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This publication discusses criteria for post-secondary education of technicians as illustrated by the accumulated experience of successful programs which have had their graduates sought after by employees. Chapter headings are (1) Technicians: Who They Are and What They Do, (2) Administration of Programs to Educate Technicians, (3) Physical Facilities, (4) Faculty, (5) Student Selection and Services, and (6) The Curriculum. The objective of such programs is to provide a broadly based competency in a field of applied sciences of sufficient depth that the graduate may be employed in one of a cluster of related work opportunities. They have no predetermined implications for transferability to a baccalaureate or professional programs, but do not preclude a student's continuation toward such an objective. Courses in a technician's curriculum are usually grouped as basic science, mathematics, technical, communication, and social studies courses. Illustrative 2-year curriculums are given for electronics, metallurgy, ornamental horticulture, dental hygiene and nursing. A bibliography and list of persons who are involved in the development of the guide are included. (EM)

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CRITERIA FOR

Technician Education

A SUGGESTED GUIDE

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OE-80056

CRITERIA FOR Technician Education

A SUGGESTED GUIDE

U.S. Department of Health, Education, and Welfare

WILBUR J. COHEN, *Secretary*

Office of Education

HAROLD HOWE II, *Commissioner*

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FOREWORD

Rapid technological change has made it necessary to educate larger numbers and more kinds of skilled technicians to serve as specialized assistants to professional scientists and engineers. This has caused an explosive growth in the number and variety of programs to prepare technicians in public junior and community colleges, technical institutes, area vocational and technical schools, and divisions of 4-year colleges and universities.

Guidelines for establishing quality programs for technicians are needed by the many administrators who want to establish such programs but who are unfamiliar with them. Although this publication deals only with post high school programs, some of the material may be adapted for high school programs which lead either to technical employment or to continued study.

This suggested guide tells who technicians are and what they do and describes special problems in defining, initiating, and operating programs; the required physical and library facilities; the library itself; the faculty; student selection and services; and the curriculum. The material presented reflects the accumulated experience of successful programs and the consensus of more than one hundred technician educators, employers, school administrators, teacher educators, consultants, and other persons who have distinguished themselves in the field of technician education and who reviewed and offered useful suggestions of drafts of the manuscript. Although all the suggestions could not be incorporated, each was considered carefully in the light of the publication's intended use. It should, therefore, be recognized that the guide may not be completely endorsed by any one institution, agency, or person.

This publication will assist Federal, regional, State, and local technician educators and their advisory committees in initiating new high quality programs or improving existing ones. It will also assist teacher educators, program evaluators, employers of technicians, guidance counselors, and others interested in technical education. This guide was developed in the Division of Vocational and Technical Education by Walter J. Brooking, assisted by Alexander C. Ducat, technical education specialists of the Office of Education.

GRANT VENN
Associate Commissioner for
Adult, Vocational, and
Library Programs

CONTENTS

Technicians: Who They Are and What They Do

Programs to educate highly skilled technicians are increasing in number, size, and variety in response to the need for a more widely shared and greatly expanded technical competence to cope with the demands of an increasingly sophisticated technology.

The education of technicians was not until recently recognized as so essential as to require the involvement of a large number of educational institutions. A small number of public and private schools had been providing excellent education for various kinds of technicians for many years. Because the number of schools had been small, the special nature of technician education programs is not generally known to many persons who are now required to consider initiating them.

This publication discusses criteria for the education of technicians as illustrated by the accumulated experience of successful programs. "Successful" in this context means that employers compete vigorously for graduates of the programs and that the competencies and capabilities of these graduates constitute the norm which graduates of other programs must approach to become employed and grow to greater responsibilities and rewards as technicians.

There are many kinds of technicians, just as there are many kinds of professional scientists. They are usually educated in rigorous 2-year post secondary programs designed to provide them with the knowledge, skills, and attitudes necessary for them to perform in a specific field of applied science. Many are employed in the physical sciences and related engineering fields as chemical, metallurgical, mechanical design or production, civil, electrical and electronics, or architectural technicians. Others are employed in the applied biological sciences—particularly in the medical field and in the broad spectrums of agricultural research, processing, and utilization. They may be medical laboratory, dental hygiene, dental laboratory, radiological, horticultural, food processing, oceanographic, crop and livestock production, soil science, or forestry technicians. Some combine biological and physical science disciplines; examples of these workers are water and sanitation, pharmaceutical, or special clinical or hospital and equipment technicians.

Technicians are becoming an increasingly essential part of the scientific and management team for research, development, production, and provision of special services in all fields of applied science. The team is comprised of professional scientists, specially trained technicians, and skilled production, laboratory, or service workers. The ratio of technicians to professional physical scientists or engineers at present is usually less than one to one, but the trend seems to be toward two or more for each engineer or physical scientist.

The increase in services in the health field requires from 6 to 10 clinical, nursing, laboratory, and similarly specialized technicians to support the professional services and research of each medical doctor, podiatrist, dentist, laboratory technologist, or other professional health practitioner.

Agricultural production, service, and research technicians are needed in increasing numbers because of the impact of technology on agricultural production and processing. Knowledge of plant and/or animal science at the technician level is becoming necessary in the management of farms and in dairy production. Agricultural technicians excel in the distributive and service areas related to agriculture because they are technically competent and knowledgeable.

The explosion of new scientific knowledge has caused changes in education so that the recently graduated scientist or engineer often has had limited laboratory experience and functions more as a theoretical, diagnostic, interpretive, creative, or administrative professional than in the past. He now must delegate much of his scientific work to other skilled members of the scientific team. Thus, a serious shortage in trained manpower capable of giving the technical laboratory or clinical service formerly performed by the engineer or medical professional has developed. The number of new technicians of all kinds needed each year is estimated to be at least 200,000, and the needs for new kinds of technicians and for upgrading or updating employed technicians of all kinds will evidently continue to increase.

The best definition of technicians and the best description of the special nature of programs to educate technicians, whether in engineering-related, medical, or health occupations or in agriculture, may be obtained from an analysis of what the technicians must know, what special abilities they must possess, and what they must be able to do.

Special Abilities Required of Technicians [1]

Technicians must have the following special abilities:

1. Proficiency in the use of the disciplined and objective scientific method of inquiry and observation and in the application of the basic principles, concepts, and laws of physics, chemistry, and/or the biological science pertinent to the individual's field of technology.
2. Facility with mathematics; ability to use algebra and usually trigonometry as tools in the development, definition, or quantification of scientific phenomena or principles according to the requirements of the technology. Some must have an understanding of, though not necessarily facility in using higher mathematics through analytical geometry, calculus, and differential equations. Some may not even need a knowledge of trigonometry; for example, associate degree nurses.
3. A thorough understanding and facility in use of the materials, processes, apparatus, procedures, equipment, methods, and techniques commonly used to perform the laboratory, field, or clinical work; and the capability to use them to provide the specialized services required in the technology.
4. An extensive knowledge of a field of specialization, with an understanding of the application of the underlying physical or biological sciences as they relate to the engineering, health, agricultural, or industrial processing or research activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to establish effective rapport with scientists, doctors, managers, researchers, or engineers, and customers, workmen, or patients, and to do detailed scientific or technical work as outlined in general procedures or instructions. It requires individual judgment, initiative, and resourcefulness in the use of techniques, procedures, handbook information, and recorded scientific data or clinical practice.
5. Communication skills that include the ability to record, analyze, interpret, and transmit facts and ideas orally, graphically, or in writing with complete objectivity; and to continuously locate and master new information pertinent to the technology. Technicians must be able to communicate easily with all persons involved in their work.

While the foregoing special abilities are essential to all technicians, certain personal characteristics are also desirable and in some measure necessary. As employees and as citizens, tech-

[1] Adapted from U.S. Office of Education, *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs* Catalog No. FS 5.280:80015, pp. 5–6. Washington: Superintendent of Documents, U.S. Government Printing Office, 1965.

nicians must have some understanding of social and economic factors, a knowledge of the organization of society in general and their employer's organization in particular, and acceptable personal attitudes based on an understanding of person-to-person relationships.

Activities Performed by Technicians [2]

Every technician must be prepared to perform some combination of the activities listed below at the level defined in the description of special abilities. He must be able to:

1. Apply knowledge of science and mathematics extensively in rendering direct technical assistance to physical and/or biological scientists, engineers, or medical personnel engaged in scientific research and experimentation.
2. Design, develop, or plan modifications of new products, procedures, techniques, services, processes, or applications *under the supervision of professional* scientific, engineering, or medical personnel in applied research, design, and development.
3. Plan, supervise, or assist in installation, and inspect complex scientific apparatus, equipment, and control systems.
4. Advise regarding the operation, maintenance, and repair of complex apparatus and equipment with extensive control systems.
5. Plan production, operations, or services as a member of the management unit responsible for efficient use of manpower, materials, money, and equipment or apparatus in mass production or routine technical or specialized personal service.
6. Advise, plan, and estimate costs as a field representative of a manufacturer or distributor of technical apparatus, equipment, services, and/or products.
7. Be responsible for the performance of tests of mechanical, hydraulic, pneumatic, electrical, or electronic components or systems in the physical sciences; and/or determine, measure, and make specialized preparations, tests, or analyses of substances in the physical, agricultural, biological, medical, or health related sciences; and prepare appropriate technical reports covering such tests.
8. Prepare or interpret engineering drawings and sketches, or write detailed scientific specifications or procedures for work related to physical and/or biological sciences.
9. Select, compile, and use technical information from such

[2] Ibid., pp. 6–8.

references as engineering standards; handbooks; biological, agricultural, or medical and health-related procedural outlines; and technical digests or research findings.

10. Analyze and interpret information obtained from precision measuring and recording instruments and/or special procedures, determinations, and techniques, and make evaluations upon which technical decisions can be based.
11. Analyze and diagnose technical problems that involve independent decisions. Judgment requires substantive experience in the occupational field in addition to knowledge of scientific principles and technical know-how.
12. Deal with a variety of technical problems involving many factors and variables which require an understanding of several technical fields. This versatility is a characteristic that relates to breadth of applied scientific and technical understanding, the antithesis of narrow specialization.

Some of the foregoing activities are broadly inclusive, while others describe specific functions. They neither exclude nor include functions or activities that might be considered the special prerogatives of recognized professional or skilled worker groups. The technician must comprehend the work of the professional scientists or engineers and the skilled workers in his technical field since he usually works with either or both in performing his duties. Few if any technicians perform all 12 activities listed, but the work of all technicians requires some combination of them.

The five special abilities described in the previous section provide a framework which defines the level of competence being exercised when a technician performs whatever combination of the 12 activities constituting his work. The definition of any particular type of technician, and the program required to educate him, may be described in terms of *what he does* (which of the 12 activities he performs) within the context of the quality or level of ability prescribed. *The combination of abilities and activities are criteria for defining both the type of technician and the education program required to prepare him* for beginning employment in his technical field. When these criteria are used for such definitions, no single activity criterion can be considered definitive unless the level of competence required is within the framework established by the five ability requirements.

When using these criteria to make occupational analyses, one should recognize that job titles associated with technical work are often misleading and will have little or no significance in selecting occupations to which these criteria are to be applied. The name "technician" has been widely and popularly used in occupational titles or work classifications; usually imprecisely, but generally to imply some degree of technological involvement. The criteria are designed to identify occupational requirements which can be translated into educational programs for technicians.

Some definitions of technicians have attained some degree of common acceptance; such as, for example, that of the technicians who work in engineering-related occupations,[3] but even they require further description before they identify the elements needed in an educational program or a clear statement of the capability of a particular technician. The characteristics of some specialized occupations, such as 2-year associate degree nurses, meet all of the criteria to justify the term technician, but they are not popularly known as such.

A particular kind of technician can be defined by describing what special abilities he must have in the context of what he must be able to do. This definition in turn defines the elements of the program required to prepare him to enter his occupation. Therefore an analysis of the special abilities required, and the activities any particular kind of technician must be capable of performing in context with those special abilities, must precede the design of a program to educate him.

Identification of a Technology

A field of technology for which technicians may be educated is characterized by the following:

1. The existence of specialized professionals in the field and commonly recognized clusters or groups of related employment opportunities for both the professionals and the technicians.
2. National scientific or technical societies or associations, having a total membership of several thousand professionals and other leading practitioners, whose programs and publications promote a substantive development and reporting of the progress and specialized aspects of their particular branch of applied science. The specialty is sufficiently different from other branches of applied science to justify such organizations or associations because a significant body of specialized knowledge is required by a large number of specialists.
3. Scientific knowledge applicable in the specialized field which is well enough developed and sufficiently needed by the present and foreseeable social environment to require a division of the work that must be done to provide the research, development,

[3] American Society for Engineering Education. *Characteristics of Excellence in Engineering Technology Education.* Washington: The Society, 1962.

and products, or services in the field. The professionals lead in formulating theory and practice, and technicians, with the aid of skilled workers, assist them by making tests, products, equipment, apparatus, procedural or material prototypes and by providing special services and assistance to perform the necessary work of the field.

4. A requirement of usually 2 years and less than 4 years of rigorous, college-level study, or its equivalent, to learn the basic physical and/or biological science; the supporting mathematics; and the special techniques, processes, apparatus, related technical and interpersonal skills, services, and competencies in order to be employed as a beginning technician.
5. A body of specialized knowledge which requires a technician preparatory curriculum to be *a sequence of related courses.* Beginning with courses in basic applied science and mathematics underlying the field, and with at least one elementary course to teach the apparatus, techniques, procedures, and processes of the specialty, each succeeding course must contribute to the depth of understanding and the student's skills and competencies in the specialty. Such a curriculum must provide the variety and depth of preparation the beginning technician must have to cope with inevitable changes that will occur in his special field.

Unless a field of applied science is broad enough and at the same time sufficiently specialized to meet the foregoing criteria, it is probably too narrow to identify it as a field requiring specially trained technicians. The emergence of an identifiable cadre of professional specialists in a developing field of applied science is the first indication of the emergence of a new field of technology.

Kinds of Technicians

Various descriptive names are given to the different kinds of programs for technicians, but almost all may be placed within the following general classifications:

Physical Science and Related Engineering Technologies

- Aeronautical and Aerospace
- Architectural and Building Construction
- Civil (highway and structural)
- Chemical
- Electrical and/or Electronic
- Electro-Mechanical
- Fire Protection

Instrumentation
Mechanical, Design or Production (including heating, air conditioning and refrigeration, plastics, and welding)
Metallurgical (including ceramic)
Mining (including earth sciences)
Nuclear
Oceanographic (physical)
Printing (including photography and graphic arts)
Radiological (physical)
Other

Biological Science Technologies
Health and Related Technologies
Dental Hygiene
Dental Laboratory
Occupational and Rehabilitation Therapy
Physical Therapy
Medical Laboratory
Nursing (2-year associate degree)
Radiological (including X-ray)
Other
Agricultural and Related Technologies
Livestock Production (cattle, sheep, swine, horses)
Dairy Production
Poultry
Other specialized animal sciences
Diversified Farm Production
Farm Crop Production (field crops, forage, and vineyards, intensive vegetable culture)
Ornamental Horticulture (nursery, floriculture, turf management, arboriculture, landscape development)
Other specialized plant sciences
Grain, Feed, Seed, and Farm Supply Services
Forestry
Conservation, Recreation, and Wildlife
Soil Science, Reclamation, and Conservation
Other

Combined Physical and Biological Science Technologies
Agricultural Equipment (farm machines and mechanization systems)
Dairy Product Processing
Food Processing (canning, drying, freezing, freeze drying, etc.)

Bio-Medical Mechanisms
Oceanographic (fishing, aquiculture, mariculture, and other biological specialties)
Sanitation and Environmental Control (water and waste-water, solid waste, atmosphere)
Scientific Data Processing
Other

Programs Associated with Technician Education

While this publication considers the post high school preparatory education of technicians, it is important to recognize that there is a whole spectrum of specialized non baccalaureate post high school occupations which support and assist professional management, and the technician is only one of these. The occupational equivalent of the technician is required in the financial and administrative management sector of business, in the marketing, transportation, and servicing of the products of industry, in law enforcement, and in many other fields led by professional specialists. The education of these specialized management-supporting personnel is also a task of post high school educational institutions. Programs for educating such occupational specialists may be and often are offered in institutions which also educate technicians.

In addition, many institutions which provide programs to educate technicians may develop substantial evening or part-time programs to update or upgrade the skills and knowledge of employed adults or to teach them entirely new ones. The faculty, laboratories, libraries, and occupational education environment associated with high quality technician education programs are peculiarly suited to such employee upgrading programs. The need for such programs will increase because of technological changes. Even today's graduate technician will find tomorrow that he needs to update his skills if he is to remain employed or grow in his occupation. Many employed people find that they need more basic mathematics and science or more specialized laboratory training. Knowledge in these fields can best be obtained in an organized school program.

Many schools enroll a larger number of employed adults in special courses than they do full-time students in preparatory technician curriculums. These part-time adult occupational programs usually are administered separately from those for technicians because they serve different specific objectives and the needs of a different group of people. Since all technicians must continue to study to be successful, some such courses may be provided to meet the advanced and specialized needs of technicians for greater depth in their field or to meet the challenge of change or different kinds of responsibilities in their work. Courses in management and supervision are examples of further study often needed by employed technicians.

Administration of Programs To Educate Technicians

The quality and effectiveness of a program is the responsibility of the administration of the institution which offers it. The extent to which a program is understood and supported by administrative policy and staff is ultimately clearly reflected in the vigor and success of the program.

The objective of programs for educating technicians is to provide a broadly based competency in a field of applied science of sufficient depth that the graduate technician may be employed in one of a cluster of related work opportunities in his field. Upon employment, a brief period of orientation to his particular duties in the employer's organization, together with continued on-the-job study, permits him to advance to higher levels of productivity and increased responsibility.

The criteria of required special abilities and the activities which must be performed at the level of these special abilities as discussed in the previous chapter clearly require that the formal preparatory education of technicians be of college level and intensity, providing the special knowledge, skills, competencies, and experience needed for beginning employment, within a period of about 2 years and usually less than 4 years. *College level,* in this use of the term, describes the maturity, preparation, and attitude of the students; the quality, relationship, facilities, and environment for teaching; and the rigor, expected achievement, and nature of the educational objective. The programs have no predetermined implications for transferability to baccalaureate or professional programs, but do not preclude a student's continuation toward such objectives.

Programs to educate technicians should clearly be described as college education in terms readily recognizable by students, school, staff, parents, employers, legislators, other educational institutions, and the public-at-large. They should be described *as a curriculum* and in terms of 16- to 18-week semester or trimester hours, or in 12-week quarter hours. One *semester or quarter hour* is normally allowed for (1) each 50-minute hour in class lecture or recitation and 2 hours of related outside study per week, or (2) 3 hours of laboratory work not requiring outside study to complete the exercise per week, or (3) 2 hours of laboratory work and 1 hour of outside work per week, or (4) any equivalent combination of (1), (2), or (3).

The objective and duration of the program must be clearly stated, and the *sequence of courses must start at a requisite level,* beginning with the fundamentals and basic terminology, principles, and laboratory practice upon which successive coordinated courses build specialized knowledge, experience, and skills *leading to a formal certification of accomplishment.* More and more technician education programs terminate with the award of 2-year college Associate Degrees. *The student's progress must be recorded and available as a formal transcript of college accomplishment.*

High quality is mandatory for successful technician educating programs. They require a competent and enthusiastic teaching staff, laboratories equipped with apparatus representative of those used by the most up-to-date employers, a good library, adequate classrooms, and an administrative direction sincerely dedicated to quality occupational education.

High quality programs for educating technicians cannot be short term or transitory. If they are to prepare skilled technicians in a given field of applied science for challenging employment and growth as responsible employees, they must be seriously considered and well planned and administered programs. It usually takes a minimum of 5 years and many thousands of dollars to establish a new program, assemble the staff, equip facilities, and graduate the first two classes. When these graduates are successfully employed and confidently advertising their success to their peers and parents, the program is well started. *A poor program is by far the most expensive of all* because it costs almost as much as a good one, wastes the time and effort of students and school staff, and, worst of all, disappoints potential employers, and disillusions students and their parents.

The administration of programs to educate technicians requires consideration of the several major factors characteristic of college level education. However, because of the specialized nature of technician preparatory programs, the conditions peculiar to them will be considered in separate chapters on facilities, faculty, student selection and services, and curriculum. The rest of this chapter will deal with the administrative policy and practice necessary to provide excellent programs to educate technicians, the relation of those programs to others in the institutions, and the special administrative involvements in the justification for and initiation of programs for technicians in the various kinds of institutions which can offer them.

Administrative Definition of a Technical Program Objective

Each separate technician educating program should clearly be defined *and published* as an officially stated objective of the institution. This is the first responsibility of the administration because it becomes the basis for evaluation of all factors relating to the program, its implementation, operation, and success.

The description of the program should specifically state the particular type of technician being educated, and that the program is designed to prepare the student for employment as a technician in a clearly defined cluster of present and reasonably predictable future employment opportunities.

The duration of the program for the normal student should be clearly stated and adhered to in practice. Acquired competency is the objective, hence proficiency examinations passed may shorten the program for some students.

The details of the program should be clearly described as an integrated curriculum in which successive courses build upon the previous ones toward the development of the skills, knowledge, experiences, competencies, and capabilities required by the technician for employability and growth in his specialty. The administration of the curriculum should clearly demonstrate that the objective is employability, and that the student who graduates from the program has acquired the skills, competencies, and capabilities the program is designed to provide him, which give him a clear occupational advantage over persons not having completed such a program.

The program must be uncompromisingly directed toward employment objectives, and it should be clearly stated that the program is not designed for transfer to baccalaureate or professional programs. If a student changes his objective from a technician to a professional program, the school, at the request of the student, should forward the student's official transcript to the senior institution. Whatever credit may be allowed in transfer rests solely on the policy of the senior institution which receives the transcript.

Student scholastic entrance requirements must be *published* and consistently adhered to. (See chapter on student selection and services, and note the discussion of *pretechnical programs.*)

Resources Required for Technician Programs

Adequate financial capability and reasonably predictable financial stability are basic requirements for any institution which offers programs to educate technicians. Without it the required physical plant, specialized teaching staff, special laboratories and related learning facilities, library content and service, and administrative staff services cannot be provided. Major compromise in one or more of these essential elements due to financial restrictions will seriously impair the program or cause it to fail. The need to finance new laboratory equipment and library content to overcome technological obsolescence in technical programs must be recognized, and financial planning must provide the funds required to keep these essential learning tools up-to-date.

It is not uncommon for the special laboratories required in teaching technicians to cost more than those for baccalaureate programs in the same general discipline. This is because technician teaching laboratories need facilities for providing experience, equipment, and apparatus of the kinds currently used in up-to-date places of employment.

Physical facilities must be suitable and adequate to meet the technician program objective. If the plant is not owned by the institution, arrangement for a long-term occupancy or plans to build and move into new facilities should be made to insure the stability of the institution.

It is particularly important that the special facilities required for the technician program be provided in sufficient quantity to permit every student technician to acquire the necessary experience, skills, and competencies. (See the chapter Physical Facilities for further discussion).

Library facilities must be provided specifically to support each technician education program. The library must contain current and pertinent books, periodicals, and trade journals relating to each technician field and must be staffed to provide the necessary library services.

The *teaching faculty, library staff, and administrative personnel* are obviously indispensable resources for technician programs and will be discussed in sections and chapters which follow.

Institutional Organization for Technical Programs

Technician programs are offered in several types of schools, both public and private. *Technical institutes* or *technical colleges* have, for many years, provided this type of specialized occupational education.

Divisions of 4-year colleges and universities provide programs for several technical objectives often including nursing, medical or dental laboratory technicians, and other health-related specialties; some engineering related; and some in the fields of agricultural research, development, and production.

Community or junior colleges are increasingly providing specialized occupational education and probably will expand their total offerings in technician education in most fields because of the rapidly increasing number of such institutions, the resulting enlarged percentage of all post high school education provided in them, and the increasing awareness of the importance of educating more technicians.

Many *area vocational and technical schools* provide programs for educating technicians, for training highly skilled workers and craftsmen (some starting at the 11th or 12th grade), and for updating and upgrading the knowledge and skills of persons who have left high school and are already employed. These schools are created to provide specialized occupational education and are rapidly becoming more numerous. More and more such schools are developing technician programs because the specialized staff, sophisticated laboratories, and total facilities for such programs provide the technical nucleus and a favorable environment for the full development of their skilled worker and adult occupational programs.

Single purpose institutions (largely private, but some public) specialize in providing technician education for a single field such as electronics, medical laboratory, or aeronautical technicians.

Whatever the type of institution, when it *adopts and publishes the objective* of providing programs for educating technicians, the criteria for organizing, administering, and evaluating the programs *must be consistent with the accumulated evidence of successful experience in accomplishing that objective if the programs are to be successful.*

Whatever the type of institution, the first essential in organizing a technician program is to clearly and specifically provide full administrative support. In institutions whose sole objective is to provide education for technicians, this administrative support is assured. However, in any institution which has *other* objectives, the technician education program or programs should be clearly defined as part of a separate technical or occupational division or department administered by a department head or dean who has a direct delegation of responsibility and authority from the main administrative head of the school. *They should never be organized subordinate to leadership which is primarily devoted to other objectives.*

The technical division or department must have an adequate capital and operating budget to support its needs. Some institutions, especially those using Federal funds, have separate budgets for the technical programs.

The relationship of the programs for technicians to the other programs in the institution should be clearly defined. Program interrelationships involving shared use of facilities, staff, faculty, and administrative services must be officially described and should be comprehended by all who are involved if the objective of each program is to be creditably attained.

The faculty for the technical or occupational department or division should be comprised of at least the teachers of the technical specialty courses and the division head. If the institution offers curriculums to educate several separate kinds of technicians, the technical or occupational division may be comprised of several departments or sections, often one for each technology or occupational objective taught, in which case at least all technical faculty should report to one overall division administrative head. Teachers of other courses in the technical curriculums also are often included as technical division faculty when the technical program provides most of their work load. This makes it easier for *all* teachers in such programs to coordinate and integrate their day-to-day teaching to meet the peculiar needs and interests of the students in each technical curriculum.

Where teachers of communications, basic science, mathematics, or social studies (such as economics, citizenship, institutions, and organizations) are in other divisions of the institution, administrative persuasion and provision should make it clear that their teaching of technicians is an essential service to the technical division and of equal importance to any other activity they perform. To be effective, they must sincerely devote their best teaching talents to providing student technicians with instruction which is closely coordinated and integrated with that of the technical division staff. If they are professionally or psychologically unable to do so, they must be considered inadequate and unqualified to support that objective of the institution.

Staff members of the technical department or division should have equal status with any others with like responsibilities in the institution, and should participate in all major institutional considerations, responsibilities, policies, benefits, involvements, and organizational recognition.

Initiation of Programs

The decision to start a program to educate any kind of technician is an important administrative responsibility of the chief administrator of the school and his controlling board. Each technician program requires a separate justification, and involves long-term staff and financial commitments which are continuing responsibilities of the institution. No program should be undertaken unless a careful study, made with advisory committee support, gives convincing evidence that the technicians are needed and that the need will continue in the foreseeable future. A program should not be started unless there is a good prospect of its being needed for several (perhaps 10) years, with the normal modifications made to meet technological change.

Evidence of need to initiate new programs usually is developed by surveys of the employment opportunities in the locality, area, region, or even the Nation. To conduct such a survey for each proposed new technician program is the responsibility of the school administration. The survey becomes the justification for the program and also defines details of its content.

Technicians of many kinds are in such demand that an increasing number of employers recruit nationally to meet their needs. Studies and surveys to determine the need for a particular technician program must usually involve agencies other than the school. Conferences with employers, the Department of Labor, the State board for vocational and technical education, and other interested State or regional agencies yield important data on the capability of existing programs to meet the needs and help to describe local, State, regional, and national requirements for the technicians.

To explore existing programs during the survey is probably the least expensive and most rewarding approach to the study of a proposed new program, and most institutions with successful programs welcome visits by the administrators and staff members who have similar programs or are starting them. Administrators can profit from the experience of others when considering whether to start a program. Much can be learned about curriculum, cost, staff, facilities, student recruitment, and placement from the experience of others. Such visits provide invaluable opportunity to see laboratories or farm or clinical facilities, learn details about the program, locate consultants, learn about clinical or field experience arrangements and requirements, and study many other important and pertinent matters.

Informal advisory service and use of consultants also contribute significantly to the excellence of programs. Many experienced department heads and staff members from institutions with well established, successful programs are willing to serve for a reasonable recompense. They are especially helpful when a program is being initiated, details of facilities and equipment are being determined, and new department heads are seeking or organizing instructional materials. State directors of vocational education, regional and national representatives of the U.S. Office of Education, and associations such as the American Society of Engineering Education, American Association of Junior Colleges, and American Technical Education Association can suggest exemplary programs and sources of consultants for various kinds of technician programs.

There is some evidence that in order to justify adequate facilities and faculty an institution needs to enroll 60–100 freshman students per year in each technician program.

The elements of the curriculum will be evident from the survey analysis which provides the details of what abilities and capabilities the technicians must have, what they must be able to do, and with whom they will work.

After determining that a new program is needed and feasible for the institution, the administration's first step in initiating a program is to select and employ a qualified department head to develop the program. He (or she) should then develop the curriculum, plan and direct the development of the necessary facilities, arrange for clerical or other work experience in community facilities if needed or desirable, assist in selecting the instructors for the program, work with the library staff to provide the library materials for the program, assist in student recruitment and selection, and provide faculty and student orientation to the new program.

The head instructor should work closely with the advisory committee on all aspects of the program in order to acquaint himself with all important considerations involved and reflect them in the program, and to insure the support of all agencies represented.

If licensure or other official regulation or recognition of the technicians' work is involved, the department head and the school administrator should acquaint themselves with details of the requirements and take the necessary steps before the program starts to insure that the requirements will be met.

Use of Advisory Committees and Consultants

Almost all successful technical education programs are supported by and demonstrate the benefits of advisory committees and special consultants.

There should be a special advisory committee for each specific technology program or other specialized occupational objective. It should be made up of representatives of operating managements, employers, professional practitioners, knowledgeable civic leaders, public employment services, local employment security, scientific or technical societies and associations in the field, and other interested specialists.

The curriculum advisory committee usually is appointed by the chief administrator or the dean when the initiation of a particular technology is being considered by the institution. The advisory committee then assists in making the necessary surveys of the need for the technicians, what they should be able to bring to an employer, available student population, curriculum, faculty, laboratory facilities and equipment, and cost and financing of the program. Often they provide substantial support to school administrators in requesting appropriations, in raising public funds, and in obtaining State or Federal support for the program.

When the studies indicate that a program should be initiated, the support and assistance of the committee is invaluable, especially in planning, initiating, and providing public support for the program. When the first few classes of students graduate and seek employment, the committee assists in placing them in jobs and helps evaluate their performance. Modifications often are made in the program as a result of these evaluations.

Other especially important matters on which employers, managers, and advisory personnel can assist are in providing consultants and part-time personnel to serve on the instructional staff, and in cooperating to provide clinical, field, or cooperative employment experience in programs to educate technicians.

Committee members usually are appointed for 1 to 3 years, so that their duties will not be over burdensome and so that others who are qualified and interested may serve. Usually a committee numbers from 8 to 16, averaging about 12. Usually terms of service on a committee end for only part of the committee each year so that new as well as experienced members may serve together. Those selected to serve are always busy people, and meetings should be called only when there are problems to be solved or tasks that committee action can best accomplish. The department head of the technology usually serves as chairman, and he often recommends nominees for appointments to the committee because of his acquaintance with the employers from liaison with them.

Advisory committees serve without pay as interested citizens; they enjoy no legal status but provide invaluable assistance whether serving formally or informally. The continuous support of an advisory committee has been found to be a constant source of strength for the program and the most reliable means of keeping it up to date, of high quality, and successful.

Scientific and Technical Societies and Associations

A clear policy and practice of cooperative support and involvement in programs of scientific and technical societies and employer or trade associations is a common characteristic of successful programs to educate technicians.

Although membership in technical societies and trade associations may not be as important for school administrators as for instructors, it is urgent that both assist such organizations in various cooperative activities. For example, they can encourage local scientific and technical societies to use school classrooms, meeting halls, libraries, and professional personnel. Many benefits may grow out of these cooperative efforts because they open a two-way street for communication with the school and leaders in technical societies or trade associations. Often they are heads of local industries, laboratories, or medical institutions, and their services are invaluable on advisory committees as described above.

School administrators find help from these societies in fostering continued study and professional growth of their technical staff members. Contact with such societies frequently leads to establishment of local student chapters which help to develop both staff and students. More and more schools are providing both personal encouragement and financial assistance to induce members of their faculties to become active society participants. This assistance usually includes both membership costs and some travel allowance to attend conferences.

Evaluation

Evaluative processes must be dynamic in all activities in the program. To foster an analytical attitude of open-minded evaluation of each individual on the staff is an important administrative responsibility. The challenge to try to improve each facet of every staff member's contribution to the program can provide a strong incentive toward excellence. Administrative recognition and commendation for outstanding progress and resourceful achievement of program objectives by the staff can be an important morale builder.

Evaluations may take many forms and be made for many purposes. The stated objectives of the program or the part that is being evaluated should always be the point of reference for evaluative processes.

A systematic and organized evaluation by the entire staff should periodically be undertaken by the institution. A critical self evaluation by all of the segments which are involved in a program in an institution usually yields information which leads to constructive organizational material, or psychological readjustments which improve both the total program and the morale and confidence of all associated with it.

Physical Facilities

The physical facilities must be suitable and adequate for the technician program, and should equal the quality and standard of those for any other program offered by the institution. They should exhibit the characteristics of attractiveness, functional efficiency, and quality of environment associated with any good college program.

The head of the technical or occupational division and his staff should be responsible for recommending detailed plans on the physical facilities to the administrative head of the institution, and supervise the installation of the laboratories and equipment. When plans are made to build or utilize space for programs for technicians, the technical staff is responsible for the effectiveness and use of their facilities. Maximum consideration should be given to modular construction, flexible use of building spaces, and use of portable equipment to provide most economical adjustment to growth or change in the program. The use of outside consultants and visits to other schools offering programs like those planned are recommended.

Classrooms and lecture-demonstration rooms should be equipped with the necessary teaching aids and demonstration equipment.

Adequately furnished, lighted, and equipped office and study space is necessary for all staff members. For instructors who teach science or technical specialty laboratory courses, sufficiently spacious and well-equipped work and preparation areas supplied with all necessary utilities and ample and conveniently located storage are essential. Offices for teachers and other staff members should provide some degree of privacy and sufficient space for work and for conferences with students. They should be adequately furnished and provide a functional and attractive environment commensurate with the professional quality of work which must be accomplished in them.

Laboratory facilities and training provisions for the health technologies require special planning with the assistance of professional practitioners. Often cooperative use of community facilities such as hospitals must be made to provide clinical and training experience. Such clinical or field training capability is essential to such programs, but cannot take the place of science laboratories, classrooms, and technical specialty facilities equipped like doctors' or dentists' offices or other similarly realistically planned and equipped facilities.

Some programs, particularly in the agricultural field, require extensive and highly specialized laboratories such as the nursery areas and greenhouses for ornamental horticulture, the barns, feeding and milking facilities for diary production technology, the farm area for crop production or agricultural equipment technologies, or the timber management area for a forestry technology. These serve most satisfactorily when owned, but workable leasing arrangements may be feasible in some cases. In such instances the facilities must be planned to provide the necessary elements of educational experience and exercise.

Laboratories and Their Equipment

Laboratories and equipment for technician programs must meet high standards of quality since the objectives and the strength of the programs lie in providing valid laboratory experience, basic in nature, broad in variety, and intensive in practical experience. Well-equipped laboratories with sufficient facilities for each student to perform the laboratory work are required for the specialized courses. If the facilities are shared with classes of students studying other objectives, the facilities should not be compromised for either group and their use by each group should usually be scheduled separately. The training program should provide for experiences which illustrate the function and application of principles, using as wide a variety of components, devices, units, systems, procedures, practices, techniques, services, or interpersonal relationships as is practicable and consistent with the technician's special work.

Normal environmental control for most technology laboratories and classrooms is necessary, and in geographic areas where extremes of warm weather and high humidity prevail for any appreciable part of the year when the facilities are to be used, air conditioning has been found to be almost necessary. Classroom and lecture demonstration rooms near the laboratories usually are desirable.

Laboratory equipment and facilities are a major element of the cost of a technician program, and they are indispensable if the training objectives are to be met. Variety and quality of equipment and facilities are more important than quantity in equipping laboratories. Inferior equipment may not show the principles being studied or may not be sensitive enough to provide reliable or precise data or experience; it may require unreasonable amounts of time and expense to keep it repaired or adjusted to usable condition. It is recognized that the initial cost of high quality equipment is usually greater than that of low quality, but the difference in cost is justifiable because of precise results and valid experience.

Equipment for the specialized laboratories for any technical program should be selected by the technical specialists who head the program and teach it. Visits to well-equipped laboratories and consulting assistance by practitioners in the field help to provide realistic laboratories.

When specifying laboratory equipment, the need for each item should be well established. Expensive apparatus may not always be required. Many significant experiments can be performed and experiences acquired with relatively inexpensive components. They can, in many cases, make the principles more evident because they present only the essentials.

The ingenuity of the instructor(s) in adapting apparatus to teaching needs will play a major part in governing clinical or laboratory equipment which is selected and its costs. Throughout the program the emphasis should be on teaching principles which are applied in the specialized technologies, and on the students developing understanding of as well as skill in the techniques, procedures, measurements, determinations, and services that are peculiar to the technology.

Demonstrators and simulators for teaching various concepts, processes, principles, devices, and interrelations in systems are available for many specialized technical subjects. In equipping a laboratory, however, a thorough study should be made of all the simulation, demonstration, and teaching systems available *at that time*. There is an increasing number of manufacturers of such instructional equipment. The pertinence, excellence, and effectiveness of their products provide a means of placing pre-assembled equipment systems in the laboratory, usually designed specifically as a teaching unit. Such products save considerable time and effort for the instructor who otherwise would have to build or assemble these systems for his laboratory.

When demonstration or simulation equipment is used to teach specific principles, it is essential that *real apparatus*, typical of that used in employment also be used so that the student may complete his learning experience. It is not enough to demonstrate the principle clearly—the student must see and understand the principle *as applied with the standard apparatus* currently used in the technology, and he must learn how to use the apparatus.

Surplus equipment from either private or public organizations can be a good source of equipment for technical laboratories. Government surplus property may often be an attractive source of equipments of many varieties at a small fraction of their cost new. Educational institutions, both public and private, are high on the priority list of agencies to which government surplus property is made available.[1]

It is important to exercise the same elements of judgment and care in acquiring surplus equipment as in buying new equipment. Specific plans and justification should clearly be established for each piece of surplus equipment and a careful analysis made of its total effectiveness in the program; its cost, including transportation, space required, installation, repair or tune-up, and maintenance; and its pertinence in terms of obsolescence and educational adequacy.

Only technically competent, responsible, imaginative, and experienced staff persons should select surplus equipment, and then only after a thorough on-site inspection. This practice avoids the temptation or tendency to acquire attractive but obsolete, irrelevant, bulky, or excessive amounts of equipment.

However, granted the foregoing approach, the resourceful department head or instructor can often obtain quantities of components and materials (often by disassembling units of systems), meters, instruments, apparatus and other essential units of equipment for technical laboratories at a very reasonable cost.

Equipping adequate laboratories for teaching technicians is expensive, but a program should almost never be started unless the major buildings, land, greenhouses, student work stations, and major equipment can be provided. It is most desirable to start a program in fully equipped laboratories, but, if necessary, it is feasible to build laboratories, install work stations, provide the *minimum required laboratory equipment*, and then begin the teaching program. This allows the program to be started with a minimum outlay of funds and permits the cost of additional equipment required for a well-equipped facility to be spread over a period of time. Budgeting for equipment and facilities should provide for the *entire* minimum requirement within the first 2 years of the program. At the end of the second year the program is considered established, and it is usually very difficult to raise additional funds to equip it. It is essential that equipment be

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1 U.S. Department of Health, Education, and Welfare. Office of Field Administration. Division of Surplus Property Utilization:

Directory: Directors of State Agencies for Surplus Property an' Regional Representatives Division of Surplus Property Utilization, Department of Hea .h, Education, and Welfare (current edition).

How To Acquire Federal Surplus Personal Property fc Health, Education and Civil Defense Purposes and Federal Surplus Real Property for Health and Educational Purposes (1965).

Surplus Materials and Science Education (1964).

Washington: Superintendent of Documents, U.S. Government Printing Office.

available *at the time it is needed* to give all students the required laboratory experiences.

It is especially important that lecture-demonstration rooms be adequately equipped at the beginning of a new program. A variety of demonstration apparatus and audiovisual equipment should be immediately available in the rooms as needed, and overhead projectors and screens usually should be permanent equipment.

Most facilities and equipment for technician programs must be purchased. However, it is sometimes advantageous to lease or rent some kinds of apparatus or equipment. Electronic data processing equipment is often leased because rapid technological changes soon make parts of the system obsolete, and because the initial purchase of a computer system may cost several hundred thousand dollars. Various kinds of agricultural equipment may also be rented or leased for much less than purchase cost.

When any technician program gets underway and all the required equipment has been purchased, it is still necessary to provide an annual equipment and supply budget. These funds are required to replace or repair equipment, re-stock expendable items, and purchase new equipment required by technological change. Substantially more than the annual allowance may be required if new types of special equipment are needed to keep the program up to date. No program can attain its technical education objective with an obsolete laboratory.

Library Facilities and Content

A library is an essential facility for a technician program. The growth and success of technicians depend in large measure on their ability to keep abreast of the changes in their field. Employed technicians are expected to obtain information without supervision and must therefore be experienced in using a library. The best place to gain this experience is in a centralized library located on the school campus.

A central library under the direction of a professional librarian insures the acquisition and cataloging of the materials according to accepted library practice and provides the mechanics for locating reference materials by the use of systematic card catalogs and indexes. A central library also provides the mechanics for acquiring material on an inter-library loan in a controlled and orderly manner typical of the libraries students will use when they are employed.

The library is an important extension of the instructional facilities and resources for every course in every technician curriculum. The library should be strongly centralized; it should usually be in one location; and it must meet the special requirements of both the staff and the students.

How the library organizes its material is less important than *what* it contains and *how often* and *how well* the materials are used.

Library facilities for technical schools should be planned according to the principles established for school libraries.

The library should be housed in a building centrally located on the campus if possible, with sufficient space to meet the standard requirements for reading areas, seating, movement, faculty and staff study and use areas, service, process, and work areas, and for shelving and displaying the content without crowding.

It should be provided with sound-level control and lighting arrangements consistent with the purpose for which it is used. Furnishings and equipment should be functional and adequate to meet the normal needs for processing, use, storage, and display of the materials it contains. Space and arrangement should permit change and flexibility of use and expansion if possible.

The concept of a library as a *learning center* with audiovisual films, tutoring machines, records, slides, microfilm and microfiche readers, listening stations, and learning laboratory equipment is growing in acceptance and importance. Planning and financing this part of the facility should allow for growth. Study carrels and small group study rooms should be included. A faculty study and work room should be provided. Adequate work and office space is needed. The library should be as attractive aesthetically as is practicable because it will be more inviting to students and faculty if it is a pleasant place in which to work and study.

Library content must serve the objectives of each technician program offered by the institution. As a minimum requirement it must adequately provide materials containing the knowledge encompassed by all subjects in each technical curriculum and extending somewhat beyond the degree of complexity or depth encountered in classroom or teacher preparation activities. Literature dealing with highly specialized aspects of a subject may be acquired as needed, or it may be borrowed by the librarian from more comprehensive libraries.

Acquiring and maintaining the books, periodicals, magazines. newspapers, and other printed materials, plus the films and other visual aid materials which are the content of the library must be a dynamic and continuous preoccupation of the library staff and the teaching faculty. The materials must be periodically analyzed and modified to reflect the dynamics of technological change and discovery of new knowledge by adding pertinent materials of any kind which serve the needs of the programs and staff. Obsolete materials must be ruthlessly weeded out to make way for the new.

ALA Standards for Junior College Libraries are those most applicable to the libraries of 2-year post high school technical institutes and other institutions offering technician programs. They include the following (selected) statements about library content:

> The collection of a junior college library, consisting of books, periodicals, pamphlets, maps, micro-publications, archival and audiovisual materials, should be selected and organized so as to promote and strengthen the teaching program in all its aspects. It should also seek to aid faculty members in their professional and scholarly growth.
>
> A two-year institution of up to 1,000 students (full-time equivalent) cannot discharge its mission without a carefully selected collection of at least 20,000 volumes, exclusive of duplicates and textbooks ....
>
> The following categories of library materials should be weeded and discarded. Obsolete materials and editions; broken files of unindexed periodicals; unnecessary duplicates; old recreational periodicals which do not have permanent value; and worn out books, pamphlets, periodicals, and audiovisual materials ....
>
> Gifts should be accepted only in case they add to the strength of the library collection ....[2]

The foregoing standards represent the consensus of junior or community college librarians and administrators including librarians from technical institutes. Their acceptance usually presents no serious problems for community colleges or on-campus divisions of 4-year colleges offering academic (transfer) programs in addition to specialized programs for educating technicians.

Technical institutes, area vocational and technical schools, off-campus university occupational and technical education centers, and other trade and technical schools which offer only specialized occupational education at the post secondary level sometimes find that the 20,000-volume standard needs to be interpreted and modified in application.

The number of *different* curriculums being supported by a library makes a difference in the required number and variety of volumes. Obviously the content of the library for a school with 500 to 600 students all with one occupational objective—electronic technology, for example—would be different from that for a school with the same total enrollment divided among five or six different technical curriculums.

Usually from 200 to 400 timely, pertinent, technical college-level books and references (often many more) are available *to*

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[2] Association of College and Research Libraries. "ALA Standards for Junior College Libraries," *College and Research Libraries*. Volume XXI. Washington: The Association, May 1960, pp. 201–202.

support the group of specialized courses peculiar to any particular technology. This number does not include periodicals, technical brochures, trade literature, pamphlets, and Government publications, the combined number of which may far exceed the number of published books available to support the technical specialties in a curriculum. At least another 1,200 to 1,500 book titles of current pertinence may be found to support the other courses in the curriculum, not counting periodicals, trade journals, or general interest reading materials. These numbers should be considered as a minimum at the beginning and should increase with the growth of the program.

Many books must be selected specifically to support or supply the special course content required for technicians. This information must usually be gathered from many sources because no extensive body of literature is written specifically for each type of technician. The science and mathematics books normally used for advanced preprofessional medical students or for baccalaureate students in engineering, agriculture, physics, biology, or chemistry usually *are not entirely suited* to all of the student technicians' needs. Books selected for advanced professional scientific education are written to emphasize basic scientific theory in depth and usually do not emphasize the applications of the theory.

Technicians obviously learn scientific theory, but their needs are best served by books which *emphasize both theory and applications of theory* in the physical or biological science and the related mathematics of their speciality.

The importance of *periodicals, trade and technical journals,* and the publications of associations of manufacturers, employers, or technical service organizations in fields related to technical specialties can hardly be overemphasized. These journals and publications contain the newest scientific and technical data available in their particular field of applied science in terms understandable to professional scientists and technicians; they are indispensable for student technicians.

The extent and nature of general or current-interest reading materials in a library which supports programs for technicians will depend on many factors. A student body largely housed on the campus might be expected to depend more on the library for general reading materials than a commuting student body.

Interpretation of what is pertinent and related to technical education programs should not be unduly narrow. The objective of these programs is to prepare the student for gainful employment as a highly skilled specialist in his field, but such preparation must also reflect recognition that the student is an individual and a citizen whose occupational preparation must predominantly, but not solely, be confined to technical knowledge and related skills.

Students of technical objectives need to be informed about current events, current political and social developments, sports and recreational news, art in its various forms as it currently affects the public and its tastes and attitudes, and information that helps to develop hobbies and other special interests. It is generally agreed that libraries in schools offering technical programs should provide not only the technical materials but also a broadly representative collection of general materials. In schools offering mostly vocational and technical subjects, the library can in some measure compensate for the necessary limitation of courses in the liberal arts. Their rigorous studies cause students to seek change and variety in general reading.

To what extent the collection should include novels, fiction or nonfiction books, and other groups of general or recreational reading materials is a matter of choice. General interest materials need not be confined solely to books and printed materials. Recordings of music for listening rooms and various forms of art can also be interesting, decorative, and instructive. In some institutions whose programs are primarily occupational or technical, the library is perhaps the most likely organization on the campus to assume responsibility for acquiring and making general interest materials available to students.

Faculty

A highly trained, experienced, technically competent, and enthusiastic staff is one of the most important factors in the success of any program to educate technicians. The faculty should be considered to include the department heads, teaching staff, coordinators, counselors, librarians, and all who assist them in the instructional processes.

To be effective, members of the faculty responsible for technical programs must have interests and capabilities which transcend their area of specialization. All of the faculty members should be well enough informed about the nature of any particular technology to teach from a point of view which focuses on the students' main interest. This permits them to use pertinent examples or subject matter when they begin the courses and to develop meaningful supporting material as they teach their courses. For example, if the communications course is to be of maximum value, the teacher should have enough general knowledge of the terminology and general activities in each technology taught in the school to allow the students to use examples or topics of special interest to them as they learn to communicate. Without such an interest and effort, the course will not provide for the maximum development that the student technician needs.

Total instructional staff coordination is necessary to provide an orderly, interrelated, relevant, timely, and interesting development of the curriculum for the students in any particular program. Science and technical specialty courses which emphasize various scientific principles should be taught when the student needs them. Instructors of physics, mathematics, and measurements, for example, should be aware of the time when students in a particular curriculum learn a concept or principle. Then the instructor of each course should exercise and reinforce the students' understanding of how the principle is applied in the students' special field.

Because the time permitted by the curriculum is limited, skill in coordinated teaching as a member of a team is required by all instructors, including language and communications, mathematics, basic science, social studies, and technical specialty teachers. All must be able to coordinate their teaching with all others to correspond to the objectives and state of subject development at any particular time for their student technicians. How instructors learn to coordinate their instruction as a team has important implications for the organization of the faculty and for early in service training for new staff members.

Qualifications of Instructional Staff

Faculty qualifications may be considered in these broad areas: educational, experience, and personal or attitudinal.

The *educational qualifications* of faculty members require that they have a mastery of their subject which is greater than the subject content they will teach to their students. The depth and breadth of understanding of and competence in the subject gives the teachers the comprehension they need to teach its various concepts, principles, techniques, and aspects with the complete confidence which comes from knowing the subject.

The educational preparation of the instructors of the technical specialty courses must include a comprehensive understanding of the scientific principles and phenomena underlying each aspect of each subject. They must have the knowledge and capability to use all of the appropriate apparatus, materials, equipment, procedures, techniques, measurements, and determinations, and to perform the required special services with the confident skill and adequacy required of the skilled technician. They must also be proficient in and be able to teach the interpersonal relationships and their required skills in their special field.

Usually the instructional staff acquire their subject specialty preparation in professional schools such as engineering, medical or other professional health occupation schools, bachelor-degree nursing schools, professional agricultural schools, library schools, professional schools for teachers of physics, botany, zoology, physiology, mathematics, language, and social studies. The attainment of professional or equivalent preparation in the subject specialty is required, whether by conventional educational preparation or by its valid equivalent.

Recent experience has shown that graduates of high quality technician education programs who have acquired suitable employment experience and who have continued their technical education to professional level (baccalaureate or beyond) often become excellent teachers in programs for technicians. Persons with this background are more likely to understand the objectives and unique instructional requirements of technical education. Furthermore, individuals with this particular background often bring to the program enthusiasm and an appreciation of the values and characteristics of technical education that are essential to the success of the program. This source of technical specialty teachers may become increasingly important because of the trend toward more and more theory and less and less laboratory experience in most of the programs for educating the professional physical scientist and engineers and applied biological scientists. The increased emphasis on theory usually does not prepare the recently graduated professional to be either educationally or psychologically capable of teaching technicians because he has not learned and practiced the skills, procedural competencies, and special techniques or services required of technicians.

The instructional staff should consistently exhibit an understanding of and positive sympathy with the philosophy and objectives of technical education. Usually, this preparation is obtained in formal courses in vocational and technical education and pedagogy, and by teaching in technician programs. However, teachers whose preparation is comprised of large amounts of study of professional education and who have not acquired competency in their subject specialty in depth are not qualified, even though their academic credentials may be impressive.

The library staff is an integral part of the teaching staff. Many of the most successful have a science and technical background and a professional library science education. Some formal preparation in the teaching field is a great advantage to them because service to the teaching staff and to the students is the main function of the library; thus, the teaching function should be understood and practiced by the library staff.

The *employment or experience qualifications* are important for all of the teaching staff, and for instructors of technical specialty courses there are special requirements. Employment experience recent enough to be valid and representative of current practice, either as a professional or a technician, involving extensive practice of the skills and competencies they will teach, is almost mandatory. The duration of the employment experience should be sufficient for the teachers to have developed the skills and related interpretive judgments and mature capabilities expected of the technicians in a particular field; from 3 to 5 years is the usual duration of such experience. The majority of professional scientists and the other members of the teaching staff should have had professional experience in their field of specialization. For them to have been employed in some capacity besides formal teaching is usually an advantage because it broadens their understanding of the world of work and makes them better teachers.

Experience in a technical library as a reference librarian is excellent experience for any of the library staff because it involves assisting the users of the library in matters involving scientific and technical materials.

The most important *personal or attitudinal qualification* required of instructional staff members is, of course, their teaching ability. They must want to teach students to be highly competent technicians and be challenged by and enthusiastic in their work.

Research to discover new knowledge is not usually the duty nor desire of teachers in technician programs, but constant study in their special field is required. Some department heads and instructors do professional consulting work; the study required for consulting work usually helps broaden their competence in the field and keeps their experience current. Continuous study of new methods and development of new materials for teaching current or new developments in the field of their specialty are necessary.

Qualifications of non-professional assistants with non-instructional duties vary with the duties they perform. Graduate technicians and technical assistants who assist in the laboratories and library should be graduates of good technical programs or have valid equivalent preparation. They usually should have had employment experience in their specialty or work closely related to it, and they should exhibit the same interest in and attitudes toward their duties as the professional faculty even though they are not responsible for teaching laboratory or lecture classes.

Administrative Climate for Faculty

Faculty morale, enthusiasm, and effectiveness are influenced in large measure by the attitudes shown by the school administration in selecting its members, and in the definition and consistent administration of the duties, conditions, and rewards for their employment. This administrative climate must be sufficiently attractive to encourage qualified personnel to enthusiastically become a part of the organization in pursuit of a desired career.

New faculty members should be selected by the department head or administrator in charge of the particular technical program in which they will teach, and they should be officially appointed upon recommendation of the chief administrative officer of the institution. Notices of appointment should be in writing, and they should clearly state all the conditions of employment, including the period of time for which employment is offered. Such notices when accepted in writing by the staff member, usually constitute the contract between the individual and the institution.

All staff members should have full and equivalent faculty standing. There should be one faculty standard for all professional instructional staff in the institution. This should include the library professional staff as well as instructors in each of the programs. All should be accorded the same treatment in rank and status.

The salary schedule for instructors and department heads should be related to preparation and experience, and should aid in attracting and retaining qualified staff. The basis for judging salary status is a salary schedule in context with the entire organizational and promotional system for the institution. More and more institutions are adopting a 12-month annual salary and employment structure for all professional staff members. This is found to be especially advantageous in attracting and developing teachers of the technical specialty courses. The annual salary plan is attractive when compared to other employment opportunities in institutional, private, or industrial employment. It provides the staff members with year-round employment, permits time for study and development of new programs or improvements in existing ones, and facilitates operation of summer programs.

Administrative policy concerning faculty salaries, insurance, retirement plans and policies, tenure, sabbatical and other leave, and other significant matters bearing on the employment relationship should be clearly stated in writing. Some institutions print complete faculty handbooks. Good faculty morale shows how these policies and some of the more subtle but important administrative relationships are affected by the administrative and faculty operative climate. The whole relationship must promote conditions that encourage instructors to their best teaching effort. Freedom of each instructor to make such decisions as selection of textbooks and other teaching materials and teaching methods, and to set standards for awarding credits and grades is important in this respect.

Intergroup teaching-staff relationships are important, and it is necessary for new instructional staff members to understand and be willing to support the required activities.

Teaching assignments are made on the basis of the individual member's special training and talents. All of the staff who teach all of the courses in a curriculum operate as a team. This teamwork can be developed and nourished only by the teaching faculty under the leadership of a competent department head.

Regularly scheduled *departmental staff meetings* to encourage the development of closely coordinated teaching is recommended. At these meetings each instructor should check with instructors of concurrent courses to insure that course coordination is being maintained. This is especially important when new courses or techniques are involved. If less than optimum coordination is evident, the important factors can be analyzed by those involved and a solution to the problems found quickly. The library staff should be represented so that members may plan any special library services needed to support the program of instruction.

In addition to keeping concurrent courses well coordinated, staff meetings provide for free exchange of ideas on new and useful teaching techniques and laboratory projects which seem to be particularly successful. Any new project which seems especially beneficial to students should be analyzed to see if the same principles of presentation can be employed in developing other projects. Special attention should be given to any scientific, technical, or educational journal articles that may improve teaching of a subject or present new information which should be taught.

Maximum use of audiovisual aids, techniques, and equipment must be encouraged and perfected. Films, overhead projection materials, and demonstration devices are increasingly required to develop maximum teaching efficiency. Experienced instructors make liberal use of charts, slides, models, samples, and specimens, which illustrate special technical aspects of the subject. These usually are accumulated by each instructor from work experience or laboratory or lecture preparations and should be updated regularly when new developments require it.

Relationship of Library and Instructional Staffs

The library is an extension of every classroom and laboratory. Thus the library staff functions as a part of the instructional staff for all courses, and their relationships should be clearly understood.

Instruction should be consciously library oriented. Instructors in all courses should constantly keep the students aware of the extent to which the library contains useful information which is a part of their curriculum. Planned assignments of library projects and open book examinations requiring students to use the library teach them the resources available in libraries and how they relate to their technology. Services provided should invite continued and expanded use of library resources.

It is recommended that the books for a library to support the teaching of any technology be selected with maximum participation and assistance of the instructors and department heads of the relevant technical division. The library staff should represent the bibliographical know-how necessary to maintain a balanced collection and to give the proper attention to the many materials that fall between specialties or cut across them (notably reference materials and periodicals) which are frequently overlooked or underestimated by specialists concerned with their own fields. The need for the librarian to keep track of the collection as a whole, to maintain its balance in the light of all of the objectives of the institution, and to stay within its budgetary limits is well recognized. The library staff can be especially helpful in selecting and providing the required broadly representative collection of general interest materials and in providing related materials and services.

Instructional staff should be expected to recommend the special books which support their courses. It is not reasonable to expect the library staff to be so technically competent that they can determine the relative merits of the available materials which may support each technical specialty. *Further, unless the instructional staff selects the books, they may not be in sympathy with, nor aware of, the reference books and materials in the library which they should be encouraging students to use.*

The library staff should call to the attention of instructors and department heads new publications and materials which may assist them. When a new curriculum is added or major changes are made in existing ones, the librarian and the teaching staff must select and provide library materials to meet the new needs. They should also cooperate regularly to weed out and discard obsolete materials.

Faculty Requirements and Teaching Loads

A minimum of two, and usually three full-time equivalent faculty members are required to teach the technical specialty courses in a typical technology curriculum, bearing in mind that entering classes of 25 to 40 students can be taught in lectures but may have to be divided into two sections of 12 to 20 for laboratory work. One of the full-time instructors is usually recognized as the head of the program. He must be technically competent in all phases of the technology, able to plan and equip the facilities, capable of developing and initiating the details of the curriculum, able to provide the necessary leadership in student selection and graduate placement, and qualified to develop the coordinative departmental teaching effort which will develop completeness and excellence in the program. He should work with the local advisory committee for his program, and in other ways lead the program with the support of the school administration. The department head and at least one instructor must be employed during the first year of operation of the program, and all three (and perhaps more) will be needed during the second and subsequent years.

In addition to the staff which teaches the technical specialty courses, it is obvious that provision must be made for faculty to teach the communication skills, technical reporting, mathematics, basic science, and general courses in the curriculum. Sufficient staff to teach these courses to technicians may already be in the institution, but sufficient teaching capacity must be provided in these subjects without overloading the staff.

Staff to teach and supervise clinical, medical, or other laboratory teaching or work experience in cooperative educational programs in agriculture, health, or engineering related technologies off campus must be professionally and technically competent, able to cope with the interpersonal relationships of school and clinic or employer, and able to exercise a high degree of independent judgment as teachers and representatives of the school.

The most successful technician programs are usually taught by almost exclusively full-time staffs. Considering the cost in time and money (4 or 5 years and usually hundreds of thousands of dollars) required to get a new program started and the time required to gain experience as a teacher in a closely coordinated team, it is understandable that part-time teachers cannot bring the real leadership, permanent interest, and maximum effectiveness to a program that is expected of a staff member who is an experienced full-time employee. The extensive use of part-time teachers from local institutions whose objectives are either to teach professionals (engineers, health practitioners, agricultural scientists) or to provide vocational training involving little scientific theory and mostly specialized crafts or skills, does not provide maximum quality of instruction.

To rely extensively on a common staff in a multi-objective institution for part-time teachers of mathematics, humanistic social studies, basic science, or language and communication skills for technicians often meets only with marginal success. Teachers whose primary interests and major efforts are to teach preprofessional courses or other baccalaureate curriculum components may find it too difficult to modify their courses to best serve the coordinated teaching and learning process for technicians and may not feel that it should be necessary to do so. Course content and organization for pre-professional or liberal arts, or other objectives than those specifically for technicians, is unsuited to the technicians' needs because the educational objectives are different. If teachers of such courses are used, they must direct their efforts toward the technicians' program and must serve sincerely and effectively as a part of the technician educating team if the program is to succeed. Excessive use of vocational or industrial arts teachers in technical programs always involves the risk of using teachers whose educational qualifications do not meet those necessary to teach technicians.

The teaching staff which supports a technical program should have as diverse educational and employment experience backgrounds as possible so as to provide variety of attitude, experience, and outlook to the student technicians. Employment of more than a few teachers who have been graduated by the same institution or gained work experience in the same employment patterns tends to limit the program and is to be avoided.

Teaching loads for the faculty should be defined and adhered to. When determining teaching loads for teachers of science or technical specialty courses special consideration should be given to the number of student contact hours required by their schedules. These instructors require considerably more time to develop the most effective lecture-demonstration and laboratory materials than do shop instructors or teachers of general education courses. A work load of 15, and not more than 20 contact hours per week constitutes a full teaching load for instructors in technician programs. The rest of their time should be spent in assisting students, developing courses, planning effective laboratory experiments, or improving the organization and techniques for effective lectures, demonstrations, examinations, and other classroom activities.

Attention to the individual is recognized as a vital teaching element. The maximum size of a lecture class may vary somewhat depending on the material to be covered, the lecture room, and the teaching techniques, but for blackboard teaching, 20 to 30 students are usually optimum. If little or no class discussion is attendant to the lecture, the size of the class may be significantly increased by use of overhead or other mechanical projection of carefully prepared portions of the lecture normally written on the blackboards.

Careful planning of laboratory teaching schedules is important. Laboratory sections should not be overloaded with students. Effective teaching cannot be accomplished if there are too many students per work group or if too many different experiments are being conducted simultaneously in the same laboratory. If too many students try to work on a project, most of them will not benefit from the experiment because of being unable to participate sufficiently in doing the work. In many technical specialty courses two students per laboratory setup will provide the necessary learning experience for each student, although some experiments can be effective for groups of three or even four. If too many experiments are run simultaneously, the laboratory instructor cannot be effective and the laboratory experiments cannot be closely coordinated with the theory presented in classes or lectures.

Technical curriculums are designed to produce support personnel which increase the effectiveness of engineering or other scientific teams.The principle of using supporting personnel may be employed to increase the effectiveness of the teaching staff. Mature and experienced technicians are often used as staff assistants. Staff assistants may be used in stock control to set out the required equipment for laboratory classes, to keep equipment operating properly, to fabricate training aids, to do a limited amount of routine paper grading, and for other tasks under professional staff supervision. When these important but time-consuming activities are performed by assistants, the teaching staff can devote more time to curriculum development, preparing hand-outs to supplement lecture material, and improving their instruction in other ways. Resourceful use of support personnel makes possible the use of a small but versatile staff which may be maintained as enrollment varies. By adjusting the size of the support personnel staff to the demands of enrollment, a school may, to a degree, adjust the problem of having too few instructors when the enrollment is high and too many instructors when enrollment is reduced.

Encouragement of Professional Development

Professional enthusiasm, interest, and activity of the instructional staff is an indication of their competency and also a measure of the administrative policy which guides the program. Technological change in the various technician fields is rapid and certain to continue. Teachers must keep their knowledge current of both the scientific changes and the changes in the techniques, procedures, materials, apparatus, equipment, applications, and special services in their specialties. They must also be constantly studying their teaching techniques and the innovations in teaching. All teaching staff must be encouraged and supported in a positive way by the school administration in these professional and personnel improvement activities.

Encouragement to instructional staff self-development is increasingly being provided by technical school administrators in the form of released time and financial assistance to attend professional and technical society meetings, special technical teacher training institutes, and special courses which they need for maximum effectiveness.

One of the most effective means of self-development and maintaining technical proficiency is for instructors of technical education programs to be members of scientific and technical societies and associations related to their specialties. Major engineering and other technical societies usually have local chapters or sections with programs which provide educational services.

Instructors whose areas of specialization are served by the scientific or technical society are welcomed as an integral part of the professional group. Active membership provides a natural medium for getting acquainted with the local leaders in the instructor's technological field, as well as an opportunity for interchange of ideas and interests on a professional level in an environment of equality and mutual respect.

A participating member from an educational institution can usually offer a society cooperative use of school facilities. A school staff member through his association with a society finds an open door to research laboratories, health service centers and clinics, experimental stations, engineering establishments, or manufacturing facilities in the community. This avenue of communication is a two-way street. It fosters acquaintance of school personnel with potential employers of their students, and promotes the employers' interest in the school's technician program. The mutual acquaintance leads to a better understanding of employer needs and operations, and often permits class field trips to laboratories and plants where students may observe equipment or processes too expensive for school laboratories.

Participation in the activities of a society widens the horizon of the imaginative instructor. For example, election to program committees offers peculiar advantages. It may enable him to shape the society's program in some degree and assist in the selection of guest speakers who are outstanding authorities in their technical fields. This type of activity enlarges the instructor's circle of acquaintances, improves his professional standing, provides potential sources of information, enhances his standing and effectiveness with his students, and keeps him up to date in his profession.

Another essential horizon widener is the instructor's attendance at national meetings of the technical societies serving his field. If he can go as a delegate from the local section, national committee member, speaker, or national officer so much the better. More and more institutions with technical programs pay part or all of the cost of attendance at local or national society meetings as a means of encouraging staff activity in such societies, organizations, and associations.

Instructors in institutions with programs for educating technicians may promote the establishment of a student chapter in a society serving the technology. As a result, students receive the services of the technical society through a program planned for their interests, needs, and level of technical competency. The students thus gain experience in professional activity and leadership and an early understanding of the importance and potential values of membership in scientific and technical societies. Moreover, they get the opportunity to meet the personnel of leading research, engineering, and manufacturing organizations in their technology, enlarge the understanding of their field, and gain the attention of potential employers.

Frequent visits by the teaching staff to the places where their technicians are, or will be, employed helps them to evaluate their program's laboratories, methods, services, and performance standards and helps to keep the staff aware of the technological changes in their field. Periods of work experience for the teaching staff are especially productive in bringing instructors up to date in their field. Periodic return to formal study of their basic science to renew their competencies in the fundamental principles underlying the technology is equally important.

Sabbatical leave or other grants of time should be provided for the instructional staff and particularly the teachers of the technical specialty courses. They must keep up to date in the skills and special competencies expected of technicians in their field, currently and in the future. This requires intimate contact with employer's and practitioner's current operations. Employment experience to update teachers is very desirable, but sometimes not easy to arrange. However, active membership in technical societies and abundant reliance on active advisory committees frequently provide channels for short term (3 months to 1 year) employment.

Special, intensive summer institutes or 1-year fellowship programs financially supported by the school to update the teachers' scientific or technical proficiency, or to provide special study and preparation to strengthen them for administrative or department head responsibilities are becoming an increasingly common requirement for maintaining a professionally competent staff. More and more special summer or academic year institutes, workshops, and conferences are being presented for teachers of technician programs. Many provide stipends and/or other financial assistance, and administrators are increasingly helping to finance such teacher education programs.

Research by the instructional staff (including librarians) into problems of all kinds related to instructional matters are a further means of developing professional staff and teaching excellence. Some such research may be supported by funds provided by Federal legislation for the purposes of staff development and improvement of programs nationally. Such research should be encouraged.

To serve as consultants in their fields of specialization also motivates the instructional staff to broaden their horizons, keep them up to date, retain and improve their technical competencies, and make them more interesting and effective instructors.

Student Selection and Services

Prerequisites

The importance of enrolling qualified and adequately prepared students in sufficient numbers properly to fill each beginning class of students in any technician education program cannot be overemphasized. If too few students are enrolled, the whole program will be uneconomical and lead to poor morale of both the students and the instructional staff.

Enrollment of a majority of a beginning class of students who are not prepared to start at the level required in a high quality technician program will require the teaching staff to lower the level of their course material, and thus to graduate the students without the breadth and depth of preparation required for attractive employment. This practice discredits the institution, disillusions both the graduates and the employers, and, if it is continued year after year, causes the program to fail. To enroll classes of unprepared students also wastes the best teaching capabilities of the faculty and leads to demoralization for lack of challenge and opportunity to utilize their best teaching abilities.

If a few unprepared students are permitted to enroll in a class where the majority are qualified, they will almost certainly fail because the rigor and intensity of the program at its proper level do not leave sufficient time for unprepared students to make up deficiencies and master the curriculum at the same time.

Institutions with an unusually high percentage of students who fail to graduate and obtain employment as skilled technicians or to gain an equivalent advantage in their careers must assume the responsibility for the failure. Some students will leave the program because of various personal reasons, but if an unduly large percentage is eliminated because of scholastic failure it must be interpreted as a failure in the student selection. To plead that such failures result from adherance to high standards of excellence is insufficient, and cannot repair the injustice done to students who were permitted to enter the program without adequate preparation to permit them to succeed in it. (See discussion of pretechnical programs later in this chapter.)

Usually the prerequisites include graduation from high school or its equivalent, with accreditable completion of:

Three standard secondary units of English. The student should be able to demonstrate capability in reading, writing, and oral communication.

Two standard secondary units of mathematics, including algebra and plane geometry or their equivalents. Intermediate algebra and trigonometry are desirable (and may be required) for many programs in physical science and related engineering technologies.

At least one standard secondary unit of science. Laboratory physics is considered most desirable for the physical science and related engineering technologies, with chemistry a second choice. Chemistry usually is the preferred science requisite for the biological science based technologies in health fields or in agriculture, with physics or biology considered second choice.

The foregoing prerequisites do not imply that the student may not have been given preliminary preparation in the elementary aspects and special knowledge of a particular field of technical specialization while in high school. Many students may have had such preparation, if for no better reason than to serve their special interests while in high school. It is as appropriate for high schools to provide for elementary technical preparation in electronics or agriculture as it is for them to teach basic science, mathematics, and language skills, and it should be accepted as appropriate in the high school preparation of students who want to become technicians. However, *it is not appropriate* to expect that the high school student can normally become adequately prepared in all of the technical specialties expected of an adequately prepared technician. Greater depth and variety of technical understanding and capability must be provided for in the post high school study, just as additional science, mathematics, and communications skill development must be provided for after high school.

Students who enter technical programs should have relatively similar capabilities and should exhibit some evidence of maturity and seriousness of purpose; otherwise the program may not be able to achieve its objectives. Curiosity, the ability to reason, and strong motivation are characteristics of most student technicians. The amount of material to be studied and the principles to be mastered require students who are well prepared in formal course material and have the ambition, desire, and will to master a difficult program and to develop their capabilities to the limit.

The ability levels of those who do and those who do not meet these requirements will vary greatly as will their motivation toward the program. Motivation alone is not enough to insure a student's success in a technical program. If applicants for admission do not have the necessary communication (language) skills, mathematics, or science preparation, they should be required to remove their deficiencies and to meet the requirements before being permitted to enter the technical program.

Recruitment of a sufficient number of qualified students is a major problem in many technical education programs. The academic requirements to enter high quality technical programs are practically the same as for the baccalaureate science or engineering students. The number of qualified high school graduates who want to become engineers, scientists, or technicians is not sufficient to satisfy the needs of all categories. All who aspire to the baccalaureate program should be encouraged toward that objective. It is becoming evident that the future of many technical programs, and indeed the capability to satisfy the total needs of the Nation for highly skilled technicians, may well depend upon the development of post high school programs for promising youth who have the desire but lack scholastic preparation to enter high quality technical programs.

Pretechnical Programs [1]

Many institutions which offer programs for educating technicians provide pretechnical programs up to a full year's duration to give promising but underprepared students the opportunity to enter a technical program of their choice with a good probability of successfully completing it.

High school graduates who have creditably passed all of the prerequisite courses might be considered the normal population from which students for technical programs are drawn. However, in many localities there is an even larger population of *potential* technical students which is available to enter technical programs but which, for one of several reasons, may not have all of the prerequisites. Some may have attended high schools with limited offerings; some did not take the necessary courses for technical program entry; some allowed other activities or interests to dominate their efforts at the expense of their basic science, language, or mathematical skills. The common need of all of these students is to strengthen their mathematics, science, language skills, or their basic study skills.

Experience has shown that organized programs to provide the elementary courses necessary to enter high quality technical cur-

[1] U.S. Department of Health. Education, and Welfare. Office of Education. *Pretechnical Post High School Programs, A Suggested Guide.* Catalog No. FS 5.280:80049. Washington: Superintendent of Documents, U.S. Government Printing Office, 1967.

riculums should be provided *in the institution which teaches the technical program.* Such an institution can best design these preparatory programs so they may meet the objects of their students and thus become an integral part of the students' program objective. This is why such programs should be a part of the post secondary institution and not a part of the high school where facilities, teaching capability or incentive, and understanding of specific necessary requisites to the students' technical program may not be available.

There are several advantages to the institution organizing pretechnical programs. In addition to solving recruitment problems and providing an educational opportunity to promising students, it insures attainment of high quality trainees and graduation of well-prepared technicians who will be in demand by employers. Pretechnical programs tend to reduce the first semester loss of students due to scholastic failure. This is very important. In many good technical schools, first year attrition amounts to 40 percent, and in some it is as high as 60 percent. To lose so large a percentage of a class reduces the effectiveness of the facilities; teachers have to teach smaller groups than they should, and the morale of everybody drops.

It should be emphasized that students selected to enter pretechnical programs should show promise and should be partially or moderately well prepared. These programs are not designed to provide basic education, but rather to fill the gaps or strengthen the students' preparation when they have the ability and desire to enter post high school technical education programs but lack scholastic requirements.

The acceptance of a student seeking admission to a pretechnical program must depend on whether, in the judgment of the school, based on all available information, he has at least the minimum potential for success in the preparatory program and *in the technical curriculum* of his choice.

Federal support is available for these programs from vocational education funds under the Vocational Education Act of 1963. In order to qualify for support under the Act for such programs, the institution which teaches technicians must provide an organized program of courses to provide the up-grading study in their institution as a part of the over-all plan for educating technicians.

Student Recruitment and Selection

Adequate staff and funds to perform necessary recruiting activities and related services must be provided by the administration of the institution. While the staff of each technology offered in the institution is almost always involved to some degree in the recruiting and selection of students for their programs, experience has shown that to depend on them exclusively for recruiting is not very successful. To require the teaching staff to do student recruiting without released time from other duties is almost always unsatisfactory and is to be avoided.

Recruiting involves some *publicity*, if no more than a catalog or equivalent published description of the program. Such a publication must be an official, complete, clear, and factual description of the program. It must show: (1) the procedure for applying for admission and the prerequisites for entry; (2) the programmed cost to students in detail and all related possible financial arrangements and assistance available; (3) the program's duration and content described as a curriculum showing sequence of courses and options (if any); (4) regulations for students of the program; (5) housing arrangements; (6) associate degree or certificate awarded on graduation; (7) what advantages the student may expect for having completed the program; (8) faculty and all related staff responsible for the program; (9) a statement of the identity and organization of the institution; (10) how long it has provided the program, and the status of the program's recognition by evaluative bodies and other important recognition; (11) a statement that the objective is to prepare for gainful employment as a skilled technician and not primarily for transfer toward a baccalaureate or professional program; (12) a description of the employment opportunities for which the program prepares the student; and (13) other pertinent information which would fully inform prospective students, their parents, their prospective employers, or the public-at-large.

There should be an orderly procedure for application to the institution and program, and it must be followed consistently. It should require the information considered by the institution to be necessary, including an authentic transcript of the applicant's school record to date, all of which should be made a part of the student's permanent record when the applicant is enrolled in any program in the institution.

It is usually desirable to consider opinions of the guidance or counseling personnel of the school from which the student came, a statement of the student's interests and activities, and the results of scholastic achievement or interest tests that have become a part of his school record.

Testing of the student by the institution or by a State or local agency for his probable scholastic success as a student technician is becoming more common. All such testing should carefully be validated by each institution by comparing results over a series of beginning classes. A few examples of the many available tests which may be used are:

College Entrance Examination Board	(CEEB)[2]
American College Testing Program	(ACT)[3]
College Qualifying Test	(CQT)[4]
American Council on Education	(ACE)[5]
General Abilities Testing Battery	(GATB)[6]

Each institution selects tests which best meet its own admission standards for all applicants.

A personal interview is recommended for all applicants for technical or pretechnical programs. Evidence of interest and readiness for a pretechnical or technical program may best be determined in the interview. Applicants who have been employed or served in the armed services may demonstrate their maturity and motivation more clearly in an interview than on the written application. Military training and/or work experience contributing to an interest in and readiness for entry into a technician program may be discussed and evaluated.

It should be recognized that many tests traditionally used to predict probable success of students in post high school programs tend to measure a set of skills that is equated with probable success in *academic*, usually baccalaureate, or pre-professional, college study. Some students who have consuming interests in applied and specialized scientific, mechanical, or technical matters may have neglected to develop the skills measured by the tests for college aptitude and may be considered of too low ability. Actually in many cases they have great ability but have not developed the skills which demonstrate it in scholastic-ability measuring tests. Many such students, after some pretechnical preparatory studies, progress rapidly to honor student status in technician educating programs, and not infrequently proceed later to baccalaureate, professional, and doctoral levels.

The ability of the applicant to meet the physical requirements imposed by the college curriculum and in the anticipated field of technical employment should also be carefully considered. If, for example, an applicant were color blind, he should be advised of the resulting limitations if his technician duties required clear differentiations of colors. The record of a recent comprehensive

[2] College Entrance Examination Board, 475 Riverside Drive, New York, N.Y. 10027.

[3] American College Testing Program, 5197 Sheridan Road, McHenry, Ill. 60050.

[4] College Qualifying Test, the Psychological Corporation, 304 East 45th Street, New York, N.Y. 10017.

[5] American Council on Education, 1785 Massachusetts Avenue, NW., Washington, D.C. 20206.

[6] U.S. Department of Labor, Bureau of Employment Security.

physical examination should be a part of the information available about an applicant and should be considered by the admissions officer.

Admission of a student who does not fully meet the published scholastic prerequisites for entrance, or acceptance of a student to a status of advanced standing in the program may sometimes be justifiable. Such cases should be substantiated with evidence of the student's performance, capability, or valid test results, any of which should clearly be noted in the student's permanent and official record in the institution.

Acceptance of each applicant to an institution's technical program should be formal, in writing, and part of the student's permanent record in the institution.

Guidance and Counseling

Guidance and counseling service should be available to students during the selection process, and at all times after they have enrolled in the program.

Pre-enrollment counseling is especially important. If, in the opinion of the institution's counseling personnel, a prospective student's aptitudes, interests, and real desires would be better served by a skilled trade, craftsman, pre-professional, or other type of occupational objective than by the institution's technical preparatory program, the prospective student should be guided accordingly.

Similarly, after enrollment (and especially if there is a sizeable pretechnical program), guidance and counseling services should constantly be available and employed to assist students in adjusting to the transition of the program, and to assist them in solving their scholastic or personal problems.

A student should be advised to revise his educational objectives if it becomes apparent that he is more suited to other programs either by reason of interest or lack of ability to satisfactorily complete the curriculum. In such cases, whatever arrangements are needed to guide him to a different program should be made without prejudicing the student's future efforts.

Technician students are usually assigned a staff member of their particular program to serve as faculty advisor. Although all teachers serve in some degree as guidance counselors, exclusive dependence on them for guidance and counseling is usually not in the best interest of the students and the instructional staff. Guidance and counseling are usually accomplished best by staff members who are not members of the full-time instructional faculty.

Counselors should assist students with their problems of personal relationship, attitudes, and financial concerns, and should be acquainted with each student, his curriculum and objectives, and his instructors. They should be knowledgeable about and assist students with such problems as selective service obligations and options, scholarships, grants, loans, other financial matters, student work programs, school and local health services, housing, recreation, student activities, community programs of special interest to students, and similar important matters. Usually guidance and counseling is organized under a director or dean of counseling, guidance, or student affairs.

Student Records and Services

It is essential that *adequate records* be maintained to assist students during and after admission, and subsequent to graduation. Such records should show both academic and non-academic accomplishments.

Academic records should include the complete official history of a student's academic career at the institution and a summary of his previous scholastic work. Students are entitled, in accordance with reasonable regulations, to have transcripts of their academic records sent to prospective employers, other schools, or interested agencies. The non-academic records usually include such information as reports of interviews and vocational interests, health notes, employment experience, family history, participation in extra-curricular activities, test results of various sorts, and financial relations with the college.

Most institutions find it both to their interest and those of the students to provide at least minimum health services to their students in the form of professional medical services. This usually is more important for residential schools than for those whose students commute.

Similarly, institutions usually need insurance which protects them from liabilities in operation and which protects students in their exposure to various hazards.

Assistance and information concerning scholarships, loans, and grants of aid should be published and made available to students. Students should be made aware of the conditions under which such aid is available and the obligations of recipients. The procedure in applying for such aid should be clearly stated.

Students should be informed about any regulations on licensing which may affect their employability so that they may be psychologically as well as technically prepared for it. Although it is usually not part of the curriculum, most students prepared by high quality technician programs have little difficulty in acquiring their licenses. Students should be made aware that certification may be one of the criteria or provide an advantage for employment.[7]

Student Activities

New students should be quickly familiarized with facilities on the campus. They should be given a tour of the library facilities and taught the procedures and rules governing the use of the library. If possible, organized field trips to nearby places of employment should be arranged early in the program to give new students an opportunity to see technicians on the job. These tours may provide motivation and perhaps point out why certain required subjects are important.

A departmental student organization may be formed to help bring together people with similar interests. The meetings of this organization should provide exercise for the students in arranging their own technical programs. Speakers representative of employers of technicians or scientific associations, or selected films may be used to stimulate interest at meetings. Student organizations may assist with and participate in departmental activities such as "career days" and "open house" visitation events.

One function of a departmental organization may be to make an annual presentation of an outstanding graduate award. It is not uncommon for employers or other interested organizations to contribute to or offer an annual scholarship award or recognition for special papers on competitive projects identifiable with the technical studies of the students.

Intramural activities such as debating, athletics, and musical activities and organized hobby clubs, recreational activities, student publications, and social activities make important contributions to the educational programs for technicians.

Student membership in technical societies should be explained and students encouraged to join such societies. Student chapters of professional societies on campus offer many opportunities for student activity, growth, and experience in their technical field.

To the degree possible, it is desirable that students participate in extracurricular activities which broaden their horizons and heighten the tone of the esprit-de-corps of all associated with the program. The experience and satisfaction gained by students

[7] Information on the certification of engineering technicians may be secured from Institute for the Certification of Engineering Technicians, 2029 K Street, NW., Washington, D.C. 20006.

and their staff advisors in creditably doing outside projects which are not necessarily a part of their studies contribute a special "extra" to the attitude of all. They develop and exercise elements of judgment, imagination, and objective creativity that extend far beyond the minimal concept of education for technicians.

Student Placement and Follow-Up

Placement and follow-up of students is an important school function and responsibility. Graduates of technical programs should be aided in every way possible to find suitable employment. The placement function is an extremely valuable service to the student, the institution, and the employers. In the final analysis, the placement of graduates is an important responsibility directly or indirectly of the department head. An excellent placement record is important in getting new students to enroll. Each department or division in the school should make periodic follow-up studies of its graduates to determine their progress, how their training has aided them, and if it was deficient in any area. Many times this information can indicate how the curriculum or teaching techniques may be improved.

The responsibility for placement is not usually delegated solely to the instructional staff, but experience shows that the staff should be involved as much as possible and that it should make frequent contact with employers. This results in reality in curriculum content which will best meet employers' needs.

Placement and follow-up of students should be an organized and continuous program. Every available medium should be employed to acquaint potential employers with the nature and qualifications of the students. Conference facilities for recruiters to interview students should be available at the school. Students should be helped to prepare suitable résumés, and these should be made available to recruiters, along with students' school records. Students should be schooled in the art of meeting interviewers, and they should be given advice and assistance by their instructors and counsellors regarding employment opportunities as these become pertinent and available.

Some institutions provide a placement service which is nationwide in scope. This is particularly advantageous to students of technologies which are almost unique or for whose preparation there are only a few programs in the Nation.

The placement and follow-up service is often closely allied to the recruitment and public relations functions in the school's organization. Whoever is responsible for it must be knowledgeable about the curriculum, the qualifications and aspirations of the graduates; he must have a comprehensive knowledge of the various prospective employers and a well-organized means of communicating information about available employment opportunity to students and, conversely, of qualified students to employers. The faculty's evaluation of the students and its involvement in these functions are indispensable.

Most placement and follow-up personnel find that outstandingly successful graduates and their employers are the most effective advertisement of the institution's programs for educating technicians and also the most important factors in student recruitment.

The Curriculum

A curriculum for a technician is the organized program of study and experience designed to meet the specific requirements for the preparation of a particular kind of technician, within a stated period of time. Each curriculum must be designed specifically to prepare a technician for a particular field of technology.

The courses in a technician's curriculum are usually grouped under the following classifications:

1. *Basic science* and courses which provide the foundation of scientific facts, principles, methods, and attitudes on which the technician's specialized application of that science depends.
2. *Mathematics courses* as required by the technology to enable the student to quantify scientific phenomena and to establish precise definition and interpretation of such phenomena, observations, or applications.
3. *Technical specialty courses* and their auxiliary *supporting studies* which teach the special skills, knowledge, techniques, applications, procedures, materials, processes, apparatus, operations, and services that identify the technology and prepare the student for a variety of employment opportunities in that technical field.
4. *Communications courses* which teach oral, written, and graphic skills, the required reading capability, and the ability to communicate successfully with coworkers and others.
5. *Social studies courses* which provide a technician with an elementary frame of reference in economics, citizenship, and social relationships as an individual, member of a family, employee, and citizen.

The first four of these groups of courses are preparatory to the five special abilities required of technicians. Each group of courses in technical curriculums will be discussed in detail in later sections of this chapter.

Elements Required To Develop a Curriculum for Technicians

The curriculum for any high quality technician program must be based on the assumption that the following information and resources are available and will be completely operative in the program:

1. A clear and complete definition of what special abilities the technician must have and, in context with the nature and level of those abilities, the activities he must be able to perform, who he works with, and the employment opportunities for which he will be prepared.
2. Administrative support which uncompromisingly provides the organizational, financial, and philosophical resources necessary to attain the objectives of the program.
3. Adequate physical facilities equipped to meet all requirements of the program, including provisions for clinical or other specialized study, and available when needed in the program.
4. A well qualified, willing, and enthusiastic instructional and supporting staff capable of teaching all of the specific knowledge, skills, concepts, and competencies at the level required.
5. Students of at least average ability who meet the requirements for entering the program and who exhibit seriousness of purpose and mature interest motivated by a desire to succeed in the program.

All of the foregoing elements must be present or available. Weakness in any one of them will lower the quality of the preparation of the technicians and will prevent the full attainment of the objective of the institution, and of the students who seek the advantages of a technician program.

If all of the foregoing information and resources are available and operative, the curriculum to prepare a particular kind of technician can be developed. It will have not only the specific content but also the provisions for learning experience which distinguish it from the curriculum for other technician education objectives. However, it will also have characteristics common to all technician curriculums, and it should be consistent with the accumulated evidence of successful experience in teaching technical occupational objectives.

General Philosophy of the Curriculum

Judging by the analysis of the special abilities which technicians must have, and the level at which they must be exercised in performing the required activities, it is evident that technician education must be of college level and intensity. A series of courses, their sequential arrangement, and the details of the plan for teaching each course will constitute the curriculum which implements the program.

The *length of the program* is a vital and limiting factor in designing the curriculum. Experience indicates that technician educating programs can usually be accomplished in a minimum of 2 academic years of approximately 9 months each, and that such programs can, at present at least, effectively prepare persons for successful employment as beginning technicians. The preparation of some technicians, especially those in some agricultural specialties and some of the health-related occupations, such as 2-year nursing programs, may require the students to use the summer period between the first and second year of their program, and even perhaps the second summer. The additional time is required for special work such as hospital-clinical experience which may not be effectively duplicated or provided in school laboratories. The discussion of curriculums for technicians that follows assumes they are 2 academic years in length.

Because of the time limitation, a loose collection of courses taken at random and independently of one another cannot adequately educate technicians. The sequence of courses in a technical curriculum is as important as the content if the time available is to be used effectively.

The subject matter is carefully coordinated in groups of concurrent courses which are arranged to blend smoothly from one group of courses into the next, and to carry the student to a deeper understanding in his field of specialization. This is in sharp contrast to the arrangement of most baccalaureate or professional curriculums in which basic and relatively unrelated courses make up the first few years and specialization is deferred to subsequent terms.

The relationship between laboratory time and class lecture and demonstration of theory time is of special importance in a technician curriculum. All of the theory, skills, techniques, applied principles, materials, related knowledge, processes, special services, and understandings needed by the technician could be taught in the laboratory, with suitable explanations by instructors, without separate and organized theoretical classes. The *reverse is not true*—because laboratory experience, skills, know-how, and capability which are the most characteristic attributes of technicians cannot be learned in classrooms *without laboratories.*

However, organized theory and related ideas, concepts, and factual information can be taught in lecture classes by the judicious use of demonstrations and visual aids, employing selected texts and references and requiring the students to do regular and systematic outside study. Group teaching usually is more efficient in a lecture and demonstration class than in a laboratory, and it helps to develop the student's skills in obtaining knowledge from oral and printed sources. Thus, there must be a special relationship between the amount of the scientific and technical specialty taught in the "theory" classes and that taught in the laboratory.

The typical technical curriculum provides a relatively large number of laboratory hours in science and technical specialty courses during the first year, because the student can and should acquire introductory and elementary laboratory skills and knowledge of apparatus, tools, processes, materials, devices, and good practice in the laboratory as early as possible, and he can start without much underlying theory. As soon as the underlying theory can be developed, it can be incorporated into the laboratory work and it becomes a significant experience for increasing depth of understanding.

In the second year the total laboratory time often is greater than in the first year because more technical specialty courses are studied. Experience has shown that the total semester hours of science or technical specialty laboratory work should be about equal to classroom study hours in those subjects and usually should not be reduced much below that level. Such a reduction often causes students to lose interest and fail or to abandon the course. Insufficient laboratory experience produces a graduate who is deficient in the laboratory capabilities necessary for success as a technician.

The laboratory hours in typical technical curriculums are scheduled in reasonable and effective increments. For example, a 6-hour laboratory total per week for a course might be scheduled as three 2-hour sessions, or two 3-hour sessions, but would seldom be scheduled for longer periods, except perhaps in certain seasonal or field laboratory experiences in agriculture or forestry or in clinical experiences in health-related technologies.

In technical curriculums it is especially important that specialized technical course work be introduced in the first semester. Deferring this introduction even for one term imposes serious limitations on the effectiveness of the total curriculum. Several important advantages occur from an early introduction of the technical specialty:

1. It provides motivation. If the first semester consists entirely of general subjects—mathematics, English, general science, and social studies—technical students often lose interest.
2. The introduction of the technical specialty in the first semester makes it possible for the student to achieve greater depth of understanding in specialized subjects in the later stages of the 2-year program.
3. The student sees immediate application of the principles he studies in the basic science and related mathematics courses which he is studying concurrently.

Physical Science and Related Engineering Technology Curriculums

A better understanding of the organization and content of curriculums for technicians in the physical science and related engineering field may be gained from two sample curriculums which represent a consensus of experienced and knowledgeable technician educators in the field. They are reprinted below.

ELECTRONIC TECHNOLOGY CURRICULUM [1]

Courses	*Class hours*	*Lab. hours*	*Outside study*	*Total hours*
First Semester				
Physics for Electronics I (Electricity)	3	6	6	15
Technical Mathematics I (Algebra and Trigonometry)	5	0	10	15
Electronic Devices	3	6	6	15
Communication Skills	3	0	6	9
Total	14	12	28	54
Second Semester				
Physics for Electronics II (Mechanics, Heat)	3	3	6	12
Technical Mathematics II (Applied Calculus)	4	0	8	12
Circuit Analysis, AC and DC	3	6	6	15
Electronic Amplifiers	3	6	6	15
Total	13	15	26	54
Summer Session (Optional)				
Studies to meet special requirements of State or institution.				
Third Semester				
Instruments and Measurements	3	6	6	15
Communication Circuits	3	6	6	15
Introduction to Computers	4	3	8	15
Technical Reporting	2	0	4	6
Drawing, Sketching, and Diagramming	0	3	0	3
Total	12	18	24	54
Fourth Semester				
Control Circuits and Systems	3	3	6	12
Communication Systems	3	3	6	12
Electronic Design and Fabrication	1	5	0	6
Introduction to New Electronic Devices	2	0	4	6
General and Industrial Economics	3	0	6	9
Industrial Organizations and Institutes	3	0	6	9
Total	15	11	28	54

[1] U.S. Department of Health, Education, and Welfare, Office of Education. *Electronic Technology, A Suggested 2-Year Post High School Curriculum.* Catalog No. FS 5.280:80009-A. Washington: Superintendent of Documents, U.S. Government Printing Office, 1966.

METALLURGICAL TECHNOLOGY CURRICULUM [2]

Courses	Class hours	Lab. hours	Outside study	Total hours
First Semester				
Mathematics	5	0	10	15
Physics I (Heat and Optics)	3	2	6	11
General Chemistry	3	3	6	12
Communication Skills	3	0	6	9
Introduction to Metallurgy	2	3	4	9
Total	16	8	32	56
Second Semester				
Mathematics	4	0	8	12
Physics II (Electricity and Mechanics)	3	4	6	13
Analytical Chemistry	3	3	6	12
Foundry	2	4	4	10
Technical Reporting	2	0	4	6
Technical Drawing and Graphic Representation	0	2	0	2
Total	14	13	28	55
Third Semester				
Physical Metallurgy and Metallography	4	7	8	19
Properties of Materials	4	4	8	16
Refractories and Furnaces	2	3	4	9
General and Industrial Economics	3	0	6	9
Total	13	14	26	53
Fourth Semester				
Process Metallurgy	4	7	8	19
Non-Destructive Inspection	3	3	6	12
Control Instrumentation	3	4	6	13
Industrial Organization and Institutions	3	0	6	9
Total	13	14	26	53

In both curriculums the technical specialty, basic science, and mathematics are introduced in the first semester. Each curriculum illustrates the sequential progression of courses toward more technical content through the second year, with liberal allowance for laboratory experience. Formal courses in drafting and mechanical drawing are not included in the electronic or metallurgical technology curriculums as they would be in a mechanical or archi-

[2] U.S. Department of Health, Education, and Welfare. Office of Education. *Metallurgical Technology—A Suggested 2-Year Post High School Curriculum.* FS 281:81012 Washington: Superintendent of Documents, U.S. Government Printing Office, 1968.

tectural technology, but graphic representation is included to prepare the students to interpret design drawings and to report and communicate graphically—some of the essential skills of all technicians.

The metallurgical curriculum provides both physics and chemistry as the required basic sciences, whereas the electronic curriculum's basic science is physics. Both include the mathematics required to provide definition and quantification.

A study by the U.S. Office of Education [3] of engineering-related curriculums in 25 institutions whose graduates have been highly successful reports that:

> These curriculums required an average of 71 semester credit hours for completion, with 35 credit hours (49 percent of the credit) devoted to courses in the field of specialization. Mathematics requirements averaged 9 credit hours, science 9 hours, auxiliary and supporting technical courses 7 hours, and general education 11 hours. The following table indicates the range of requirements in these subject-matter areas. Since the number of curriculums represented in this study is limited, the range of credit requirements in each curriculum division may reflect this limitation. An analysis of this nature is always subject to errors in grouping because of disparity in course titles. The errors in this study, however, should not be significant.
>
> This analysis was primarily quantitative and serves only to indicate the relative subject-matter emphasis in terms of credit requirements. The semester credit-hour unit was chosen as a commonly understood measure of instructional content. In the majority of the curriculums, three hours of laboratory study per week were required for one hour of credit.
>
> The student contact hour provides another base for comparing the relative emphasis on subject-matter in the curriculum. The contact hour represents one period of 50 minutes in either class or laboratory work. The mean requirement for 32 curriculums analyzed in the study was 1,810 contact hours.
>
> A comparison of credit-hour and contact-hour requirements is shown in figure 1. . . . . Technical courses make up 59 percent of the total credit-hour requirement in these curriculums but require 69 percent of the student's total time in attendance. This is due to the extensive laboratory work necessary in technical study.
>
> Mathematics and general education courses normally do not require laboratory work, and science laboratory requirements are not as time-consuming as those of technical courses.

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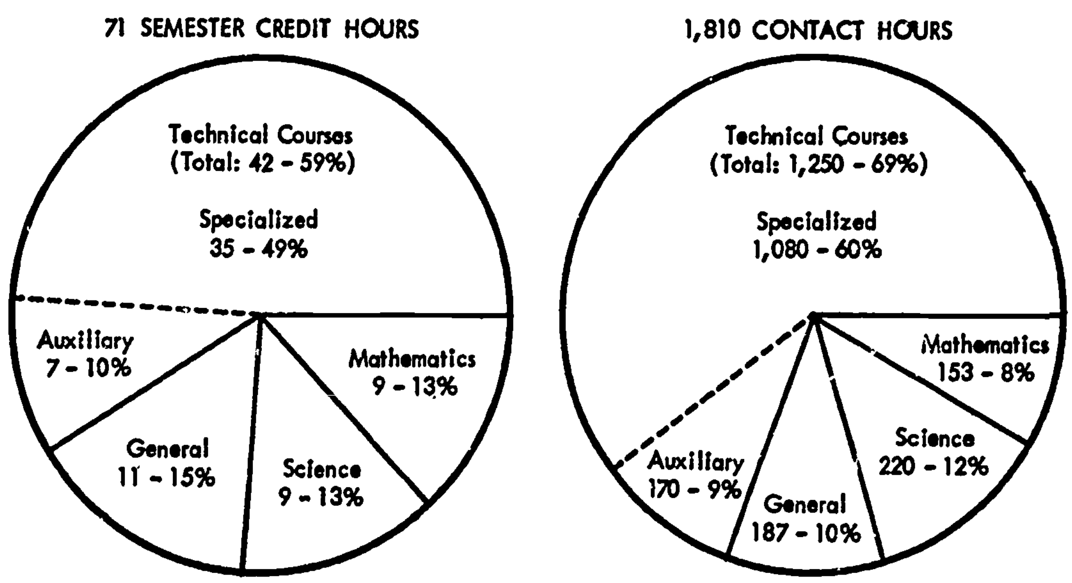
[3] U.S. Department of Health, Education, and Welfare, Office of Education. *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs*. Catalog No. FS 5.280:80015. Washington, D.C.: U.S. Government Printing Office, 1962.

ANALYSIS OF 32 SELECTED TECHNOLOGY CURRICULUMS (ELECTRICAL, ELECTRONIC, AND MECHANICAL) IN 25 POST HIGH SCHOOL INSTITUTIONS

Curriculum Division	*Credit Hour Requirement*			
	Range		*Mean*	
	Minimum	*Maximum*	*Hours*	*Percent of Total*
Total	62	80	71	100
Technical specialty courses—Basic and advanced courses in the technology (e.g. machine design)	19	47	35	49
Mathematics courses—Algebra, trigonometry, analytic geometry, calculus	5	20	9	13
Science courses—Physics, chemistry, mechanics, hydraulics, thermodynamics, etc.	3	22	9	13
Auxiliary and supporting technical courses—Mechanical drawing (general), shop, technical report writing	4	21	7	10
General education courses—Communications, humanities, social studies, health	2	24	11	15



CURRICULUM REQUIREMENTS IN POST HIGH SCHOOL INSTITUTIONS, BY CREDIT AND CONTACT HOUR

In the light of the explosive multiplication of scientific knowledge and increased technical sophistication there has recently been discussion of 3- or even 4-academic-year programs to prepare physical science and related engineering technicians. This may be a result of the trend in the education of professional engineers since 1955 towar. more and more theoretical and less specialized study and the inclusion of much less laboratory experience in technical applications than ever before.

Some 3-year technician programs provide what amounts to 1 semester or 1 year pre-technician study, followed by 2 intensive years to produce highly skilled and adequately prepared technicians. Some 3-year programs may offer additional sociological and supervisory or management courses without materially adding to the scientific or technical specialty preparation of the students, while others provide greater depth and breadth to the technical training than can be attained in 2 years.

Four-year technician programs in some cases exhibit the characteristics indicated above for 3-year programs and produce a well-rounded person who actually is more than a technician. There seems to be no evident justification for 4-year programs to the exclusion of the normal 2-year programs to educate technicians; rather, they represent a healthy diversity of programs.

Curriculums for Preparing Technicians in Agriculture and Health Occupations

Successful programs in health technologies and in agriculture are similar to engineering-related technologies in rigor, laboratory orientation to basic science, and emphasis on specialized applications of the science that underlies each particular field. Relatively less emphasis is on mathematics in the health technologies involving patients, with more emphasis on clinical experience and on social science subjects. The following curriculums are illustrative:

ORNAMENTAL HORTICULTURE CURRICULUM
FLORICULTURE OPTION

	Hours Per Week			
Courses	*Class*	*Lab.*	*Outside study*	*Total*
First Semester				
Chemistry	3	3	6	12
Communication Skills	3	0	6	9
Mathematics	3	0	6	9
Horticultural Soils	2	2	4	8
Horticultural Applications	1	3	2	6
Botany	3	3	6	12
Total	15	11	30	56

ORNAMENTAL HORTICULTURE CURRICULUM
FLORICULTURE OPTION—Continued

Courses	Hours Per Week			
	Class	*Lab.*	*Outside study*	*Total*
Second Semester				
Technical Reporting	2	2	4	8
Floriculture	1	6	2	9
Herbaceous Plants I	1	2	2	5
Woody Plants I	2	2	4	8
Horticultural Science	2	6	4	12
Entomology and Plant Disease Control	3	3	6	12
Total	11	21	22	54

Summer Session

Occupational experience and studies to meet special requirements of State or institution; approximately 12 weeks of full-time practice in floriculture on the job, or as provided by the college.

Courses	Class	Lab.	Outside study	Total
Third Semester				
Floral Design	1	3	2	6
Greenhouse Operations I	2	6	4	12
Herbaceous Plants II	1	3	2	6
House and Conservatory Plants I	2	2	4	8
General Industrial Economics	3	0	6	9
Plant Pathology	3	3	6	12
Total	12	17	24	53
Fourth Semester				
Flower Shop	2	6	4	12
Greenhouse Operations II	2	6	4	12
House and Conservatory Plants II	1	2	2	5
Salesmanship	3	0	6	9
Indoor Landscaping	1	2	2	5
Business Organization and Management	3	0	6	9
Total	12	16	24	52

DENTAL HYGIENE TECHNOLOGY CURRICULUM [4]

Courses	*Hours per week* Class	*Hours per week* Lab.	*Credit hours*
First Semester			
Introduction to Biochemistry	3	2	4
Dental and Oral Anatomy	3	3	4
Dental Manikin	0	5	2
English Composition	3	0	3
Physical Education	0	2	½
Anatomy and Physiology	3	2	4
Total	12	14	17½
Second Semester			
Preventive Dentistry	2	0	2
Dental Assisting	1	2	2
Dental Roentgenology	2	0	2
Clinical Dental Hygiene I	0	4	1
Speech	3	0	3
Physical Education	0	2	½
First Aid	2	0	2
Histology and Embryology	2	2	3
Medical Microbiology	2	2	3
Total	14	12	18½
Third Semester			
Dental Roentgenology	0	2	1
Clinical Dental Hygiene II	0	12	4
Methods and Materials in Dental Health Education	2	0	2
Nutrition	2	0	2
Pathology	2	0	2
Psychology	3	0	3
Social Science	3	0	3
Total	12	14	17
Fourth Semester			
Clinical Dental Hygiene II	0	12	4
Dental Materials	1	2	2
Public Health	2	0	2
Pharmacology	2	0	2
Sociology	3	0	3
School Organization	2	0	2
Health Services in Schools	2	0	2
Total	12	14	17

Total credits required: 70

[4] State University of New York, Agricultural and Technical College at Farmingdale, *Catalog 1964–66.*

(ASSOCIATE DEGREE) NURSING CURRICULUM [5]

(This program was designed for the State of California. Since the legal requirement in California was for a 24-month course, the program included 2 academic years and 2 summer sessions.)

Subjects	Units: First Semester	Units: Second Semester
First Year		
Nursing I—Introduction to Nursing	5	
Anatomy	3	
Sociology	3	
English	3	
Physical Education	½	½
Nursing II—Introduction to Medical-Surgical Nursing		6
Microbiology		4
Physiology		3
Home Economics		2
Total	14½	15½
Summer Session		
Nursing—Medical-Surgical	3	
Psychology	3	
Total	6	
Second Year		
Nursing—Medical-Surgical	5	
Nursing—Psychiatric	5	
History	3	
Speech	3	
Physical Education	½	½
Maternity Nursing		5
Nursing Care of Children		5
History		3
Elective		3
Total	16½	16½
Summer Session		
Nursing—Advanced Medical-Surgical	4	

A relatively larger amount of time is devoted to the basic biological sciences and the applied technical specialty courses which teach the techniques, skills, processes, and services which must be learned in the biological science technologies than in the physi-

[5] Anderson, Bernice E. *Nursing Education in Community Junior Colleges.* Philadelphia: J. B. Lippincott Co., 1966.

cal science technologies. Thus there tends to be relatively more laboratory and/or clinical time spent in the biologically based technologies.

The 2-year technician program for nurses is a development which started experimentally in 1951 with the support of the Kellogg Foundation. The nursing curriculum shown here is longer than most. Some are only 18 months long, others include the summer after the first academic year (total 21 months) to provide additional clinical experience. All require the maximum coordination of course content and clinical experience in hospitals.

Basic Science Courses

The technician must have sufficient knowledge of the basic principles and phenomena of the science underlying his specialty to be an effective, comprehending, and perceptive worker with his or her professional counterpart and to be able to master the inevitable (and often rapid) changes brought about by technological developments.

It should be assumed that the professionals in the field supply the deep theoretical components of the task, but the technician must be sufficiently grounded in the fundamental principles to permit some interpretation of phenomena he encounters, to have a sound understanding of the theory as it is applied in the field, and to learn of technological changes in his specialty by independent study of reports of developments as they occur. The basic science courses in his curriculum must provide the knowledge of the scientific principles and their application needed by the technician.

The basic science courses for the physical science and related engineering technologies are fundamental and applied physics, and usually some study of chemistry; these form the base for specialized courses in mechanics, statistics, strength of materials, electronic circuitry, instruments and measurements, and other specialized applied physics as required by the particular technology.

Mechanics (statics-dynamics) and electricity are essential physics topics in every physical science and related engineering technical curriculum. Mechanics is the basic science for technical study in mechanical, civil, aeronautical, and architectural or construction technology. Electricity is fundamental for electrical, electronics, and instrumentation technologies. Some mechanics and electricity should be included in every physical science technician curriculum; both should usually be presented in well-identified discrete courses, with substantial laboratory work being required. An exception can be made in electrical or electronic technology curriculums where electrical physics may be part of a broad introductory course in the technical specialty.

Heat, light, sound, fluid mechanics, solid state, and nuclear physics are auxiliary topics in most physical science and related engineering technical curriculums, and in many are becoming more important. In general these topics are supplementary rather than basic to technical study. Exceptions may be found where one or more of these topics are integral parts of the technical course work. Mechanical technology curriculums include technical courses in which heat and fluid mechanics are essential. Direct applications of light, sound, and solid state physics may be found in electrical electronics and instrumentation technology. For those curriculums in which certain of these topics are basic rather than auxiliary sciences, they may be covered in discrete courses or in technical courses as the point of need occurs.

The basic science courses for the health-related technologies and for agricultural technologies provide a basic understanding of the biological science which underlies the technician's specialty and usually include a study of chemistry. Some technical curriculums such as water and wastewater technology require a combination of physical science and biological science where the curriculum is predominantly based on applied physics, but the student must learn the fundamentals of microbiology as they apply to water management and waste liquid disposal systems.

Basic biological courses teach the fundamental processes and characteristics of living organisms, either plants or animals or both as appropriate to the technical specialty. They may include *micro structure, anatomy, respiration, circulation, nutrition, excretion, reproduction, adaptability in response to stimuli, photosynthesis (in the case of plants)*, and the fundamental limitations of the environment in which the organisms live. An understanding of the basic concepts of chemistry is considered essential to a comprehension of the life processes, so high school chemistry (or an equivalent) is usually a requirement for entry in health or agricultural technology programs.

Basic science courses should be taught as separate courses by qualified professional teachers of the subject and should include laboratory experience for students. They must be taught early in the curriculum to provide a base for the technical specialization which follows, and the principles should be presented and demonstrated in the context of the technical specialty in which the curriculum is designed to provide competence. The courses should be taught from the standpoint of application of scientific principles. Course content should be coordinated with mathematics courses and technical specialty courses which are taught concurrently. The predominantly theoretical courses designed for preprofessional transfer programs are almost never satisfactory.

Mathematics Courses

The ability to use *mathematics* as it applies to his technology is essential to the education of any technician, whether his specialty lies in physical science and related engineering, in the health occupations, or in agriculture. Mathematics is required to quantify and provide precise definition and interpretation of basic scientific phenomena and observation. It is a basic tool which is required in varying degrees and depth by all kinds of technicians. Almost all should understand statistical analysis of data.

Technicians whose specialty requires considerable application of physical science in such subjects as strength of materials or electronic circuit analysis require relatively greater mathematical capability than is usually required of technicians in health occupations or agricultural technologies. However, mathematical competencies are required for the agricultural technologies. The requirements for health occupations may become greater as the techniques of physics and chemical inquiry, definition, and quantification are applied to biology.

Mathematics courses for technicians should teach the application of each mathematical principle, concept, or technique to the particular problems of the technician in his special field. They should be taught by professional instructors qualified to teach the mathematics required for a particular technology.

Mathematics instruction should develop skills in dimensional analysis. The function of mathematics throughout the study program is to represent physical concepts which involve mass, energy, motion, and time. For this reason, the emphasis in the instructional program should be on the use of formulas rather than on the mechanics of formula derivation. However, it is necessary that students be able to follow and comprehend the derivation of the most essential formulas in the technical specialty.

Algebra and trigonometry are the key subjects in every engineering related technical curriculum. There is need for real facility with algebraic and trigonometric expressions. Mathematical description greatly extends the learning obtained from each laboratory experience. By means of mathematical definition and mechanical interpretation, each demonstration of the application of a scientific principle can be shown to be useful in many similar or related applications.

Elements of higher mathematics should be introduced in some curriculums. Selected forms of analytic geometry, calculus, and differential equations should be introduced wherever the technical subject matter in the curriculum can make good use of these forms. In certain cases higher mathematics can provide an understanding of concepts that cannot effectively be presented through physical or graphic means. Examples are rates of change, acceleration, or interpretation of variables. Furthermore, an introduction to higher mathematics will enable the graduate to take advantage of opportunities for advanced study, where such study requires familiarity with higher mathematics forms.

Some courses in mathematics should be concurrent with, rather than entirely prerequisite for, technical courses in which the mathematics is used. Time limitations in the 2-year program make it necessary to introduce both basic science and specialized technical subject matter in the first term of the curriculum. Some of the mathematics forms required in a particular technical curriculum may well be covered in concurrent mathematics courses. A close coordination of mathematics courses has the added advantage of greatly increasing the student's interest in mathematics and his understanding of its functional value.

Technical Courses

Technical courses in the curriculum provide the skills and specialization which distinguish a particular kind of technician from others in a field of applied science. The technical courses in a curriculum usually give the name to the technology. *Unusual names for common technician education programs should be avoided.* It helps both the technician and his potential employer to use descriptive and generally understood terminology in naming programs for technicians.

The *technical specialty* courses provide the detailed and disciplined study and practice in the application of basic scientific principles in the specialized procedures, processes, techniques, determinations, interpretations, and services which will constitute the major activities in the technician's work. Closely related are the *auxiliary or supporting technical courses* which provide special skills and interpretive capabilities needed by the technician as he applies his technical specialties.

The differences between technical specialty and supporting technical courses are not always clear and often do not need to be. Mechanical drafting or the development of skills in the operation of machine tools are considered to be supplementary "skill teaching" courses for many technicians who must understand such skills and the related knowledge and who must exercise the judgment which comes with some competence in their performance. Practice in machine tool operation for a mechanical design or production technician should teach him differences in machinability of a material under different conditions of heat treatment and cutting tool contour. It should also teach him to evaluate machinery processes, but it is not intended to make him a highly skilled machinist.

Similarly, practice in the procedures for preparing blood samples or tissues for microscopic examinations by a medical laboratory technician or the routine practice of soil analysis by an agricultural technician provides some skill. It also demonstrates the scientific phenomenon and the special techniques or procedures used to bring samples to a point where a consistent and valid observation may be made. A technician must understand why each step of each procedure or technique is necessary, how it works, what it does, and what happens if it is not correctly performed.

A special project which is a major part of or an entire technical specialty course is usually offered near the end of the curriculum. Its objective is for the student to undertake a technical task of sufficient depth and magnitude to require him to integrate and use what he learned in all previous courses. Such major projects make the interrelationships of previous courses more evident, provide a challenge to the student as he seeks solutions to problems in the project, and help to develop the student's confidence and satisfaction in his ability to perform in his specialty.

The technical courses usually comprise from 45 to 65 percent of the technician's curriculum. They comprise the part of the preparatory program that provides the special abilities of the technician. They impart the capability to *do,* to *perform,* to *provide* special services; hence, they must be strongly laboratory oriented and they must emphasize practice and exercise using the apparatus, materials, procedures, techniques, and equipment currently used in the most up-to-date employer's laboratories, clinics, or institutions. This is why the instructors for such courses must have the qualifications discussed earlier under Faculty.

The clinical experience in a hospital or laboratory required in the education of a 2-year associate degree nurse or the on-the-job experience for agricultural technicians are examples of educational experiences for student technicians which have reality, the necessary equipment, and professional supervision. Such "real work" experience might be very difficult or impossible to provide in a school laboratory. Adequate and qualified coordinating and supervisory staff must be provided by the educational institution to insure maximum educational achievement in these work experience programs.

The technical specialty and skill areas of a technician's work are always subject to change by technological development. Automation, instrumentation, and mechanization tend to reduce the routine and time consuming operations in the strictly "skill" areas of almost all the work of a technician: thus, the need for technical courses to provide a solid foundation of the "why" and "how" of all of his work. This must be supplemented by constant study of scientific and technical literature to keep him up to date. Technical specialty instructors must constantly revise course content and replace laboratory equipment to keep them up to date.

Technical courses must present a broad enough range of knowledge and capability in the specialty area to permit the technician to enter any of several different, but related, employment opportunities in his field upon graduation. Then, after a brief period of orientation to a particular employer's work and institution, and with continued study on the job, the technician may grow to greater responsibilities. The broad technical base will also prepare him to make the necessary adjustments if he should choose or be forced by technological change to seek employment in a related field.

The broad fields of technology are not normally localized in any community, State, or region. The important principles of electronics, medical laboratory analysis, or food and fiber production and processing are basically the same in any community, State, or modern nation. Wide distribution and consumption of goods and technological services, and the mobility of highly skilled technicians further point to the importance of providing broad but thorough education in the technical courses for any technician.

Communications Courses

Technicians of all types must have competence in the communications skills. All must obtain information from publications, communicate with their co-workers, make oral reports, prepare formal or informal reports, and record test data or services. All must develop listening and oral communication skills if they are to become responsible people who will deal with ideas and concepts in their daily work. As they influence and direct the efforts of others they must have some competence in narrative or persuasive presentation.

Courses in communications skills provide instruction and practice in the use of grammar, spelling, composition, reading, comprehension, and vocabulary development, all directed toward written or oral presentation of data or concepts, clearly, simply, objectively, and concisely.

At least an elementary capability to graphically represent ideas, concepts, or data is important to technicians. Drawing, diagramming, and sketching is almost a second language between scientist and technician. Thus the communications and technical reporting courses usually devote some study to freehand drawing generally using squared paper and drawing aids. Elementary orthographic projection, the use of graphs and charts to portray information, and diagrams or sketches to illustrate apparatus, plans, or ideas are introduced. Formal drafting and engineering drawing are usually classed as auxiliary to the technical specialties courses.

The importance of communications skills to technicians can scarcely be over-emphasized. The ability or inability to communicate is almost immediately evident to employers and coworkers. Everyone expects the technician to be able to communicate as an educated person. Failure seriously affects interpersonal relationships and may significantly impede advancement. Special skills and perceptive use of communication are necessary for technicians who work with patients or clients in the health occupations or who enter sales or product service work.

Communication skills are usually taught in separate courses by professional teachers of the subjects, and should involve subject matter and examples related to the student technicians' interest as far as practicable. However, good communication practices should be emphasized by all instructors in all courses.

Social Studies Courses

A technician needs an elementary preparation in the social and economic aspects of living to help him develop an informed and socially acceptable understanding of and regard for *financial management* and *responsibility*, important *social organizations* and *person to person relationships;* as an individual, a member of a family, a citizen, and an employee. Limitation of time usually permits the inclusion of only 6 to 9 semester hours of such courses in a typical 2-year curriculum.

A course in elementary economics can teach the student something about the economic basis of productivity, management of his own personal finances, cost consciousness in his work, and taxation and governmental financing.

A course in organizations and institutions helps the student to understand his relationships as an individual, a member of a family, a member of an employer's organization, and a citizen.

Courses in person-to-person relationships are perhaps the most difficult to teach. They are directed toward teaching a student how to project and maintain a good impression with other persons, and how to relate more effectively to the various individuals or groups with which he works. Such courses must be taught as applied social and personal psychology. General, clinical, or educational psychology courses usually do not interest nor serve the particular needs of the student technician.

Elements of the social sciences occur in varying degree and emphases in the specialty courses in technician curriculums. Economic implications are stressed in all engineering related and agricultural technologies. Intelligent application of social psychological principles of behavior is necessary for all technicians who meet the public as technical representative of employers and is of paramount importance for success in all of the health technologies where patients are involved.

Unduly rigid interpretations of what constitutes a social science course in a technician program tend to obscure the total objective of the curriculum. It is more important that the necessary social science concepts and content be effectively included at an appropriate point in the program than to provide them exclusively in separate and isolated courses.

Social science courses should be taught by professionally qualified instructors who are well versed in the subject and sympathetic to the technician's program. Instructors who have had employment experience in technical or related work often can relate their subject to the student's interests most effectively. All instructors should stress and exemplify good practice in person-to-person relationships.

Cooperative Work-Study Programs

Some technician education programs are peculiarly adaptable to organized classroom and laboratory study in school, combined with carefully planned and coordinated paid employment experience in the field of specialization at appropriate intervals in the curriculum. This is commonly known as cooperative education or a cooperative program.

Cooperative programs for technicians offer special advantages to the student. Usually, they extend the length of the organized preparatory program, utilizing a summer period and often 1 or 2 quarters or more. Their principal advantage is that they provide real working practice in an environment the technician will experience after graduation. They make it possible for the student to use the equipment and perform the processes and services required of his specialty under close supervision and with responsibility commensurate with his capabilities.

While almost a necessity in some programs, cooperative education is beneficial to almost all technician students. The cooperative work experience must be carefully planned and closely supervised according to an official agreement with the agency where the student works. The agreement provides for a programmed sequence of duties to be performed by the student, with supervision responsibilities for the educational elements of the work clearly defined.

Usually two and sometimes three work experience terms, interspersed at appropriate times between school study terms, are required to obtain the best advantage for the student's learning process. The financial reward for his work often helps the student meet the cost of an important part of his educational program.

Cooperative work programs keep the total curriculum up-to-date and realistic because of the necessarily close relationship with employers, provide an almost automatic and highly effective avenue for graduate placement, and provide a motivation for students in the form of monetary returns as they learn their technical specialty and develop confidence in their competence on the job.

Some special administrative considerations in cooperative programs are:

1. Employment opportunities must be found with agencies sincerely interested in providing real educational work experience for the student. Agreements must be negotiated for scheduled work, supervision, and rates of pay.
2. Students must be available and ready to fit into the employer's organization at regular intervals and continuously so that the agency can have students at all times to do the scheduled work.
3. Supervisory and coordinative staff must be provided to plan the program of work and to visit, supervise, and counsel the students on the job. This work cannot be required of the staff in addition to a full-time teaching program at the school. Close supervision is required to help the students adjust to the work and meet reasonable expectations of the employer. The work

must never be allowed to become routine production or service work with little or no new experience in the technical specialty.
4. Students should be required to do a limited amount of organized study while on the job. Often this is a daily diary of work activity, an account of the week-by-week development of some technical aspect of the job, or a detailed analysis of the progress of some project on which the student worked.
5. The employer's evaluation of the student's work and attitudes should be sought and recorded with the objective of assisting the student, maintaining satisfactory relationships with the employer, and counseling both that student and others who follow him to the job in the important elements of success in an employment situation.

Cooperative work-study programs are growing in number. Further information on them can be obtained from National Commission for Cooperative Education, 8 West 40th Street, New York, N.Y. 10018.

The necessary clinical experience in a hospital or laboratory in the education of 2-year associate degree nurses and certain other health or social worker personnel is an educational experience similar to a cooperative work-study program but usually does not include pay for the student's work. It must be work experience *under the supervision of the school.* It provides the necessary equipment and working environment, including the professional personnel and patients, which would be difficult or impossible to provide in a school laboratory.

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