brook; and William Torpey, Education and Manpower Specialist, Office of Emergency Planning, Executive Office of the President, Washington, D. C.

This study has been supported by the National Science Foundation through grants to the American Association for the Advancement of Science for the work of the AAAS Commission on Science Education.

This report has been prepared for the Task Force and the Commission by Howard F. Foncannon.
November, 1968

Contents

Introduction

Within the time of our brief national history the orientation of our social philosophy has turned completely about, from preoccupation with the protection and preservation of the values of the past to the forging of new values for the future. The continuing change that is characteristic of our technological society involves not only the physical applications of science but social and cultural evolution as well.[1] Not only must we find ways to preserve and perfect our republic, but at the same time we must learn how to adapt to a continually changing environment. Our type of society involves the direct participation of a far greater share of the population in policy- and decision-making than has been the case in the past. This places a direct and immediate responsibility upon the educational system which, as an organic part of the societal structure, must also adjust its orientation to produce the intellectual tools which, themselves, are a part of change.

Both the general public and the educational community are aware of the need for radical changes in our educational system. There is growing concern that education may have to be basically restructured in objectives, form, content, and methodology if it is to meet its responsibilities.

All who are involved in education know that one of the most complex and difficult problems of our time is how to bring about the needed improvements. In view of our mounting societal pressures, it also is one of the most vital and urgent problems. The burden of responsibility for leadership in educational reform falls most

[1] For example, see *How Technology Will Shape the Future* by Emmanuel G. Mesthene. Harvard University, Program on Technology and Society. Reprint Number 5.

heavily upon the universities, but the task cannot be accomplished without help and cooperation from every other sector of society.

Education must focus more and more on the practical realities of life, but at the same time continue to serve as the vehicle for the preservation of knowledge about the past. The first task of education, however, is to make it possible for the individual to develop his talents and to find a productive place in society.

Almost everyone must have some specific occupational education and training, whether it be for the service occupations and the trades or for the professions. A diminishing number of jobs can be performed without any formal training. At the other end of the scale, the research scholar must continue with postdoctoral education if his work is to be relevant and productive. For the vast middle range of occupations, education must prepare the individual to meet not only the day-to-day needs of his life but also enable him to adapt to rapid and continuing change.

This study represents a first step in defining the major issues and problems in a relatively new, but increasingly important, sector of education and in pointing out some of the things that need to be done. Technical education at the college level has emerged only recently as a major component of American higher education. It is growing rapidly, and is beset by problems that call for immediate attention.

Shortly after the end of World War II, the critical shortage of scientists and engineers in the United States became apparent. While massive programs of federal support for graduate students and basic research in the sciences were effective in alleviating the problem, it was clear almost from the beginning that many college science and engineering students were deficient in their high school science and mathematics preparation, and that this presented a serious obstacle in the national effort to improve the supply of scientific and technical manpower. The federal government stepped in again with support for large-scale programs of science and mathematics course-content revision. The generally enthusiastic acceptance of these new materials for the preparation of students for further science and engineering education attests to the success of the approaches that have been used.

In these endeavors to improve the quality and supply of scientific and technical manpower, university scientists, mathematicians, and engineers assumed the leadership in conceiving and carrying out imaginative and innovative programs of reform. In cooperation with

governmental agencies, the scientific community as a whole closed ranks in mutual efforts which produced almost immediate results.

Almost unnoticed, however, some new problems were developing. The highly trained "technician"[2] had emerged as an essential member of the scientific and technical manpower "family," and 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.

The education of technicians[3] is based on science and mathematics. Technical education has unique requirements and characteristics—quite different in numerous ways from the education of scientists and engineers—and has an identity of its own.

The Congress, aware of the critical and growing need for the development and improvement of technical education, has made available large amounts of money[4] for this purpose, administered largely through the U. S. Office of Education. As a result of this and other factors, there has been a rapid increase in the number of institutions offering technical education programs, primarily junior and commu-

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[2] For the purpose of this study, *technical education* is defined as the educational programs at post secondary school level which combine the learning of complex skills with sufficient scientific and technological theory to prepare the *technician* to provide close support to the scientist and to the engineer throughout the range of scientific and technological work from basic research to industrial production. The educational programs are of two or three years in duration and usually lead to the associate degree or to a certificate. The highly trained technician has a broader range of complex skills than either the skilled craftsman or the engineer. His educational program is oriented toward scientific and technological theory, but it is directed more toward application of theory than is the education of the engineer or the scientist. Technical education programs can be classified very roughly, into (1) those based upon the physical sciences and engineering, (2) those based upon the biological sciences, and (3) those based upon both the physical and biological sciences. The present study was directed toward the first category—technical education programs based upon the physical sciences and engineering. Since most technical education of this type takes place in junior and community colleges and public technical institutes, and this trend is expected to continue, the major focus of the study has been on these institutions. It is recognized that an important contribution to technical education also is being made by private technical institutes and proprietary technical schools, university extension centers, and other types of educational institutions.

[3] In the remainder of this report, unless specified, the terms "technician" and "technical education" will refer only to the physical science and engineering related technologies. The conditions and problems in technical education related to the biological sciences are sufficiently different to call for separate treatment.

[4] Notably, through the Vocational Education Amendments of 1968, an outgrowth of the Smith-Hughes Act of 1917, the George Barden Act of 1946, and the Vocational Education Act of 1963.

nity colleges and technical institutes. There has also been a large increase in the number of technical students, although, according to both governmental and private estimates, the number of technical graduates in the years to come will be far short of the need.

Two basic issues call for immediate and concentrated attention:

1. How can the number of qualified technical students and graduates be increased enough to meet the demand for technicians?
2. How can we be certain that the education and training of these technicians is of high quality and relevant to their needs?

Cognizant of the urgency of these problems, the AAAS Commission on Science Education decided that it was time for an examination of the status of science in technical education, with the initial focus on educational programs for the physical science and engineering related technical occupations.

Staff studies revealed that the education of technicians largely has been untouched by the reforms in science education which have affected the training of scientists and engineers, and that there are serious problems in technical education that call for cooperative action by the technical education community, higher education, the scientific community, and private industry. Accordingly, the Commission convened a national conference on science in technical education, which was held in Washington, D. C. on 22-23 July 1968.

Part I. Background Information

The AAAS Conference on Science in Technical Education, with particular reference to the physical science and engineering related technologies, was organized around nine sets of problems that were grouped, somewhat arbitrarily, within three general categories, as follows:

A. The Need for Technicians
   1. The Place of Technical Education in the American Educational System
   2. Technicians in the Labor Force
   3. The Measurement of Supply and Demand

B. Institutions, Students, and Teachers
   1. Institutions
   2. Students
   3. Teachers

C. Offerings in Technical Education Programs
   1. Curricula
   2. Science and Mathematics Courses
   3. Methods

Each set of problems was considered by a discussion group which formulated a limited number of "recommended courses of action." At the final session, conference participants again reviewed the recommendations and reduced them in number to those which were considered to be of greatest urgency.

A working paper was prepared by the staff on each of the topics listed above. These papers are summarized in the following pages.

A. THE NEED FOR TECHNICIANS

1. *The Place of Technical Education in the American Educational System*

Technical education, as defined for this study, is at the college level. Junior and community colleges and technical institutes offer the ideal setting for the education and training of technicians, since a major objective is to meet local and regional technical manpower needs. Although the growth of technical education in these institutions has been rapid and is continuing to accelerate, their effectiveness has been inhibited by two factors related to status: (1) the general lack of understanding of the position of the technician in the scientific and technical work force and the nature of the education and training that he requires, and (2) a general lack of recognition that the technical training institution is at the college level.

Higher education, in general, has failed to accept technical education as a specialized part of its own structure—as it has accepted medical and engineering education, for example—and has not offered the full measure of cooperation that must exist if technical education is to be able fully to carry out its mission.

A share of the confusion about the place of technical education in the educational system arises from the fact that there still is lack of understanding by many of the distinction between manual arts, vocational education, and technical education. Each has its unique and essential role in education, but their immediate objectives and characteristics are quite different.

The scientific community is not fully aware of the function and academic requirements of technical education, nor that the assistance of scientists and engineers is urgently needed, particularly at the local level, in the development of technical curricula, the preparation of science and mathematics courses, and the initial preparation and continuing education of teachers in technical education programs.

2. *Technicians in the Labor Force*

An oversimplified definition of a technician, but one adequate for this report is that a technician is a worker whose education combines learning many of the skills of the craftsman and enough of the theory of the professional so that he can provide close support to the professional in making practical applications of new scientific and technological ideas. He may design and construct research apparatus;

he may record research or quality control data and prepare them for analysis; he may be deeply involved in the "machinery" of experimentation; he may supervise the work of skilled craftsmen; he may repair, calibrate, or adjust delicate and complex laboratory equipment; he may instruct craftsmen or junior technicians; or he may be employed in any number of other ways in which his combination of skills and theory are required.

A considerable injustice has been done to the highly trained technician in the assumption that he *always* works below the level of the scientist and engineer in *all* of the functions of scientific research, development, or application of science and technology to production. Chapman[5] makes this point in his comment that: Verbal and graphical attempts to provide a meaningful definition of engineering and physical science technicians have generally provided a basis for interpreting technology education as an apology for neither developing the theoretical knowledge of the professional nor the skills of the craftsman . . . ." In situations where the abilities of the technician are used wisely there is a great deal of interaction between him and the engineers and scientists. The technician works at neither a lower nor a higher level than someone else but within a range of capabilities for which he explicitly has been prepared.

Within the past two decades, the technician has appeared as a new man on the science-engineering-production team. He emerged, along with counterparts in other major sectors of the labor force, as "middle manpower" has expanded its function, largely as a result of the rapidly increasing complexity of work that needs to be done. Harris[6] has described the vast changes that have taken place in the labor force and the major shifts in education and training requirements since 1930, with projections to 1970 (see Fig. 1).

The magnitude of the task of technical education can be seen in the supply and demand statistics. According to the Bureau of Labor Statistics,[7] there were about 845,000 engineering and physical and biological science technicians in the labor force in 1963; between 1963 and 1975 there will be need for about 1,000,000 new technicians to fill new jobs and to replace those who have left the technician work

[5] Kenneth Chapman, Assistant Educational Secretary, American Chemical Society, in a manuscript being prepared for publication.

[6] Norman C. Harris, *Technical Education in the Junior College/New Programs for New Jobs*. American Association of Junior Colleges, Washington, D. C., 1964.

[7] U. S. Department of Labor, Bureau of Labor Statistics, *Technician Manpower: Requirements, Resources, and Training Needs*, Bulletin No. 1512, 1966.

force. In 1963, 52 percent of the technicians were in the physical science and engineering related technologies. About 90,000 technicians in all fields entered the technician work force in 1963—one-half of them upgraded by employers without having completed formal training courses.

The extent to which the associate degree programs probably will fail to meet estimated needs within the next few years has been pointed out by Brodsky[8] in a discussion of "The Need for Technicians in Fields Related to Mechanical Engineering," as follows: "Let us return to the supply-demand situation for technicians in fields related to mechanical engineering. The previous projection was a need for 303,000 new technicians of these types. We will supply about 98,000 associate degree entry technicians during the period [1963-1975], of which only 80,000 will stay to 1975. The remainder (205,000) will need to come from other formal sources and upgrading. . . ."

An indication of the rate of increase in the number of educational programs for the physical science and engineering related technologies can be seen in data from the Sixth and Seventh Editions of *American Junior Colleges,* published by the American Council on Education. In 1962-63, 271 training programs in eight selected fields were reported by junior and community colleges. By 1965-66, the number had increased to 461—a total of 190 new programs.[9] There is little doubt that the rate of increase in the establishment of new programs in these fields has continued to rise.

3. *The Measurement of Supply and Demand*

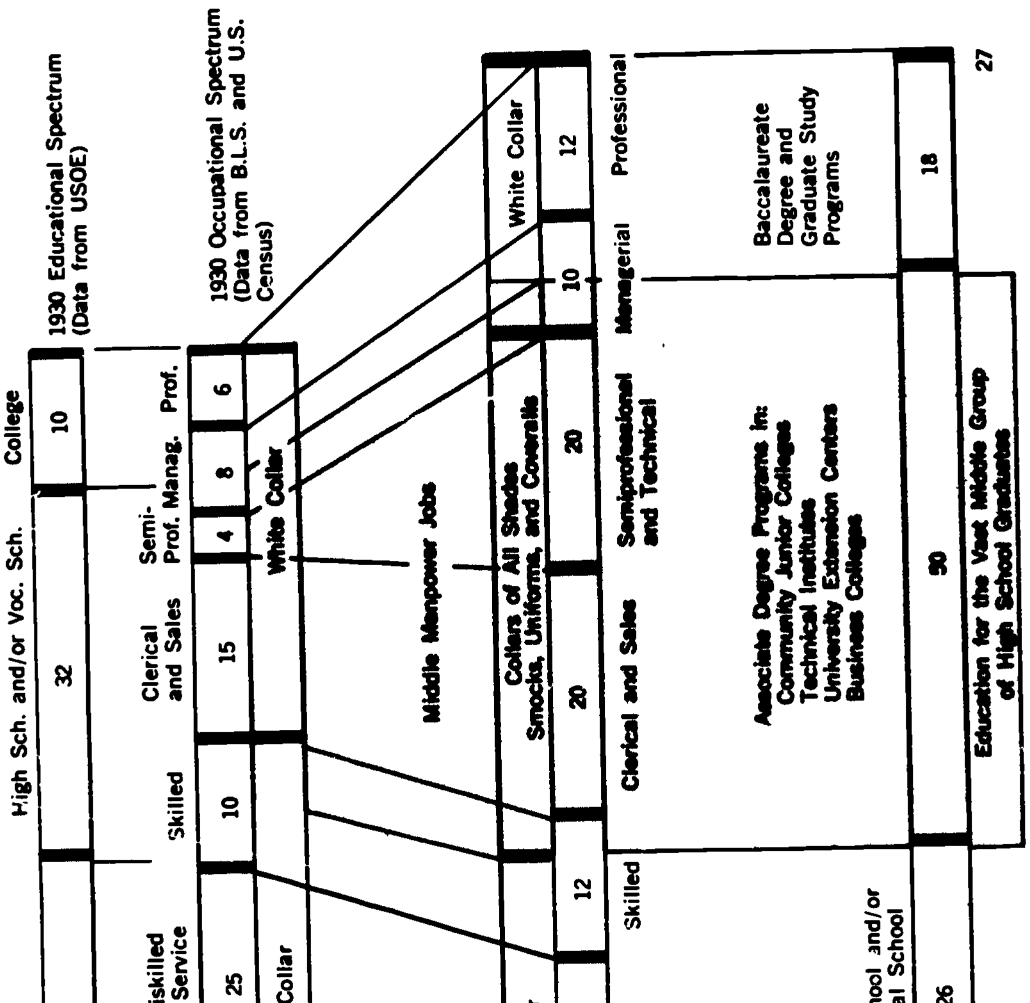
Planning for technical education at the community, state, and national levels depends heavily upon current and projected estimates of supply and demand for technicians with particular kinds of training. Such studies are extremely complex and difficult for a number of reasons, including: (1) lack of agreement on nomenclature, classification, and definition, (2) lack of stability of technical occupations—changes in existing occupations and the emergence of new ones, often cross- or multi-disciplinary, (3) lack of sufficiently refined methods

[8] Stanley M. Brodsky, Coordinator, Division of Technology, New York Community College, in *Proceedings of A Consultants Workshop on Technologies Related to Mechanical Engineering,* American Association of Junior Colleges, Washington, D. C. 1968 ($1.50).

[9] Aeronautical and aerospace, from 6 to 15; air conditioning, 20 to 30; architecture and civil, 39 to 68; chemical, 19 to 47; electrical and electronic, 93 to 143; industrial, 26 to 43; mechanical, 56 to 98; and metallurgical, 12 to 17.

FIG. 1. OCCUPATIONAL TRENDS AND EDUCATIONAL REQUIREMENTS

(U.S. Labor Force—1930 and 1970)



Source: Norman C. Harris, *Technical Education in the Junior College/New Programs for New Jobs*, The American Association of Junior Colleges, Washington, D. C., 1964.

and tools of research to make the fine distinctions that are necessary, (4) inability to foresee the probable directions of science and technology for the years ahead, (5) unanticipated major shifts in local or regional industry, and (6) lack of adequate communication and cooperation between technical education researchers and the employers of technicians.

The status of research on manpower supply and demand, especially as it relates to vocational and technical education has been analyzed by Kaufman and Brown[10] who concluded that, "Manpower analysis needs to be recognized as a tool for educational planning, and further research is necessary to improve this tool. At the same time, a forecast can seldom be more than a very sophisticated and knowledgeable guess about the future, and so should be treated only as an approximate guideline. Finally, manpower projections and analysis are concerned only with the economic effects of education; the social and other effects should also be considered."

B. Institutions, Students, and Teachers

1. *Institutions*

More than 500 institutions in the United States offer physical science and engineering related technical curricula of at least two but less than four years' duration leading to the associate degree or a certificate. Most of these institutions are junior and community colleges and technical institutes. Two basic institutional problems were discussed in the conference:

a. The providing of technical education in a community junior college broad enough to permit adequate mobility of technicians from one place to another and from one industry to another, but at the same time narrow enough to provide local employability in response to local pressures to meet local needs is a problem of major dimensions. This also has implications as far as meeting long-range national needs is concerned, especially in emerging technologies where numbers needed in individual communities are not large enough to justify establishment of training programs, but where the overall national need is significant.

[10] Jacob J. Kaufman and Anne F. Brown, "Manpower Supply and Demand," *Review of Educational Research*. American Educational Research Association, October, 1968.

b. The degree of institutional or program control or regulation is a topic of much controversy. Taken together, the various kinds of regulations—involuntary and voluntary—certainly affect both the nature and quality of technical education—hopefully for the better. Regulations and controls have caused such serious difficulties that the National Commission on Accrediting has called for cooperation and careful attention to the public interest by organizations involved in the accreditation or "approval" of institutions and technical education programs.

2. *Students*

There is a shortage of qualified, properly motivated students applying for admission to technical education programs. Many students who do apply are not qualified. Problems related to the motivation, guidance, and academic preparation of high school students otherwise qualified for technical education are complex and will require much more study. Most of these problems stem from the fact that the bridge between the high school and the technical training institution still is inadequate in many places.

Two major misunderstandings apparently are having a serious inhibiting effect on the preparation of qualified technical students. Many high school guidance counselors and teachers do not understand the nature of the talents and the educational needs of potential technical students. In general, the "abilities" of all students are measured by the "academic" scales. The technical education oriented student does not measure up well by these standards, even though, in his own way, he may be highly talented and capable. The potential technical student is oriented more toward the application of knowledge than to its acquisition or discovery, and, too frequently, there is not much in the high school curriculum to challenge his interest or to meet his academic needs.

Inadequate academic preparation of students applying for technical education programs is so serious a problem that the U.S. Office of Education [11] has recommended that technician training institutions

[11] U. S. Office of Education, *Pretechnical Post High School Programs, A Suggested Guide*, Technical Education Program Series No. 12. The following reasons for need for pretechnical post high school programs are listed: "Many students have not studied the required courses in science or mathematics because: (1) They did not know they needed them; (2) They did not realize the courses were important until it was too late to study them in high school; (3) They considered the courses unusually difficult and avoided them; (4) They didn't need them for the career objective for which they were preparing in high school; (5) The

establish "pretechnical post high school programs"—especially high school level science, mathematics, and communication arts—which applicants with academic deficiencies must successfully complete prior to full acceptance into the technical education program.

Attrition in the technical education programs is another problem of serious concern. About one-half the students who enroll fail to graduate. Research on this problem is fragmentary, and much more needs to be done.

Finally, the technical education community is aware of its double responsibility—to educate and train highly competent technicians for employment, and to serve as a force in the community to open channels of opportunity to groups of youths who, for many reasons, might not otherwise be able to develop their talents and to achieve the economic, social, and cultural levels that they are capable of attaining.

3. *Teachers*

There probably are between 15,000 and 18,000 full-time equivalent faculty members in the junior and community colleges. It is not known how many of them teach science and mathematics to technical students only, to transfer students only, or to both technical and transfer students.

There are many indications that there are serious shortages of qualified science and mathematics teachers in many technical training institutions, and, considering the rate of increase in the number of institutions, the shortage probably will grow more acute.

There is general agreement that the traditional, research-oriented graduate program which leads toward the Ph.D. degree is not the best preparation for the teaching of science and mathematics in technical education programs. There is much support for a new masters degree program that would be subject-matter oriented but that would include appropriate pedagogy and some exposure to the working environment of the technician.

The problems of teachers in technical programs are many, and include: too little opportunity for refresher training, heavy teaching loads, isolation from their peers in other higher educational institutions, lack of adequate opportunity for professional development, and problems of professional status.

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schools they attended didn't offer the courses, or offered them in a schedule which made it impossible for the students to take them."

C. Offerings in Technical Education

1. *Curricula*

What should a technical student learn in his two, or possibly three, years of formal study to prepare him for employment as a technician? How much science and mathematics should he study—and what kind? What, in terms of knowledge, skills, and judgment will his future job actually demand of him? How can this information be obtained? Since this is a program of *education* as well as *training*, how much "general education" should there be, and what subjects should be included? Should the background of science and technology be broad so that the graduate can adapt, with a little additional training, to a variety of occupational situations, or should it hew to the line in meeting the specific needs of local employers? Can there be a common "core" of science, mathematics and technical courses to serve as the basis of preparation for a number of related technical occupations? These are only a few of the problems that the curriculum-maker must study.

Many of the complexities of curriculum-making for technical education arise from the fact that the technician is not the mirror image of a scientist or engineer in any specific discipline. Increasingly, as technology becomes more complex, the technicians must have knowledge and skills related to several disciplines. The problems of curriculum construction become more complex as technicians are needed to work in cross- and multi-disciplinary fields such as "Bio-Medical Equipment Technology," or "Electro-Mechanical Engineering Technology."

2 *Courses in Science and Mathematics*

It is generally agreed that technical education curricula falling within the scope of this study should include at least one year of college-level physics (or chemistry) and at least one year of college-level mathematics. There is much disagreement on what the specific content of these courses should be, and on how they should be taught.

There is almost complete agreement that these courses should not be the "traditional" college physics, chemistry, and mathematics, oriented toward theory with limited emphasis on applications, but that they should be inclined toward the applied.

The discussion group at the conference expressed enthusiasm for the development of a physics course that would focus student atten-

tion on real physical systems in the laboratory work. Basic physical principles would be introduced as needed to understand the observed behavior of the experimental systems.

It appears to be the consensus that the mathematics and physics courses be maintained at a relatively high academic level, even if non-credit preparatory instruction needs to be given to the students, and that if there are two levels of instruction (e.g., for "engineering technology students" and "industrial technology students") the two groups do not necessarily need completely distinct courses, but different exit points.

While there are differences of opinion on this point, it is felt generally that technical students and liberal arts students should not be taught science and mathematics courses in the same classes, but that the technical students should have their own classes with content and presentation designed to meet their particular needs.

The consensus is that science and mathematics should be taught by scientists and mathematicians who maintain communication with the technology instructors and who have an understanding of the needs of technical students.

3. *Methods*

There is much evidence that technical educators, in general, see a great need for innovation and change throughout the structure of technical education. Technical education must be far more than a simple mixture of advanced shop and watered-down engineering—and it is, except that it has not as yet ventured far enough from that concept to have established fully its own identity or to have developed completely its own processes. Many believe that technical education offers the ideal laboratory for experimentation on the development of new systems for learning. A large number of efforts are being made at the present time, both by individual institutions and by consortia, to bring about at least some of the needed change, but more adequate financial support and more help from the academic and scientific community are needed to make these efforts as productive as possible.

There is much interest in cooperative work-study programs in which the technical student studies and works himself along a line to full employment as a technician. Ideally, in such a program the employer consciously is as much a part of the training program as is the academic institution, and the work is a practical part of the curriculum.

Part II. Conference Recommendations

The following re:ommendations were agreed to at the final session of the conference.

A. The Need for Technicians

1. The Place of Technical Education in the American Educational System

a. *Establishing the identity of technical education*

Greater efforts should be made to identify technical education more closely with higher education—but with the preservation of its unique mission and goals. This will help to improve the status of the institutions, teachers, students, and graduates working as technicians.

b. *Public information about technical education*

The widespread misconceptions about the goals and nature of technical education, and about the kinds and level of work that technicians perform, should be dispelled by a vigorous program of public information.

c. *Articulation*

There is need for much closer articulation of technical education with secondary education and with other sectors of higher education.

1) *Secondary education.* High school counselors and teachers should be provided with better information about the academic prerequisites and the academic level of technical education. There should be a

study of the adequacy and relevance of science and mathematics courses that are available to high school students who plan to enroll in technical education programs.

2) *Higher education.* Efforts should be made to devise and establish a more satisfactory "vertical structure" in technical education. For example, special attention should be given to the development of standards for the "2+2" programs so that graduates of post secondary school technical training programs who elect to continue to the baccalaureate degree in "technology" can do so, either immediately after graduation or after a period of employment as technicians. In this process, the basic mission of technical education—the preparation of students for employment as technicians directly after graduation—should not be interfered with.

d. *Federal and State Legislation*

Federal and state legislative bodies have enacted important legislation intended to encourage and support technical education. Rapidly changing conditions require that this legislation be kept up-to-date. Technical educators and administrators should review these laws continually and provide advice to governmental legislative agencies for the amendment of existing laws or the enactment of new ones, as needed.

2. Technicians in the Labor Force, and the Measurement of Supply and Demand

a. *Research on techniques for study of supply and demand*

There is urgent need for additional research on techniques for the study of technician supply and demand—especially with respect to the complex new technical occupations.[12] Ways should be sought to express estimates of future demand by employers in terms of both occupational titles and technical education curricula. There needs to be better communication between employers and technical educators so that more reliable supply and demand studies can be made, and so that the new technical occupations and changes in existing ones can be discerned and educational requirements determined. Sources of information other than employers should be utilized in efforts to foresee the directions of scientific and technological change

[12] This recommendation does not refer to the highly sophisticated, long-range manpower studies represented by the Bureau of Labor Statistics, *Technician Manpower: Requirements, Resources, and Training Needs*, Bulletin No. 1512.

that will affect technical education. These steps are necessary if technical education program planning is to be realistic in accommodating to the needs of the future.

B. Institutions, Students, and Teachers

1. Institutions

a. Study of regulation and control of technical education

Continuing study should be made of the various kinds of regulatory influences—public and private, voluntary and involuntary—that affect technical education. This is necessary in order to make more evident the ways in which the best interests of technical education can be served through cooperation by agencies and organizations that have regulatory responsibilities and functions. The work of the National Commission on Accrediting is cited as an example of a productive cooperative effort in this direction.

2. Students

a. Studies of high school student motivation

Extensive studies should be made of the factors that affect high school student motivation and the choice, or rejection, of technical education programs. These studies should cover a wide range, including the effectiveness of guidance—in school and outside of school—adequacy of high school science and mathematics courses in preparing capable and properly motivated students for technical education programs, the image of technical education in the view of students, teachers, parents, and peers, and other factors that tend to inhibit the choice of technical careers, and the academic preparation for technical education.

b. Studies of student retention in technical education programs

In view of the high rate of attrition in technical education programs, there is urgent need for studies to determine why a large percentage of technical students fail to complete their technical education. These studies, including follow-up of graduates who are employed (and not employed) as technicians, should do much to help the technical training institutions to identify and solve problems of selection of students, pretechnical training, curriculum design, and course-content and subject-matter presentation.

3. Teachers

a. *Continuing education for teachers in technical education programs*

Steps should be taken by government, industry, and higher education to provide vastly increased opportunities for teachers in technical programs—including science and mathematics teachers—to keep up-to-date in their fields and to maintain awareness of changes in the knowledge and skills required in technical occupations. Frequent refresher training for teachers is essential if curricula and courses are to keep pace with the rapid changes in science and technology and their applications. Technical education administrators should recognize the importance of refresher training and should make every effort to provide the necessary time for such activity in a way that will not involve personal or financial sacrifice on the part of the teachers.

b. *Initial preparation of teachers for technical education programs*

It is generally agreed that the traditional programs for the training of teachers, scientists, and engineers do not provide ideal preparation for teaching in technical education programs, including the teaching of science and mathematics. There is urgent need for experimentation with new kinds of preservice teacher education programs, designed expressly to meet the unique requirements of technical education.

C. Offerings in Technical Education Programs

1. Curricula

a. *The need to keep technical curricula up-to-date*

Technical educators and the employers of technicians should be fully aware of the rapidity of change in technical occupations and their corresponding educational requirements. Technical education curricula should be under continuous cooperative study by institutions and employers, and, to the extent possible, the need for change should be anticipated rather than accommodated. The scientific community can make important contributions by helping to foresee the directions of change in science and technology that will affect technical education, and by helping to plan educational programs that will take account of these trends.

b. *Study of cooperative technical education programs*

A special study should be made of cooperative technical education programs that combine formal study with work experience. Information about the most successful practices should be disseminated widely for the guidance of technical educators and employers in the hope that additional cooperative programs will be established.

c. *Analysis of successful technical curricula*

In addition to the study of cooperative programs, a study should be made of other outstanding technical education curricula to discover the reasons for their success. The results should be given wide publicity in the technical education community and among employers of technicians.

2. Science and Mathematics Courses

a. *Continuing examination of science and mathematics courses*

There should be continuing examination of the content and methods of presentation of science and mathematics courses in technical education curricula. Analysis should include their objectives (e.g., broad general applications *vs.* direct application to specific technical occupations), their relevancy in terms of the current status of science and technology, and their presentation in terms of the interests, talents, and needs of technical students.

b. *Development of supplemental instructional materials*

Textbooks cannot completely meet the needs of science and mathematics instruction in technical education. There should be a study of the kinds of supplemental instructional materials needed for science and mathematics to meet the specific requirements of technical education, a survey of existing materials that are available, and plans for the design and production of additional materials that are needed. The current and foreseeable needs of industry and the requirements of the technology courses in the curricula should be taken into account.

3. Methods

a. *Study of new instructional techniques*

A study should be made of new instructional techniques to discover

those that may be adaptable to technical education. Information about them should be disseminated widely.

Much experimentation already is being done by technical education institutions in efforts to improve methods and general pedagogic approaches for technical education. These projects should be encouraged in every way and information about successful ones should be made available throughout the technical education community. Additional comprehensive experimental and developmental programs are needed, particularly ones that will seek to discover basically new approaches to the patterns of technical education in general.

Part III. Conclusion

In October, the recommendations of the conference were presented to the Commission on Science Education by the Task Force. A summary of the discussion and proposals for further activities of the Commission follow.

1. *Summary of discussion*

a. The need for educating larger numbers of highly trained technicians is reaching the critical stage, and there is as much reason now for national concern about technical education as there was for concern about the education of scientists and engineers two decades ago.

b. Concern about technical education—both in quantitative and qualitative terms—already has been expressed by Congress through legislation which authorizes major financial support. This has placed a heavy responsibility on higher education in general, the scientific and technological community, the employers of technicians, and federal, state, and local governmental agencies to cooperate with technical educators to a far greater extent than in the past to help solve the critical problems of technical education.

c. An inhibiting factor in the development of technical education, especially as it is being conducted in the junior and community colleges and technical institutes, is that technical education has not had the recognition as a part of higher educatiton that it must have to fulfill its essential mission.

d. Major cooperative efforts must be made, as soon as possible, (1) to alleviate present problems in technical education as it now exists, while (2) experimentation proceeds to find new

approaches that will make it possible for technical education to meet the rapidly changing and mounting demands of the future.

2. *Proposed activities of the Commission on Science Education with respect to technical education*

a. The members of the Commission agreed that the Commission should continue its involvement in technical education in order to bring the needs of technical education more forcefully to the attention of the scientific community at large, and to enlist the assistance of scientists in efforts to improve technical education.

b. It is proposed that, so far as possible, the following activities be undertaken in 1969:

1) Maintain a small professional staff to provide continuity and to coordinate programmatic activities.

2) Follow up conference recommendations not specifically mentioned below by helping in coordination of project development, promoting the exchange of information, convening of small problem-evaluating conferences, and in other appropriate ways.

3) Extend the study of the role of science in vocational and technical education to include technical education at the college level for the biological science oriented technical occupations and vocational education at the secondary school level.

4) Work with the College Commissions on the development of plans for the improvement of preservice and continuing education for teachers in technical education programs.

5) Study in greater depth the content, presentation, and relevancy of the science and mathematics components in a sample of technical education curricula in junior and community colleges and technical institutes. The objective of the study will be to obtain a clearer view of the specific problems that need to be attacked.

6) Review the adequacy and relevance to the requirements of technical education of high school science and mathematics courses that are available to high school students who plan to enroll in technical education programs. Examine the feasibility of the development and management of a program to produce new science and mathematics courses to be used either (1) as prerequisite courses in high school in preparation for technical education, or (2) as post secondary school

remedial courses for technical education applicants with inadequate science and mathematics preparation. These materials would be directed especially toward the needs of students in disadvantaged areas, but would have a broader application. The project would be carried out in cooperation with technical education institutions.

7) Examine the feasibility of developing a project for the production of an entire technical curriculum for an emerging technical field which would have a catalytic effect on other technical education developmental programs. This effort would apply new instructional approaches and new educational technology to the fullest extent possible. It would be developed on a cooperative basis with technical education institutions and employers, would be based on the work-study concept, and would be oriented toward the needs of disadvantaged students.
8) Prepare an analysis of outstanding technical education curricula, including some that combine study and work on the job, and give wide publicity to those judged suitable as models.

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Participants

MERYLE ADLER, Technician, Corning Glass Works, Corning, New York

ALFRED F. BORG, Program Director, College Science Curriculum Improvement Program, Division of Undergraduate Education in Science, National Science Foundation, Washington, D. C.

CHARLES R. BOWEN, Manager, Program Development, International Business Machines Corporation, Armonk, New York

STANLEY M. BRODSKY, Chairman, Division of Technology, New York City Community College, Brooklyn

WALTER J. BROOKING, Program Officer, Development Branch, Division of Vocational and Technical Education, U. S. Office of Education, Washington, D. C.

KENNETH CHAPMAN, Assistant Education Secretary—Two-Year Colleges, American Chemical Society, Washington, D. C.

W. LEIGHTON COLLINS, Executive Secretary, American Society for Engineering Education, Washington, D. C.

BURTON H. COLVIN, Head, Mathematics Research Laboratory, Boeing Scientific Research Laboratories, Seattle, Washington

MEREDITH P. CRAWFORD, Director, Human Resources Research Office, George Washington University, Washington, D. C.

CLEVELAND L. DENNARD, President, Washington Technical Institute, Washington, D. C.

JERRY S. DOBROVOLNY, Chairman, Department of General Engineering, University of Illinois, Urbana

LOUIS J. DUNHAM, JR., Director, Franklin Institute of Boston, Boston, Massachusetts

GEORGE W. ELLIOTT, Washington Technical Institute, Washington, D. C.

CLARENCE W. EWELL, Director, Non-Teaching Personnel, Utica Junior College, Utica, Mississippi

HALE R. FARLEY, Technician, Sandia Corporation, Albuquerque, New Mexico

DOUGLAS M. FELLOWS, Administrative Director, Ward Technical Institute, University of Hartford, Hartford, Connecticut

LEWIS R. FIBEL, Specialist on Occupational Education, American Association of Junior Colleges, Washington, D. C.

RUSSELL B. FLANDERS, Chief, Division of Manpower and Occupational Outlook, Bureau of Labor Statistics, U. S. Department of Labor, Washington, D. C.

HOWARD F. FONCANNON, Staff Secretary, Task Force on Technical Education, Commission on Science Education, American Association for the Advancement of Science, Washington, D. C.

NATHANIEL H. FRANK, Professor of Physics, Massachusetts Institute of Technology, Cambridge

LINTON E. GRINTER, Dean, Graduate School, University of Florida, Gainesville

NORMAN C. HARRIS, Professor of Technical Education, Center for the Study of Higher Education, University of Michigan, Ann Arbor.

KENNETH B. HOYT, Professor of Education, University of Iowa, Iowa City

ECKHART A. JACOBSEN, Department of Industry and Technology, Northern Illinois University. DeKalb

WILLIAM A. JARACZ, Planning Officer, Education, National Science Foundation, Washington, D. C.

WILLIAM T. KABISCH, Assistant Executive Officer, American Association for the Advancement of Science, Washington, D. C.

WILLIAM C. KELLY, Director, Office of Scientific Personnel, National Research Council, Washington, D. C.

KEITH R. KELSON, Deputy Associate Director, Education, National Science Foundation, Washington, D. C.

FRANK R. KILLE, Special Assistant to the Commissioner for Science and Technology, State Department of Education, Albany, New York

THEODORE A. KOSCHLER, Vice President, Miami Dade Junior College, Miami, Florida

ROBERT D. LARSSON, Dean of Instruction, Mohawk Valley Junior College, Utica, New York

J. P. LISACK, Director, Office of Manpower Studies, School of Technology, Purdue University, Lafayette, Indiana

ARTHUR H. LIVERMORE, Deputy Director of Education, American Association for the Advancement of Science, Washington, D. C.

ROBERT B. LIVINGSTON, Department of Neurosciences, University of California San Diego, La Jolla (*Chairman* of the AAAS Commission on Science Education)

JOHN R. MAYOR, Director of Education, American Association for the Advancement of Science, Washington, D. C.

GORDON MCCLOSKEY, Director, Vocational-Technical Educational Research and Development Program, Washington State University, Pullman

C. E. MCNEIL, Consultant, Director of Education, International Business Machines Corporation, Armonk, New York

JOSEPH MIGLIACCIO, Technician, Ideal Corporation, Brooklyn, New York

WILLIAM T. MOONEY, JR., Chemistry Faculty, El Camino College, Torrance, California

LYLE W. PHILLIPS, Director, Division of Undergraduate Education in Science, National Science Foundation, Washington, D. C.

STANLEY W. PUDDIFORD, Community Relations Manager, Michigan Bell Telephone Company, Detroit

MAURICE W. RONEY, Director, School of Industrial Engineering, Oklahoma State University, Stillwater

NEAL H. ROSENTHAL, Chief, Branch of Occupational Outlook and Specialized Personnel, Division of Manpower and Occupational Outlook, Bureau of Labor Statistics, U. S. Department of Labor, Washington

VINCENT J. SCHAEFER, Director, Atmospheric Sciences Research Center, State University of New York, Albany

JULIUS SPIRO, Senior Electrical Engineer, Accelerator Department, Brookhaven National Laboratory, Upton, L.I., New York

ARNOLD A. STRASSENBURG, Professor of Physics, State University of New York at Stony Brook

WAYNE TAYLOR, Science and Mathematics Teaching Center, Michigan State University, East Lansing

WILLIAM TORPEY, Education and Manpower Specialist, Office of Emergency Planning, Executive Office of the President, Washington, D. C.

M. H. TRYTTEN, National Manpower Policy Task Force, Washington, D. C.

RICHARD J. UNGRODT, Vice President for Academic Affairs, Milwaukee School of Engineering, Milwaukee, Wisconsin

CHARLES O. WHITEHEAD, Director, State Technical Institute at Memphis, Memphis, Tennessee

CHARLES A. WHITMER, Deputy Division Director, Pre-College Education in Science, National Science Foundation, Washington, D. C.

DAEL WOLFLE, Executive Officer, American Association for the Advancement of Science, Washington, D. C.

AAAS Commission on Science Education

Robert B. Livingston, M.D., University of California San Diego, La Jolla, *Chairman*
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Addison E. Lee, University of Texas, Austin
John A. Moore, Columbia University, New York, New York
Wendell H. Pierce, Education Commission of the States, Denver, Colorado
Elizabeth Ann Quinn, Saxe Junior High School, New Canaan, Connecticut
Leonard M. Rieser, Dartmouth College, Hanover, New Hampshire
William W. Rubey, University of California, Los Angeles
Vincent J. Schaefer, Atmospheric Sciences Research Center, State University of New York, Albany
Deborah P. Wolfe, Queens College, Flushing, New York

Ex officio:

Arthur H. Livermore, AAAS, 1515 Massachusetts Avenue, N. W., Washington, D. C.
John R. Mayor, AAAS, 1515 Massachusetts Avenue, N. W., Washington, D. C.
Dael Wolfle, AAAS, 1515 Massachusetts Avenue, N. W., Washington, D. C.