1969

INDUSTRIAL TECHNOLOGY EDUCATION

18

ACIATE

JAMES J. KIRKWOOD

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Relationships of 4-Year Technology Programs with Technical Training, Engineering and Industrial Arts Teacher Education

18 th Yearbook

American Council on Industrial Arts Teacher Education

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Industrial Technology Education

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Relationships of 4-Year Technology Programs with Technical Training, Engineering and Industrial Arts Teacher Education

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18 th Yearbook of the

AMERICAN COUNCIL OF INDUSTRIAL ARTS TEACHER EDUCATION

A Division of the American Industrial Arts Association
and the National Education Association

1969

Lithographed in U.S.A.

Yearbooks of the American Council on Industrial Arts Teacher Education are produced and distributed by the McKnight & McKnight Publishing Company, Bloomington, Illinois

Orders and requests for information about cost and availability of yearbooks should be addressed to the company.

Requests to quote portions of yearbooks should be addressed to the Secretary, American Council on Industrial Arts Teacher Education, in care of the publisher, for forwarding to the current Secretary.

Foreword

The Yearbook Committee and the Officers of the American Council on Industrial Arts Teacher Education decided in 1966 that the time had come to take a look at the rapidly growing area of study called Industrial Technology. Many of the Industrial Arts Teacher Education programs were adding this area to their responsibility. Dr. C. Thomas Dean, who administers one of these joint programs, agreed to gather together the authors and editors necessary to present this material to the membership in Yearbook form. Yearbook 18, 1969 is the result of this study. Over one-third of the colleges and universities offering industrial arts and industrial education programs for teacher education have, in the past few years, changed the name of their departments to include the term technology or industrial technology. Some of these departments just changed the name, most added a program of study to prepare students for positions in industry.

The question of the relationship of the area of Industrial Technology and Industrial Arts Teacher Education has been raised formally and informally at conferences and meetings of industrial educators across the nation. Yearbook 18 has been written to provide Council members, and other interested readers, background material on the area of industrial technology.

The authors have traced the development of the area. They have shown the relationship of industrial technology to industrial arts and engineering. Two-year and four-year technology programs are compared. Faculty, student body, and facilities are described. Program evolution and a look to the future for this area conclude the chapters.

The book takes a strong (and perhaps controversial) stand that industrial technology is a separate discipline in the area of industrial studies.

It confirms this separation of industrial arts teacher education and industrial technology by endorsement of a separate channel of communication for its faculties in the form of the recently organized National Association of Industrial Technology. This stand is taken with the full understanding that most of the persons teaching in this area are graduates of industrial arts and industrial education programs with teaching responsibilities in both industrial technology and industrial education.

This work should cause considerable thinking and searching for answers for members of the ACIATE. Should we further splinter our profession? Should the Council consider a broadening of its purposes and objectives to include the preparation of teachers for industrial technology? Can students in institutions with both programs take the same classes and then graduate with equal but entirely different skills and knowledge? Can teachers of the two areas, industrial arts teacher education and industrial technology, successfully "wear two hats" and effectively teach in both of these areas? This Yearbook should prove to be a most thought-provoking experience for its readers. The profession cannot turn its head and hope that the relationship of these two areas will take care of itself.

The ACIATE gratefully acknowledges the work of the editors and authors whose efforts and dedication have given the council and the profession a background of information on this phase of our expanding discipline. The Officers and Yearbook Committee hope this writing will contribute to the professional development of all in our field.

I would be negligent in my duty if I did not, once again, express the sincere appreciation of the council to the McKnight & McKnight Publishing Company for its contributions to our profession in underwriting the Yearbook program.

FREDERICK D. KAGY
President

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* 2. *Who's Who in Industrial Arts Teacher Education,* 1953. Walter R. Williams, Jr. and Roy F. Bergengren, Jr., eds.

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* 4. *Superior Practices in Industrial Arts Teacher Education,* 1955. R. Lee Hornbake and Donald Maley, eds.

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17. *A Historical Perspective of Industry,* 1968. Joseph F. Leutkemeyer, Jr., ed.

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Contents

Preface

Yearbook eighteen is an endeavor to reflect some of the various aspects relating to the academic area commonly termed Industrial Technology. Such programs have existed for many years, but did not really come into prominence until after World War II. Since that time the curriculum has become recognized as a fully legitimate four-year college and university academic program.

The changing concepts in engineering education brought about a vital need for an applied science approach to technological training. A large gap resulted between the technician, scientist and engineer. Industry was in need of people trained in the applied areas with a broad scientific, mathematical and business administration background.

During recent years, four-year technology programs have developed and are being well received nationally by business and industry. The programs are recognized also by other academic disciplines as being a very rigorous curriculum and acceptable for the four-year degree-granting institution.

Throughout the years there have been many educational leaders who have devoted considerable time to the growth and development of industrial technology. At the present time it is still developing and it is being placed within the academic programs of more and more colleges and universities. It was because of this rapid expansion and growing interest in industrial technology that this Yearbook was considered for publication. The American Council of Industrial Arts Teacher Education approved the publication because most of the industrial technology programs were instigated by the industrial arts departments. Many of the smaller schools were confronted with serious problems as there has not been a clear delineation of objectives and in some cases the program has not gained its full academic stature.

During the past five years two groups have attempted to study the area of industrial technology. These are the American

Vocational Association and the newly formed National Association of Industrial Technology. The American Vocational Association appointed a committee which did considerable work in developing material relating to the status of the discipline. This caused the leaders in the field to develop a professional organization on the national level. This association is the National Association of Industrial Technology with membership available for industrial technology faculty members, industrial technology students and representatives of industry who are interested in the area. The association should provide real impetus to the field of technology.

The primary purpose of this Yearbook is to review the philosophy and unique characteristics of the program. It is an endeavor to indicate the need for standards, teachers, facilities and accreditations and to sum up some of the happenings within the field.

The editors wish to express appreciation to their colleagues who have so graciously contributed materials to make this yearbook possible. We wish to thank our secretarial staffs for producing the typed manuscript for the publication. Without the assistance and understanding of colleagues, wives and friends, this would not have been produced. We hope that this publication will add much towards the development and growth of Industrial Technology.

C. Thomas Dean and Nelson A. Hauer
Editors

CHAPTER ONE

Technological Developments and Industrial Technology

BERYL M. CUNNINGHAM

Many economic, political, and sociological factors as well as mechanical inventions and technological refinements have influenced the development of American industry. It is not the purpose of this presentation to deal with all these elements but rather to present those technological changes that have had a direct influence on the operation of industrial enterprises and the development of industrial technology.

Since the beginning of American culture, impressive technological changes have occurred in the process of developing natural resources. These changes have greatly influenced the character of construction and mechanical industries and the development of industrial technology. By the application of art and science to processes of producing goods and services, these enterprises are involved in creating useful forms and transforming materials into products beneficial to human beings. They also give intelligent consideration to design, methods of construction, distribution, service, and education of the consumer in the utilization of manufactured products.

Producing a product requires the availability of men, machines, tools, materials, money, and management. These factors have an economic bearing on production in that they are scarce in relation to the demand for them and because each commands a cost. (1: 668) Although the factors of production may be used in many combinations to produce goods and services, utilization of one set of combinations may prove to be more efficient than any alternative arrangement. The more efficient arrangement becomes the prevailing method for the time being. But in a dynamic society, technological change may cause the prevailing method to become obsolete because of a change in the cost of the factors of production and because of the effects of increased technological knowledge and skill. Such developments may effect discovery of a new arrangement of the factors of production — men, machines, tools, materials, and management—which will then function more economically. This new arrangement takes precedence over former arrangements, resulting in either better utilization of the factors of production or in the development of a new product which better satisfies human wants. This type of change, known as "technological progress," has had a stimulating effect on the development of American industry. The objective of technological change has always been the increasingly efficient use of the factors of production, and, thereby, the production of more goods at the same cost or the same amount of goods at a lesser cost. (1: 668-9)

Because of man's unlimited human wants, he has always been confronted with the perpetual problem of finding ways to use the factors of production more economically in attempting to satisfy his ever-increasing wants. Technological progress has been man's only solution to this enduring problem. (1: 669)

Study of industrial developments in the construction and mechanical industries since the beginning of colonial days reveals the unbelievable technological progress achieved in these industrial areas and is an example of the technological achievements of American industry. These changes represent the successful efforts of man to gain control over environment and to improve living conditions. The difficulties encountered in effecting technological changes are indicative of how man persisted in his efforts to satisfy human wants; these also provide a basis for developing a more adequate concept of industrial technology and for determining significant implications for present-day educational programs.

Each of the historical periods of technological change affecting the development of industrial enterprises has no specific set of dates that defines its beginning or ending. Because of the evolutionary nature of these periods, there is an overlapping in their time span. For convenience in presenting the long historical span of technological progress made in the construction and mechanical industries, the time is arbitrarily divided into five separate periods:

1. Domestic Production .... to 1740
2. Factory System 1740-1800
3. Mechanical Power 1800-1880
4. Mechanization 1880-1950
5. Automation .... Since 1950

DOMESTIC PRODUCTION PERIOD — TO 1740

A notable scarcity of the means of producing goods existed in early colonial days. Because of the abundance of land and the scarcity of labor and capital, many of the colonists preferred to settle on small plots of land to do independent farming rather than to work for an employer. (16: 53)

Method of Producing Goods

One of the earliest forms of producing manufactured goods was domestic production. Under this system the industrial enterprise was a rather simple organization. Production of goods and services was under the direction of the owner who performed all the functions of the enterprise in his home. Practically every family was a self-contained unit, producing goods primarily for home consumption. Sometimes goods were made for a particular consumer, and infrequently a limited amount was for general sale. The goods were of a simple homemade quality and were necessarily limited in variety. (8: 98)

Small production shops also flourished during this period. The average colonist could neither produce the manufactured articles required to meet his needs nor did he have the money to purchase goods from Europe. But he did have produce to trade. To satisfy this need, shops sprung up in every seaport and urban settlement. An artisan who was able to supply adequate tools and skills specialized in a particular craft. He was usually a person who took pride in high quality workmanship. Located in the colonial towns were such artisans as shoemakers, tailors, clothmakers, cabinetmakers, silversmiths, printers, gunsmiths, hatmakers, carpenters, glovemakers, goldsmiths, pipemakers, saddlemakers, wheelwrights, weavers, coopers and brickmasons. As a consequence, a large amount of the production of manufactured goods was done in either the home or in small workshops.

The supply of artisans for the shops was maintained through the apprenticeship system which was either voluntary or compulsory. The voluntary apprentice entered into a contract with a master craftsman or artisan who had the ability and willingness to teach his craft. The compulsory apprentice was usually a poor child who was bound out as an apprentice by officials of the community to place him in a better home environment and to provide for his proper maintenance. (6: 268-9)

Apprenticeship

The apprenticeship system filled a very essential need as an educational agency in the American colonies. In each type of apprenticeship the master craftsman was responsible for teaching the apprentice the arts, mysteries, and skills of the craft and, in addition, arithmetic, reading, and writing, and the social and moral principles established by the community. If the master craftsman was unable to conduct the educational program stated in the contract, he was required to send his apprentices to school for instruction. Many schools were conducted in the evening because master craftsman did not want to sacrifice working hours for the education of the apprentice. Rather severe penalties were imposed on the apprentice or master craftsman in the event either did not comply with regulations set forth in the contract. (28: 53-6) The term of apprenticeship was usually seven years. At the end of the period, the master craftsman made a public statement as to the accomplishment of the apprentice. If his endeavors had been satisfactory, the apprentice was allowed to practice his craft. If not, by mutual agreement he was permitted to extend his apprentice contract in an effort to meet the standards required by the master craftsman. The apprenticeship system was under strict supervision of community officials who did not permit it to be a means of exploiting the apprentice but rather a means to providing an educational program and trade training for the colonists. (32: 55-7)

With the passage of time, the economic status of the colonists improved and the demand for manufactured goods increased to the extent that home production and artisan shops were taxed beyond their capacity to satisfy the demand. Some home industries enlarged their operation and produced goods for the general market, and artisan shops began making articles for general sale rather than doing custom work. This increase in demand for manufactured goods led to the development of the factory system. (1: 648)

FACTORY SYSTEM — 1740-1800

Even though domestic and craft methods of production had become obsolete, development of the factory system moved very slowly. The colonists possessed little of the necessary means for operating an industrial enterprise under the factory system. They lacked the necessary equipment and skilled labor needed to produce manufactured goods as well as the managerial knowledge and ability to utilize men, materials, and tools economically. Therefore, the factory system did not emerge quickly. (34: 40)

In the beginning, the merchant-capitalist farmed out work to home production industries that specialized in the various types of work required to produce the desired goods. This method proved to be unsatisfactory both economically and socially. Often working conditions were unhealthy, women and children were exploited, waste was caused by careless workers, adequate supervision was difficult, and a great amount of time was lost in carrying work back and forth between specialized production centers. When the demand for high quality goods became sufficient, the entrepreneur attempted to solve these problems by bringing the production activities together in one building or factory. Here he supplied all of the facilities for production such as money, men, tools, and raw materials. Also, he could closely supervise the total operation.

By the beginning of the American Revolution, mills for cutting lumber and grinding grain and factories for making paper, glass, and iron were expanding rapidly in size. These industries were operated by water power and were of necessity located along streams that provided a dependable source of power. However, windmills were used in areas where water power was not available. These mills and the iron industries required a large investment in physical facilities as well as the employment of a considerable number of semiskilled workers. Particularly was this true for the manufacture of iron and steel. But the demand for iron and steel products attracted so many business men to pioneer in the field that by 1880 more blast furnaces and forges existed in America than in England. (39: 60-1)

Division of Labor

The factory system was a major technological accomplishment in the development of the early industrial enterprise. It was based on intelligent methods of organization and operation which resulted in increased efficiency, productivity, and profit. The economic soundness of the system made financial aid more readily available as it was considered to be a relatively safe investment. Labor could also be used more effectively by dividing work according to the nature of the jobs and the abilities of workers.

The division of labor and improved arrangement of facilities increased production efficiency of the factory. Assignment of small units of work permitted the worker to quickly become proficient in performing his task; production became a continuous process through improved arrangement of the flow of materials. The amount of labor required was reduced by eliminating the necessity of moving stock long distances between work stations, and the reduction of human energy increased the rate of production. As the factory grew in size, an increased division of labor and better arrangement of facilities were possible and, therefore, more efficiency was achieved.

Management Concept

Two new social groups were inherent in the factory system, namely, management and labor. The relationship between these two was that of buyer and seller, in which the manager was a buyer of services and the worker was a seller of services. The manager or entrepreneur provided all of the physical means for producing goods. He was also the sole owner of the goods produced and could dispose of them in any way he wished. In addition, the entrepreneur was free to employ the services of workers to carry out the activities for producing goods. The wage paid to the worker was on the basis of supply and demand, and the amount paid was determined by the level of the labor supply at that particular time. Since the purpose of employing workers was to make a profit, it is obvious that the manager through his bargaining advantage kept wages to a minimum. Although the worker was free to reject the wage offered, he was forced to accept it out of dire economic need. After the wage was paid, the entrepreneur had no further responsibility to the worker. Neither was he responsible for the conduct of the worker outside of employment hours nor for his support when no work was available. It is evident that under the factory system, the manager was in a strong bargaining position. Owning the factory, tools, and raw materials for producing goods, and feeling no personal responsibility to the workers, the manager was in a position to effect a favorable agreement on wages. The relationship of bargaining power between management and labor has continued to be a dominant problem of the industrial enterprise. (26: 43-5)

The era of the factory system ended with the emergence of a new type of manufacturing process. Machines were being invented to take the place of hand tools and power devices were being developed to operate the machines. When these mechanisms were developed to a stage of practicability, industrial production entered the new era of mechanical power.

MECHANICAL POWER AND MACHINE PERIOD — 1800-1880

The development of machines utilizing mechanical power was an instrumental factor in the growth of industrial production. Goods were produced by mechanical rather than manual power. Fortunately, the organization of the factory system was easily adapted to mechanical power and machine techniques of production. The factory system had been established on the economic concept of fixed capital and free labor. These basic principles of organization and management created the conditions compatible for the utilization of new sources of power and machines for producing industrial goods without disrupting the basic structure of the system. The inherent nature of the factory made industrial technological change a natural process of growth.

The system emerged as an evolutionary process and made relatively slow progress at the beginning. Growth was limited by the need for efficient mechanical power, new improvements in production machines, increase in the number of inventions, better means of supplying the demand for industrial machinery, and a need for more capital for industrial investment.

In spite of the many difficulties accompanying the development of industrial production in this era, the people of the new nation were experiencing a national self-sufficiency which motivated them to forge ahead in the creation of strong industrial enterprise systems. After the development of a commercially suitable steam engine by James Watt, industry began to flourish. Much greater emphasis was placed on the use of steam power when Oliver Evans invented a high pressure steam engine to which George Corliss added mechanical changes that improved steam economy. (1: 651)

The textile industry was one of the first industries to be developed. The invention of the cotton gin by Eli Whitney and the building of the equipment and the setting up of the first spinning mill by Samuel Slater gave impetus to the industry. In 1813, Francis C. Lowell perfected a new power loom and established the first mill for weaving as well as spinning. (12: 180) By 1815 millions of dollars had been invested in the textile industry and over one hundred mills were operating in America. (8: 481) Many other industries were expanding at a similar rate; after 1815, the growth of industrial enterprises was even more phenomenal.

Along with the rise of the textile industry evolved the manufacture of clothing. Machines were used for producing ready-made clothing as early as 1836. The invention and improvement of the sewing machine by Howe, Singer, and others gave further stimulus to this industry. (8: 482)

Even though the iron industry made noteworthy growth under the factory system of the preceding era, it continued to experience even greater expansion. The manufacture of goods by machinery increased the demand for metal. (8: 483) Metal was used for making production machines to equip industrial plants and for producing an unbelievable amount of goods for public consumption. Millions of dollars of machine tools were purchased to equip the plants of manufacturing enterprises. In 1850 these industrial enterprises produced in excess of one billion dollars of manufactured goods and by 1860 the annual production was approximately two billion dollars. (12: 274)

The phenomenal growth in the demand for metal created a need for technological changes in the methods and techniques of production and utilization of iron and steel. Some of the principal technological improvements include the use of coal as a fuel in the blast furnace, development of the rolling mill process, adoption of the puddling process for refining pig iron, installation of the closed furnace, utilization of castings for large peculiar shapes, installation of large steam hammers and heat-ing furnaces in heavy production forge shops, and refining the blast furnace product by use of the Bessemer and open-hearth methods. (39: 413-7)

One of the factors giving impetus to the rapid technological progress of the period was the inventive ingenuity of the people of America. Some of the innovative events which had a great influence on the lives of the people were the development of agricultural machinery, invention of the electromagnetic telegraph, improvement of the steam engine, invention and perfection of the incandescent electric light, development of the first practical typewriter, discovery of the method of vulcanizing rubber, introduction of the rotary-cylinder press for printing, invention and perfection of the sewing machine, invention of the telephone, invention of the machine lathe and the screw-cutting machine, and the invention and manufacture of precision measuring tools such as the vernier caliper, vernier protractor, American wire gauge, and micrometer. These and thousands of other industrial technological creations had a beneficial effect on the social and economic life of the people.

Interchangeability of Parts

The production principle of the standardization of parts and interchangeability of mechanisms, which is the basis for mass production, was originated during the early part of this industrial period. There is some question as to who conceived the idea, but Eli Whitney is usually given the credit. He was the first person to see its practicality and application to industrial production. In 1807, he initiated the use of the principle in the manufacture of firearms. (16: 259) By the use of jigs, fixtures, templates, and gauges, he was able to produce identical, interchangeable parts in quantities on automatic machines which he had invented. Once the practicality of the principle was demonstrated in the production of firearms, it was soon applied to the manufacture of many other kinds of goods such as agricultural equipment, machine tools, clocks, shoes, production machines, hardware, ready-made clothing, and household items.

With the improvement of machines and the development of precision gauges and measuring devices, greater accuracy was achieved. As a result, the concept of the interchangeability of parts took on a new meaning with the passing of each decade. (39: 245-7)

Development of the Labor Movement

Labor has always presented a perplexing problem for the industrial enterprise. Even before the formation of organized groups, people in the workshops complained about working conditions. But with the growing complexity of the industrial enterprise the labor problem became more acute. Ownership of the industrial concern was no longer in the hands of one person who operated it, but in the hands of many people who employed a managerial group to operate the business. (35: 4) In other words, the managers were those people who carried out the management process and were responsible to the owners, and the owners were the people who held the title to the property and supplied the capital.

This type of organization provided little opportunity for personal contact and created a relatively impersonal relationship between the worker and the manager. This situation, along with the emergence of machines and the division of labor, had a serious psychological effect on the worker. Not only did he work for a depersonalized, bodiless and often conscienceless corporation with which he held little bargaining power, but felt he was rapidly becoming a slave to the machine in a giant organization. Physically, he did not fare too well either. His general working environment was deplorable. Plants were poorly lighted, heated, and ventilated, and the worker was required to work laboriously for excessive hours at a low wage. Even at a time when industrial enterprises were prospering, he was not permitted to share proportionately in the profits. To survive, he had to accept work on the terms offered. (13: 73)

Under these conditions workers became aware of the need for more bargaining power. Finding themselves ineffective individually against giant industry, they realized united effort was necessary in order for them to secure better working conditions and improve their economic status. In spite of unfavorable labor legislation and lack of support by many workers, bold leaders persisted in their efforts to organize local craft unions. (26: 48-9) Even though these organizations experienced many problems, by 1864 the number of local craft unions had increased sufficiently that they were able to organize separate national craft unions. (16: 437) Nationally organized trade unions included such workers as blacksmiths, bricklayers, carpenters, hat finishers, iron molders, machinists, painters, plasterers, printers, stone cutters, and shoe workers.

Labor leaders and people interested in social reform recognized that labor divided into so many separate trade unions would never be able to present a solid front. These people advocated the formation of a united labor organization. In 1866, delegates from local unions, trade associations, farm groups, workingmen's associations, and many social reform organizations met in Baltimore. At this meeting the National Labor Union was organized. Annual meetings were held until 1872. (39: 612-3) The organization was then dissolved because of inability to satisfactorily reconcile the variety of problems raised by such diverse groups. Although short lived, the organization made valuable contributions to labor. It helped workers to see that a national labor union was essential if labor's demands were to receive serious consideration, and it gave birth to the modern labor movement.

Decline of Apprenticeship

The decline of apprenticeship began when mechanical power and machines were initiated for the manufacture of industrial goods and became more pronounced with the increased use of additional labor-saving machinery. The workers in these plants were placed in three categories, namely, unskilled laborers, machine operators, and highly skilled mechanics. Unskilled laborers and machine operators needed little or no training for their jobs, but the skilled mechanics needed several years of apprenticeship training. The utilization of machines reduced the number of skilled laborers required for production, but greatly increased the number of machine operators and unskilled laborers needed. (28: 62) There was little incentive for boys to go into apprenticeship training. Their entrance into industrial employment was commonly as a machine operator. Many boys possessed sufficient mechanical aptitude so that after working a relatively short time as machine operators they had acquired the necessary skills needed to advance to a position which usually required special training. The ease with which boys could obtain employment, along with the opportunity to advance to good positions while working, were the immediate causes leading to the breakdown of apprenticeship. As a result the mechanical power and machine period ended without apprenticeship or an adequate program for training skilled industrial mechanics. (28: 66)

After the close of the Civil War significant technological changes related to industrial activity encouraged rapid expansion of the construction and mechanical industries. Enactment of legislation favorable to industrial enterprises, invention and improvement of machines and processes, refinements in the division of labor, change in the organization of management, and the utilization of the principle of interchangeability of parts as a basis for mass production and assembly line methods were major factors responsible for a prosperous economy and the emergence of the era of mechanization in American industry.

MECHANIZATION PERIOD — 1880-1950

The era of mechanization was a period of unprecedented growth in population and wealth. Both of these factors created a greater demand for more and more goods of a homogeneous nature which could be manufactured more economically by mechanized processes. But mechanization required large capital outlay for expensive equipment. Even so, the market justified the unparalleled rise of huge industrial enterprises equipped to create goods by mass production. (39: 498-9)

Mass Production

Mass production is a complex concept which means more than making articles in large quantities. It involves the total process of producing goods by using standard materials, practical designs, and quality workmanship based on production principles of speed, power, accuracy, system, continuity, and economy. The achievement of these factors is necessary to produce a quality product. Therefore, the efficiency of mass production is measured by the quantity of quality goods that are produced at a given cost. (39: 496-7)

In a healthy economic environment, mass production is a gradual process of development and refinement. Progress is dependent not only on invention and refinement of machines and tools, and on discovery and improvement of materials and processes used in producing goods which are in sufficient demand but also on efficient management of an economically planned industrial enterprise. (33: 150)

Progress in mass production was made possible by the worthy contributions of the machine-making industries. In addition to making general machine tools, they also manufactured specialized and diversified mechanical equipment required for producing and assembling interchangeable parts. This equipment included such items as special purpose tools, automatic machines, turret lathes, multiple drills and general machine tools which were located in a position necessary for performing successive operations as the material passed from one work station to another. (39: 508-12)

The progressive system of assembly was another innovation that improved the mass production system. By organizing work stations along an assembly line, all the various parts going into a mechanism were brought together at proper locations along the assembly line, and were fitted into the partially assembled mechanism as it reached a particular station. This technique proved to be an economical means of assembling mechanisms composed of a large number of parts. It was first used by the automotive industry, but was soon applied to the manufacture or industrial products. (39: 513-6)

National Labor Organizations

After the National Labor Union was dissolved in 1872, several labor groups attempted to establish national labor organizations, but the American Federation of Labor was the only one that was successful. It was organized in 1886, and was a federation of national trade unions whose members were skilled tradesmen. (12: 382-4) In spite of bitter opposition by management, the A.F. of L. made steady progress. Workers commenced to look to labor leaders for help in solving their problems rather than to management. Labor began to achieve success at the bargaining table and started efforts to gain a larger share of the profits of industry for the workers. Labor also began to receive favorable recognition from the Federal government. The National Recovery Act of 1933 gave labor the right to organize and bargain collectively, and restricted the right of management to interfere with union activities. (26: 50)

During the depression years following the economic crash in 1929, dissention developed within the leadership of A.F. of L. about organizing mass production workers. Most leaders preferred to keep the A.F. of L. as a skilled trades organization, but, in 1935, rebel leaders formed within the A.F. of L. the Committee of Industrial Organization, admitting to membership all workers in an industry. Three years later the group pulled away and reorganized under the name of Congress of Industrial Organizations. (6: 769-70) The federation quickly, and apparently permanently, established itself in the giant automotive industry and soon became the sole bargaining agency for its employees. Within a relatively short time, unskilled workers pressed their advantage and soon organized the workers in practically every industry. With the assistance of the National Labor Act of 1935 and other federal legislation, organized labor has strengthened its position by placing responsibility on management for financing the cost of improving working conditions, increasing wages, providing greater security, reducing working hours, improving health and safety conditions, providing welfare and pension programs as well as other fringe benefits. Financing these benefits naturally increases the labor costs of producing industrial products. (12: 579-80)

Production Management

The cost of producing an industrial product is directly proportional to the efficiency of the industrial enterprise. The quality of management is one important factor in determining production costs. This factor increased in significance as manufacturing plants became more highly mechanized. (1: 672) At the close of the nineteenth century a system of industrial management was initiated by Frederick Winslow Taylor at the Midvale Steel Company in Nicetown, Pennsylvania. He believed that scientific management related productivity to morality and well being, to the habit of doing what is right, and to orderly procedure and mechanical efficiency. At first, technical management was applied only to technical problems of production. Its function was to assure a smooth flow of planned production by the utilization of art and science in planning, organizing, and controlling component parts of the production process. Effective arrangement of machines, tools and materials was necessary if standardization and mechanization were to function most efficiently in mass production. Consequently, extensive studies were made of machines, tools, materials, methods and skills. Analyses involved the procedures required to perform the job, operating time of the machine, manual movements performed, and degree of skill required to operate the machine. In making a study all the factors applicable were kept constant except one which was varied according to the problem being studied. The data obtained was used to establish the most effective means of getting maximum output and quality. Workers were then placed in positions where they could be most efficiently used. The simplification of work and subdivision of labor permitted the use of skilled tradesmen at tasks they were particularly qualified to perform. Work of an unskilled nature was assigned to unskilled employees at a lower wage. (35: 90-4)

Taylor also recognized the importance of the human element in management. He believed the manager should not only scientifically select and train employees to perform the specific duties of the job, but also create cooperative attitudes in order to maintain a wholesome working atmosphere. (35: 91) However, it was not until about 1930 that industrial enterprises began to place much importance on the human factor, at which time management began to take on a new dimension. (1: 658) Industrial enterprises realized that their success was dependent on competent managers who possess the ability to plan and organize work and, in addition, to enlist the cooperative efforts of employees in achieving the goals of the organization. Better scheduling of work, programing of maintenance, reducing amount of transfer of materials, frequent inspection of materials in process, closer supervision of work stations, providing adequate communication to employees, and building a mutually cooperative work force are some of the responsibilities of a good technical manager. The need for efficient technical managers increases when technological progress is made. (1: 672)

Beginning of Technical Education

Technological changes occurring in manufacturing industries were creating new types of jobs. To fill these positions employees needed more technical knowledge related to mathematics and science than that required of a skilled tradesman. As a result of this evolving need the present concept of technical education emerged. (22: 8) Some writers believe the movement started in the Gardiner Lyceum at Gardiner, Maine, in 1821. (32: 114) However, the first recognizable technical education programs did not appear until the last decade of the nineteenth century. Two of the schools starting programs during this decade were Pratt Institute (37: 67) in 1895 and Bradley Polytechnic Institute (9: 97) in 1897. Both had two-year college-level programs. The programs in technical education were not vocational education; neither were they engineering. The level of instruction was different from vocational education and the content and method were different from engineering. The curriculum was designed to meet the needs of mature students who planned to enter industrial employment after graduation, and was composed of integrated courses of mathematics and science, theory in technological areas, laboratory experiments and related shopwork. (22: 17)

During the first half of the period of mechanization, progress in the development of technical education was slow. Apparently educators were not aware of the rapidity of technological change or its effect on educational progress. Too little research was done to learn about the nature of evolving employment needs of industry and to determine the curricular program needed to prepare workers for these new positions. Another problem was the lack of suitable instructional material. Book companies experienced difficulty in interesting authors in writing textbooks which met the unique requirements of technical education.

Four-year industrial technology programs made little progress during the era of mechanization. Prior to 1950 industrial technology programs existed in only six institutions of higher education, namely, Alabama A. & M. College, Arizona State University, Bradley University, Kansas State College, Southern Illinois University, and West Virginia State College. (20: 1)

The Last Decade

As the demand for industrial products increased and as better facilities became available through the discovery or invention of such things as the steam turbine, gasoline engine, diesel power, electrical and electronic power, atomic energy, automatic machines, and precision measuring devices, the manufacturing process became more highly mechanized and more efficient. At the same time the industrial enterprise became more complex in organizational structure and management. It was fortunate that American industrial enterprises had developed such high degree of skill and efficiency in mass production and was able to meet the challenge presented by World War II.

Approximately the last ten years of the era of mechanization was devoted principally to producing military goods for World War II and to a period of readjustment to civilian production. During this time some very dramatic situations were created. Manufacturing industries went on a wartime basis and operated under the direction of the War Production Board. (19: 388) This Board reduced the amount of raw materials available for production of nonessential goods, reduced employee purchasing power through an enforced savings plan, standardized production methods, made product assignments to qualified industrial enterprises, established production quotas, and eliminated competition by freezing wages and prices of civilian goods and by putting government contracts on a cost-plus basis. When it was not feasible for industrial enterprises to contract for certain jobs, a government agency built plants to develop and produce goods (as was the case with synthetic rubber.) (12: 643)

The production achieved by manufacturing industries was amazing. For example, the government requested a production rate of 50,000 airplanes annually. Such a figure seemed to be beyond reason but, in 1942, 47,000 planes were produced and in 1944 the annual rate increased to more than 96,000 for a total output of 297,000 airplanes. Manufacturing industries set an equally impressive record in the production of other essential goods. (12: 643)

Readjustments after the close of the war created perplexing problems for manufacturing industries which required rather difficult economic decisions. On the positive side, there was tremendous demand for civilian products, and purchasing power was strong because of high employment and enforced savings during the war years.

On the negative side, inventories were at a minimum because of restrictions on raw materials allocated for civilian goods; industry had to retool for the manufacture of these goods and at the same time develop new products in fast-growing industrial areas such as electronics and plastics; increased appropriations were necessary for research and development; and labor through its strong bargaining power was being granted higher wages and greater fringe benefits. These factors were having an adverse effect on production costs and hastened the advent of the era of automation.

AUTOMATION PERIOD — SINCE 1950

Although technological change has been a major theme in the development of American industry, never before has it been so rapid nor more significant than in the past two decades. In the effort to meet civilian demands for industrial commodities, two basic elements were of greatest concern to industrial enterprises. One was the fantastic increase in labor costs and the likelihood that they would continue to rise. There was little doubt that solidly organized labor unions which had government sanction would continue to demand higher wages and expanded fringe benefits. Industrial enterprises soon became aware that rising labor costs would eventually price their product out of the market unless more efficient methods could be devised to produce commodities at a price acceptable to the consumer. The other element was the realization that the rate of production could no longer be increased with general-purpose machinery. During the war years the speed and operating capacity of this equipment had been expanded to its limit. (21: 3)

Concept of Automation

The solution to the problem, though not easy, was the creation of a new concept in the operation of the construction and mechanical industries known as "automation." Broadly conceived, automation is an integrated means of doing work through the use of self-operating devices based on information processing and self-correcting controls. (13: 155) Automation permeates all the activities of the industrial enterprise and requires new types of facilities designed around the peculiar characteristics of the work to be performed. The application of automation in producing goods are commonly classified under four headings, namely, automatic machinery, integrated material handling and processing, electronic computer, and data processing equipment. (1: 677)

These highly sophisticated facilities were made possible by relatively recent discoveries, inventions, and developments in technological fields involving automatic machinery, computerized systems, closed televison circuits, electronics, fluidics, hydraulics, instrumentation, measuring and sensing feed-back systems, numerically controlled machines and mechanisms, servomechanisms, and other related technological innovations.

Automation proved to be, at least, a partial answer to the production problem. Even with rising labor costs and heavy expenditures required for capital equipment, the increase in the rate of production reduced manufacturing costs per unit enough to enable industrial enterprises to keep the price of manufactured goods in line with purchasing power and still make an adequate profit.

Production costs were reduced in various ways such as increasing operating speeds of precision made machines; increasing production accuracy by using precision measuring and sensing gages and instruments; improving inspection techniques; reducing waste materials and parts; using improved methods of positioning parts to be machined; initiating preventive maintenance systems to determine when a machine, tool, or component is beginning to function improperly; using closed-loop feedback systems to maintain uniform performance of machines, tools, and components; and reducing lag time between machining operations. (2: 123-6)

These and many other innovations have produced major improvements in the performance and durability of consumer goods. The uniformity of interchangeable parts manufactured by precision mass production creates components and mechanisms that are of higher quality than was previously possible. For example, improved quality of materials, accurate machining, better finish on contacting surfaces of moving parts, reduced tolerances, improved lubricating techniques, and improved lubricants are some of the technological changes that enhanced the operating qualities and durability of the internal combustion engine. Some commodities give better service than formerly without any appreciable increase in price. The automobile tire is an example. Fifty years ago a 3½ by 30-inch tire guaranteed for 5,000 miles cost approximately twenty-five dollars; today, a much larger tire, 8.25 by 14-inch costs practically the same. It is guaranteed for thirty-six months and should with proper care run 25,000 to 30,000 miles. (1: 660) Electricity is another example in which the unit cost has remained almost constant.

Employment Opportunities

The technological developments in automation are affecting the educational requirements for employment in industrial enterprises. The utilization of automatic equipment is creating many new jobs necessitating the need for further division and subdivision of labor to operate the enterprise economically and efficiently. Automated facilities are doing the work formerly performed by both skilled and unskilled workers. And the new jobs require specialists that have the technological knowledge and skills needed to keep the complex production system in operation. There is, also, an ever-increasing need for more effective management. The new type of manager needs a strong technological background in addition to a knowledge of human relations and skill in coordinating the efforts of people. These technological changes are rapidly raising the educational background of the total workforce in the industrial enterprise.

Automation is affecting the structure of industrial enterprises. Changes in educational requirements, rising labor costs, rapid obsolescence of processes and products, increasing costs of automated equipment, and the accompanying complexity of organization have caused industrial enterprises to re-examine their organizational structures to determine whether they apply to the new conditions.

In discussing this problem, some industrial executives indicate an organizational structure is evolving which would permit highly specialized functions to be performed economically and efficiently. Such structure includes organizational divisions of administration, research and development, and industrial technology. Although each division has its own specific functions, all three divisions are interrelated and each is dependent upon the other for the successful operation of the enterprise. The interrelationship of these divisions and their functions are shown on Chart I, Divisions and Functions of Construction and Mechanical Industries.

Administration. The division of administration is a complex organization which defines the major goals of the industrial enterprise and plans for their achievement. It develops controls needed for the integration of its many facets into a unified and efficient organization. It also formulates policy, establishes major projects, and defines broad programs in addition to giving overall direction to such functions as finance, production, public relations, research, sales, education, and other major operations. (18: 15)

Research and Development. Competition among industrial enterprises is strong and keen. Among these enterprises there

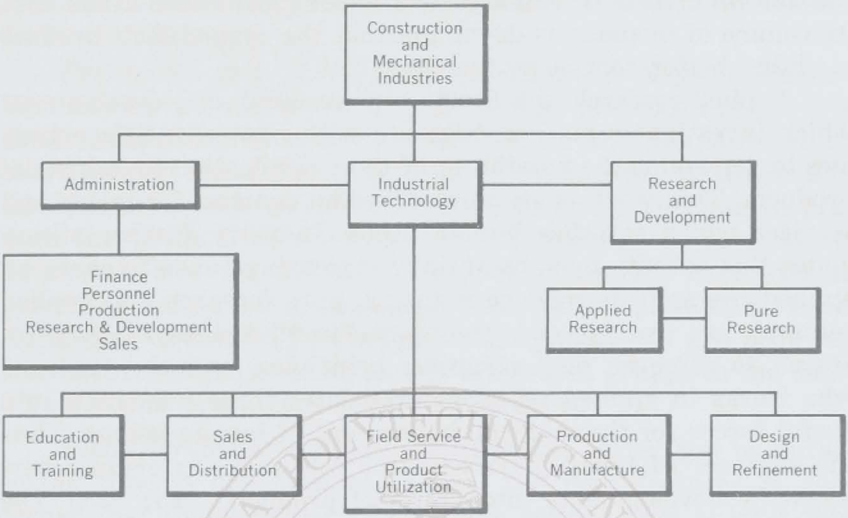

Chart 1. Divisions and Functions of Construction and Mechanical Industries

exists a great desire to produce a product that better satisfies the needs of the customer. Competition also demands the creation of new products, a factor which develops obsolescence. Today, the rapidity of obsolescence is a major problem confronting industrial enterprises. This factor has tremendous effects on industrial organizations. As a result, research and development in industry has been reorganized into two major functions, namely, pure research and applied research. Pure research is concerned with the discovery of new scientific principles and techniques which enlarge the field of knowledge.

Because of competition, industries can no longer rely solely on institutions of higher learning to do the amount of pure research needed. Therefore, industry employs large numbers of scientists and provides large, well-equipped laboratories in which these scientists do their research.

The scientist's efforts are directed toward finding truth, but he is not necessarily interested in the application of truth. (23: 382) As a result, increased emphasis is placed on applied research by industry. This emphasis is necessary because of the rapidity with which newly discovered scientific principles are applied to industrial products. The industrial enterprise that reduces its efforts in research and development soon finds that its volume of business is down and that the competitor's product is giving better service to the consumer.

Applied research is a function of research and development which investigates and experiments with new scientific principles to determine the possibility of their application to industrial products. This work is stimulated by the demand for goods and services which satisfies human needs. Industry further stimulates this activity by substantially increasing funds to carry on applied research. In modern industry, pure research and applied research are closely related. The scientist engages in pure research to discover new scientific principles, and the engineer who works in applied research, translates these principles into useful forces for the material betterment of human beings. Thus the engineer of today plays a major role in transforming new scientific developments into practical products. (25: 23) The accelerated pace at which these scientific advancements are occurring gives evidence of the need in industry for engineers who can carry out complex programs in the division of research and development. Engineering must keep pace with the new developments in science. Today, the engineer needs a rigorous program in mathematics, physical sciences, and engineering sciences if he is to be proficient in interpreting new scientific principles and applying them in the creation of new processes, new products, and new systems as well as altering existing ones.

Industrial Technology

The division of industrial technology is composed of the areas of design and refinement, production and manufacture, field service and product utilization, distribution and sales, and education and training.

Design and Refinement. The work of design and refinement begins after the engineer's idea for a product is conceived. The industrial technologist refines the design of the product to make it saleable and serviceable as well as profitable for the manufacturer to produce. In the process, the designer constructs and evaluates models for their aesthetic and functional qualities. These prototypes are usually tested extensively to determine the service they will give the customer. In addition, the designer makes detail, assembly, and pictorial drawings and renderings. Also, he designs special tools and fixtures, suggests policies for the use of such things as forgings, castings, and die-formed parts. (5:13)

Production and Manufacture. Production plays an important role in the making of a product. The procedure requires a detailed step-by-step analysis of operations and processes which must be performed. Special tools, gauges, jigs, fixtures, and machines are made to meet the necessary requirements to produce the product. A schedule for the routing of materials is developed, and the manufacturing facilities are arranged to permit an easy flow of materials through the production lines. According to carefully developed plans, materials are acquired and workers organized into closely integrated groups in the manufacture and production of the products. (5: 14)

Field Service and Product Utilization. After the manufacturing process has been completed, the manufacturer is concerned that the customer receives the service that is built into the product. For this reason, the manufacturer provides field service which involves diagnosis, correction, and testing as well as instruction in product utilizations and adaptation. Diagnosis requires the use of knowledge, techniques, procedures, methods, equipment, and skill to determine the cause of malfunction. After analyzing the data obtained from the investigation, the proper corrective procedures are initiated. The correction may range from a simple adjustment to one so complicated as to require complete disassembly, replacement of a part or complete component, reassembly, and final adjustment. The product is then tested to determine whether it operates properly. In the event it cannot be made to perform satisfactorily, it may be necessary to refer the product back to design and refinement or even to research and development for further study and alteration of design. (5: 14-5)

Distribution and Sales. Distributing the industrial product to the consumer is an important objective of the industrial enterprise. In a large company the work of distribution and sales is a massive and complex operation. The duties in the areas of distribution and in the field service may frequently be overlapping as well as cooperative. For example, the field service representative frequently has an opportunity to suggest to a dealer ways and means for increasing sales of the product. Likewise, the sales representative, who possesses technical knowledge about industrial products and manipulative skills, may assist the dealer in solving field service problems.

Education and Training. The increasing number of changes and developments occurring in modern industry makes education and training an essential part of the industrial process. This educational facility prepares recruits to fill vacancies, upgrades employees in their present positions, and grooms others for promotion to more responsible positions. It also helps to keep employees informed about new industrial processes which makes transition within the enterprise smooth and continuous.

Technical Manager

Basically, the technical manager performs his managerial duties in the industrial technology division of industry and in educational programs in the field of industrial technical education. (10: 31) Managing the operational functions of industrial technology, utilizing and maintaining automatic, interacting devices demands critical thinking on a high level. The technical manager needs a good understanding of human relations and principles of management as well as ability to direct the efforts of people in achieving the goals of the industrial enterprise. The extended use of computers, electronic data processing equipment and electronic communication systems along with other developments in automation necessarily continue to accelerate this trend in management. Reliable sources predict the need for more employees with managerial training in the next decade. (13: 160)

In order to be effective in the area of technical management, the manager needs to develop three basic skills, namely, technical, human, and conceptual. (35: 276) Technical skills are concerned with effective utilization of methods, procedures, and techniques involved in a technological field of specialization and related fields. Through the use of this skill and a knowledge of machines and materials, the manager is able to determine the equipment and the organization required for handling materials efficiently.

Human skill involves effective utilization of manpower to achieve the objectives of the industrial enterprise. A knowledge of human relations and the ability to apply this knowledge are required for the manager to get his workers to perform willingly the duties of their job assignments. A spirit of mutual cooperation exists between the manager and workers when human skill is expertly performed.

Conceptual skill is the ability to visualize the various programs of the enterprise. The successful manager is able to visualize the operation in a particular field, to see the relationships of his department with other departments, and to evaluate the work of each.

The people engaged in technical management perform four functions, namely, planning, organizing, actuating, and controlling. Planning is a process of deciding what is to be done in the future. Creativity, imagination, and foresight are required to select and relate information to new situations and to propose activities necessary to achieve a particular goal. Effective planning is based on critical analysis and intelligent thought rather than on emotion and intuition. Planning is a primary function of management, a prerequisite to all other functions and calls for a high degree of mental activity. However, it does not stop when other functions commence. Planning is an integrating activity which is performed in conjunction with the other functions of management. (35: 122)

Organizing creates an integrated structure that can be efficiently utilized to achieve the objective of the industrial enterprise forming a framework that holds together the other functions of management according to a predetermined pattern. It is composed of a systematic order of logically arranged elements that can be followed harmoniously by all people. The purpose of organizing is to set up a situation in which people can work together productively in the enterprise. (35: 246)

The actuating function (often called directing) is commenced when the functions of planning and organizing are sufficient to get the work started. Actuating is achieved exclusively through the efforts of people. By stimulating people to perform their duties willingly, the manager is able to put the process into action. He directs, guides, and supervises the activities of his subordinates in a manner that motivates them to assist in coordinating their activities. (35: 401)

The function of controlling determines the extent to which the established objectives of the enterprise are achieved and the need for initiation of remedial action in the event malfunction is discovered. It is the follow-up to the other three functions of management. Planning, organizing, and actuating are necessary to get the work done, but controlling is necessary to determine if the execution is properly performed. (18: 487) It is the manager's duty to evaluate the results of the activities for which he is responsible and to initiate corrective measures when necessary. Even though he delegates authority to others, he still must exercise control over the actions of those to whom he delegates authority.

The technical manager possesses a broad educational background and is able to visualize and initiate new technological innovations and to originate effective means of coordinating the efforts of people. (25: 339) He is appropriately defined as a college graduate who is associated with managerial and scientific activities in the industrial field as well as in the educational field. He has a solid background in mathematics, physical sciences, human relations, and extensive educational experiences in technical theory and manipulative skills in a field of specialization and related areas. He is able to work with scientific personnel and contributes to their ideas; he supervises and manages people, coordinating their efforts in the utilization of materials and machines in producing and distributing industrial products.

The technical manager has a specific job area and a definite career. He fills positions which are interrelated with the divisions of research and development and administration. He advances to positions of increased responsibility within the industrial technology division according to his abilities. However, it is possible for him to be promoted into management positions within the other divisions.

Educational Programs

Institutions of higher education are rapidly initiating educational programs in industrial technology to prepare graduates for teaching in industrial technical education and for managerial employment in construction and manufacturing industries. Prior to 1950 only six institutions offered programs in industrial technology, but by 1963 approximately forty-four were in operation, (20: 1) and in 1967 the number was in excess of seventy-five, and other programs are in the planning stage.

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CHAPTER TWO

Industrial Technology: Implications for Industrial and Technical Teacher Education

ELMER E. ERBER

Within the past two decades, the one element in human experience that man has endowed with absolute certainty is change. In every facet of living, man experiences the novel. Everywhere he perceives profound technological innovations—in buildings, materials, machines, appliances, communication systems, transportation systems, production and manufacturing systems, medicine, agriculture, and in numerous other areas. Not only is man cognizant of change, but cognizant of the accelerating rate of change. The explosive and unrelenting rate of change in the discovery of new knowledge caused by the enormous growth in research activities within universities, industries, and government has resulted in innumerable advancements on the frontiers of scientific knowledge that have made it possible to effect unprecedented technological change at a bewildering pace. These events produced highly sophisticated, technological developments that are generating dynamic changes in economic, industrial, social, political, and religious activities of today's societies. As such, man of the twentieth century has become aware of the fact that he is living in an inexorable state of physical and social evolution.

TWENTIETH CENTURY TECHNOLOGICAL INNOVATIONS

Man of the twentieth century has been confronted with technological novelty that finds no parallel in the past; much of this novelty has been experienced within the last two decades. Although the following technological innovations were foreign to man prior to the turn of the twentieth century, many were not conceptualized and materialized until within the last two decades: nuclear power, man-made satellites, nuclear head missiles, transistorized circuitry, micromodular electronics, microsecond speeds, radio-telescopes, electron microscopes, masers, color television, televised phones, laser interferometers, computer controlled machining centers, five-axis numerical control systems, transfer machines, electron beam machining and welding, electrochemical machining, ultrasonic machining and welding, laser beam boring, atomic hydrogen welding, continuous casting, high energy forming, super alloys, synthetic minerals (diamonds, rubies, sapphires, quartz), synthetic materials (dacron, nylon, orlon, arnel), synthetic coatings, butyl rubber, reading and translating machines, computerized graphics, computer-aided design systems, computer-aided production, electronic data processing, telemetry, high-compression engines, diesel engines, jet and turbine engines, fuel cells, mammoth earth-moving machines, supersonic aircraft, thermionic generators, solar batteries, immediate photography, hydrostatic power transmissions, hydraulic and pneumatic controls, ball and air bearings, and biomechanics.

THE IMPACT OF SCIENCE ON TECHNOLOGY

The above innovations are profound technological advancements that emanated directly from new discoveries and developments in scientific knowledge, instrumentation, and inquiry. Without this phenomenal evolution in science, the dramatic developments in technology of the twentieth century could not have evolved.

> . . . The role of science in the development of technology is to provide the environment in which technological ideas can be exploited, rather than in fact being itself the origin of technological ideas.
>
> One can go back in history and cite many cases in which technological ideas were suggested or invented, so to speak, yet died at birth simply because the sophistication of scientific knowledge was not sufficient to provide a fertile field for improvement and exploitation of the original idea. One finds, as early as 1910 or 1920, many suggestions regarding the use of semiconductors, or what are now known as semiconductors, fore-shadowing many of the developments in the 1950s, such as the transistor, the rectifier, and so on. One can see that none of these ideas came to fruition simply

> because there was not yet a sufficiently sophisticated science of materials and solid-state physics to permit the rapid and successful economic exploitation of these ideas. (6: 38-9)

The impact of science on technology as a primordial and an influential factor in industrial technological progress is extensively acknowledged as fact. (45: 198) Although examination of the history of industry indicates there is disagreement in the discernment of the direct effects of science on industry, there seems to be wide acceptance of the fact that the sophisticated science of today is directly linked with the technological growth of industry. Industry's technology is being increasingly augmented by innovations founded on applications of science rather than on sheer mechanical ingenuity that predominated the earlier periods of mechanization. (6: 37) This has been most evident in the chemical, electrical, power and aeronautical industries. Today, for the most part, the art of industry no longer tends to run ahead of science. (6: 38) Scientific knowledge and instrumentation have made it possible for industry to advance its older arts, to create new techniques, to produce more efficient processes, and to develop new materials, new commodities, and new industries. Because of the enormous expansion in industrial research activities, there can be little doubt as to the potency of the roles rational inquiry and empirical validation are playing in technological advancement. Knowledge evolved from rational inquiry has a prodigious potential for doing things because it works. (38: 44)

Automated Manufacturing Systems

The impact of science on technological development is further evidenced by highly qualitative technological systems presently functioning within industrial enterprises. Automated manufacturing systems are excellent illustrations. Each system has become fully automated through the integration of machines into a single, unified system that continuously produces and controls the quantity and quality of output without any direct human intervention. (7: 5-11) Electric eyes, mechanized hands, sensory and measuring devices, electronic brains, conveyors, loaders, testers, machine tools, presses, and numerous other hardware are tied together into highly complex systems. Mechanical, electrical and electronic, fluidic, and other devices are substituted in the system for functions requiring human control, perception, and decision making to achieve a specified product. The unique principle of automation is automatic control, or feedback. "This is a concept of control whereby the input of machines is regulated by the machines' own output so that the output meets the conditions of a predetermined objective." (7: 11) Without the tremendous increase in scientific knowledge and instrumentation, the sophistication of these automated manufacturing systems could not have occurred.

Computerized Systems

The dynamic integration of science and technology is further reflected in other computerized and automated machine systems. Computerized systems process and communicate information, translate from one language to another, operate batteries of machine tools, assist in the designing function, rapidly transform complex mathematical descriptions into precise technical drawings, and completely operate chemical and petroleum refineries and power plants. (27: 18) Applications in computerization will continue to expand because of the need for improving productivity and product reliability through feasible economic methods. For example, automotive manufacturers hope to reduce the high cost of service warranties through computerized testing of components such as carburetors, wiring harnesses, transmissions, and distributors. (43: 51) Such computerized systems are tools that vastly extend man's capability through new ways of doing old tasks. The magnitude and the nature of technological change affecting industry, business, and society in relation to these systems are not fully perceived. (16: 9) According to Moody's Computer Industry Survey, at least 55,000 computers will be in use by 1970.

Design Systems

The computer-aided design system may soon revolutionalize design engineering. This system combines the best qualities of man and machine; it couples man's creative and analytical ability with the machine's capability to carry out rapid calculations, interrelated decisions, and interactive operations in the design of a product and in the provision of a rapid, accurate means of producing the product. Man creates his design graphically on the face of a cathode ray tube linked with a computer. Graphic information is entered into the system by sketching on the face of the tube with an electronic light pen, or by pointing to pictorial components or alphameric characters displayed. Alphameric characters may be entered from a keyboard. By pointing the light pen to elements of a display, the operator can cause the computer to modify the display—and the "master" in the system's files—to enlarge, reduce, rotate, move, reproduce, superimpose or erase portions of the image. After a rough sketch has been produced on the face of the cathode ray tube, the computer can square angles, straighten lines, make lines parallel or a specified length. (40: 10-11) A drawing is thereby produced. The computer, understanding what this all means, can analyze it and say "alright" or "no good." In producing the details of the design, the computer will make all of the computation and specialized analysis. Furthermore, it will provide assurance that the finally accepted design will meet the parameters of specified performance. The output will be a specific communication to a man and/or a machine. (35: 6)

The computer-aided design system can also read a Cartesian "3-D" piping systems layout drawing, and control a drafting machine that will draw the isometric piping spool drawings necessary for the prefabrication of the pieces of the piping systems; the Cartesian "3-D" drawing is a "mathematical model on paper." (37: 24)

The coupling of the drafting machine with a general-purpose computer, can also produce the necessary master patterns for the manufacture of high-density, multi-layer, miniaturized circuitry; the production of these patterns is beyond the practical capabilities of the draftsman. Circuit parameters, logic functions, and necessary board requirements are fed into the computer. The information is processed by the computer and developed into the printed-circuit layout. This data then serves as input to the drafting machine, which prepares the master pattern from which the printed circuit is made. (29: 100)

Other Devices and Systems

An illustrative example of the adaption of scientific instruments and knowledge to industrial technology is reflected in the laser interferometer system for quality control inspection of numerically controlled lathes. This system can record the two-directional movement of the lathe carriage with an accuracy of 10-millionths of an inch. Measurement is accomplished by send-ing two beams—split from a single light source—and reflecting them back to a sensor. The variation in intensity between beams is translated as the distance measurement. The sensor then relays the intensity variation to a digital computer that displays the measurement instantly to six decimal places on a visual readout. (32: 10)

Another illustration that exemplifies the functional relationship between science and industrial technological advancement is the transistorized circuit. Solid state physics has paved the way for the development of transistor technology that has made possible the miniaturization of electronic components. These components, often hardly bigger than a pin head, are taking over activities currently performed by a complex assembly of coils, condensers, wires, and vacuum tubes; they have been integrated into miniaturized compact systems. Miniaturization of electronics has opened the way for a new generation of control units and compact control boards for supervising the output of completely unattended assembly lines. Computers may become no larger than a shoe box. (1: 16) Complete, integrated electronic circuits containing 50 to 100 transistors and other circuit elements have been fabricated on one paper-thin wafer of material that can fit on the head of a pin. These tiny transistors and other components in the integrated circuit can perform a function at 100 times less cost and with 1000 times the reliability of vacuum tubes. (5: 37)

IMPLICATIONS FOR TEACHING-LEARNING ACTIVITIES

The above illustrations are but a few of the multitude of existing integrations that exemplify the interdependency of modern industrial technological advancement and science. A meaningful apprehension and appreciation of the highly sophisticated technological systems of industry demand mastery of the fundamental principles of mathematics, mechanics, physics, chemistry, and many other aspects of basic science. An understanding of these disciplines is imperative to the rational interaction of man with industrial tools, machines, instruments, materials, processes, and the computerized technological systems of the future. Within the areas of technological specialization of industrial and technical teacher education programs, perception of the fundamental underlying principles of mathematics and science is essential to the creation of satisfactory solutions to technological problems that reflect understanding and wisdom. To create modern industrial and technical teacher education programs devoid of mathematics, basic science, and technical sciences as prerequisites for study in the areas of technological specialization is to be blind to the impact of mathematics and science on industry's technological advancement and operation; it is to create a travesty in industrial and technical teacher education. The implications of the impact of mathematics and science on industry's technological growth for industrial and technical teacher education are indisputably discernible. The industrial and technical teacher educator must acknowledge the fact that man's ability to perceive fully and accurately the mature technological concepts of this and future decades is a direct function of his understanding of the underlying principles of mathematics and science in industrial technology. Man neither perceives nor does he utilize that to which he is blind. As industrial technology becomes increasingly complex and scientific, the levels of mathematical and scientific conceptualization and apprehension must be augmented to enable students to cope more adequately with the rigorous demands of industry's highly sophisticated tools, machines, materials, systems, and processes. Therefore, knowledge of scientific principles must become the intellectual foundation for rational action within the problem-solving activities of industrial technology. Mathematics and science must be requisite to more meaningful and mature levels of learning in industrial and technical teacher education.

Problem-Solving Skills

Problem solving in industrial technology is not only a function of the apprehension of scientific knowledge; it is also dependent upon high levels of rational exercise. Knowledge does not become operative in and of itself; its application is dependent upon the evolution of intelligent methods of thought and action. As the problem-solving environment of industrial technology becomes rapidly augmented and increasingly intricate, more is demanded from human intellectuality for productive action. Man is challenged to creatively apply scientific principles to the design, refinement, and construction of machines, automated systems, tools, instruments, and industrial products; to imaginatively devise, plan, organize, and layout manufacturing processes; to efficently manage the installation, service, and maintenance of machines and equipment for industrial production; and to skillfully integrate manpower, materials, tools, instruments, and processes in the creation and manufacture of material products that enhance life. Herein, qualitative intelligence is brought to bear upon the dynamic applications of knowledge and skilled techniques; for it is man's powers of perception that integrate man, tools, machines, materials, knowledge, and skilled techniques in the development of meaningful and adequate solutions to technological problems. The sophisticated problem-solving activities of this decade mandate qualitative thinking in the skillful application of knowledge and techniques. Such activity requires conceptual skill in analyzing, differentiating, associating, evaluating, judging, foreseeing, and synthesizing. For these are dynamic elements that enable man to visualize, to control, and to predict behavior in his interaction with the industrial technological environment.

Conceptual Skills. The implications of technological problem-solving activities for technical teacher education are clear. Emphasis must be given to the development of conceptual skills through the provision of problematic situations that challenge the student's apprehension, imagination, and ingenuity in his interaction with tools, machines, instruments, systems, materials, and processes. Conceptual skills must be seen as prime requisites for effecting rational action that leads to productive and meaningful application of knowledge and techniques. These skills are a vital means to high levels of perception and performance within judicial, creative, and experimental problem-solving activities of industrial and technical teacher education. Neither to be concerned with the actualization of conceptual skills nor to be cognizant of their potential for creating and implementing solutions to problems is to be oblivious to the very qualities of the human being that are influential in inducing change and inciting adjustment to change. Such behavior is not sensitive to the need for developing the adaptive capacities of man that will enable him to deal more effectively with rapid, complex technological change and to successfully adjust to technological obsolescence. Conceptual skills are not subject to obsolescence, rather they subject obsolescence. As such, they are functional and transferable; thereby, saleable to industries that are engulfed by technological change.

Conceptual skills are not only basic to the advancement of industrial technology but are fundamental to the creation of free intelligence for personal effectiveness, to individual achievement in self-direction, to effective communication, to intelligible and cooperative mutual interaction, to the creation and preservation of individual dignity, and to the survival and enrichment of the democratic way of life. Within a society encompassed by unprecedented technological change, the profoundity of these functional relationships is augmented by the passage of time. (38: 45) Therefore, it is imperative that industrial and technical teacher education focus attention on the development of the rational powers of the human being through the provision of technological problem-solving activities that lead to high levels of intellectual exercise.

Teacher education programs that center on the development of isolated manipulative skills at the expense of high level conceptual involvement in problem-solving activities that demand understanding and application of the basic principles of the underlying technical science are incongruous with changing technology. A critical examination of manufacturing and processing industries will verify that skills are being built into machines and machine systems that can perform more accurately and with greater rapidity the work of numbers of men. In numerous instances, machine systems are skillfully performing very complex behaviors that are beyond all human capability. Modern industry's powerful tools, mammoth presses, intricate machines, precision instruments, and automated machine systems are highly sophisticated devices that enable man to extend his ability in effecting and implementing solutions to material processing and material embodiment. These mechanical elements are part of man's problem-solving environment that permit him to more effectively and efficiently perceive, interact, and control physical behavior in the skillful application of knowledge in the implementation of a series of operations for processing or manufacturing a product that otherwise could be possible. As such, they are influential instruments of the intellect that are integrated into an operational plan of action for the translation of thought into skillful and productive action. In and of themselves, these elements are material solutions to highly sophisticated, technological problem-solving activities; they are material solutions that radiate man's genius in the skillful integration and embodiment of basic principles of technical science.

Within the problem-solving activities of industrial technology, industry's tools, machines, instruments, and systems must be perceived as more than agents for the perfection of isolated manipulative skills or handyman abilities, but as effectual elements in man's techniques for creating, directing, and controlling behavior. Herein, they are a means to the stimulation of thought processes, to the skillful integration and application of scientific principles, and to the expression of man's genius in the embodiment of ideas in material forms. As such, these elements possess much potential for the development of the rational powers of man.

Today's changing industrial technology demands that industrial and technical teacher education place major emphasis upon the development of the abilities of man rather than upon the development of the handyman abilities. It is no longer tenable to perfect handyman abilities in the form of isolated manipulative skills, because these skills have limited potential for high level problem-solving. They are blinded by lack of rational direction, therefore, empty and non-applicable. Skilled hands can do no more than the mind perceives. If isolated manipulative skills are to become influential factors in technological problem-solving activities, they must be integrated with conceptual skills and technical knowledge; therein, skilled hands are empowered with vision; they are guided by rational action based upon qualitative thinking.

Laboratory Skills. Although skills are built into machines, and machines furnish the muscles for performing the industrial processes through automated systems, this does not imply that manipulative skills have no place within the industrial technology laboratories. They have no dynamic place as skills for skills' sake, but they do unquestionably have a prime place as effectual elements in the technical execution of learning activities within the laboratories. Herein lies the basis for the development of manipulative skills. These skills are essential to the appropriateness of technical execution in experimental activities in relation to demonstration, verification, and application of basic principles; to the testing of materials and equipment; to the assembly and disassembly of components within mechanical systems; to the creation and to the material objectification of concepts; and to the adequate and meaningful conceptualization of materials, tools, machines, systems, and processes. For within these activities, skillful performance is a requisite to producing the desired qualitative behavior and to effecting the necessary control in the achievement of foreseen consequences. The justification for manipulative skills lies in its potential for developing and carrying on meaningful learning experiences in the laboratories. Without skillful performance, the fullness of meanings are not conveyed, joys that motivate are not emanated from qualitative actions, nor is there much stimulation of the thought processes in the clarification and reconstruction of concepts.

Skill in the manipulation of tools, machines, instruments, and materials also frees the mind from preoccupation with technical execution; it enables the learner to concentrate, to interact, and to think about the principles of immediate concern. As such, it is an indispensable element in problem-solving activities that demand application and embodiment of basic technological principles.

Skilled Technique. Even though manipulative skills are indispensable in meaningful laboratory experiences, they are only one phase of the totality of skilled technique needed to carry out successful laboratory achievement. Skilled technique is inclusive of more than a high degree of motor dexterity in the manipulation of tools and materials. It encompasses skilled vision, skilled imagination, skilled planning and organization; precise coordination of hands, eyes, muscles, and mind; knowledge of materials, tools, and methodical processes; concentration of energies; and patience. Skilled technique requires that one knows what he has to do, and that he be able to apply the means for doing it. It involves the adequate and intelligent application of knowledge as purpose demands. To limit skilled technique to manipulative virtuosity with tools and materials is to sever manipulative skills from qualitative interaction with basic principles of technology. This type of action can only lead to laboratory activities that are chiefly concerned with the reproduction of inconsequential exercises, the construction of irrelevant projects, and the technical execution of routine problems that soon dull the imagination. Such activity is pleasurable for unoccupied minds, but soon loses its fascination in its emptiness. (18: 33) Skilled technique is the means to the interfusion of man, his knowledge, and his tools in meaningful and challenging problem-solving activities that are intellectually and emotionally fulfilling. According to Hermin Horne's interpretation of John Dewey:

> Skill obtained apart from thinking misses the purpose of skill, and leaves the artisan at the mercy of his own routine habits and of the authoritative and unscrupulous control of those who know what they are about. And information obtained apart from thoughtful action simulates knowledge, develops the poison of conceit, hinders further intelligent growth, is deadweight and a mind-crushing load. And the thinking which is not connected on the one hand with skill, or increase of efficency in action, and, on the other hand, with information or increase of learning about ourselves and our world, is defective, unattached, formal, and inconsequential. (23: 194)

Laboratory Problem-Solving Activities

To conceive laboratories within industrial and technical teacher education as little more than a means to the development of manipulative skills or to the assembly and disassembly of mechanical objects is to have an anemic concept of their educational potential. Education is of the head as well as of the hands. The laboratory is a necessary place for students to enhance and realize meaning in relation to basic principles taught. For thought in and of itself without application is not fully conceived in the totality of its meaning. The meaning of things is wrapped up in their consequences, in their relationships beyond themselves. The idea is more fully grasped when it is sensed, experienced, and tested in action. (18: 32)

> Application is not for the sake of something extraneous, for the sake of something designated an utility. It is for the sake of the laws, principles, ideals . . . . Without *actuality* of application, without effort to realize their intent, they are meanings, but they possess neither truth nor falsity, since without application they have no bearing and test. Thus they cease to be objects of knowledge, or even reflection; and become detached objects of contemplation (13: 436)

Laboratory problem-solving activities have great potential for providing the student with many superior opportunities to experience principles in action, first-hand, through applications in constructive and experimental activities. This is particularly true of laboratory activities that permit the student to experiment in relation to verification, application, and discovery of basic principles; to test materials and mechanical devices; to observe phenomena; to create and construct mechanical systems; to embody concepts in material forms; and to conceptualize in regard to materials, tools, machines, instruments, and processes. Herein, the student receives a direct, first-hand introduction to meanings; he develops meaningful perceptions through increased insights into laws, principles, and ideals. Thereby, inadequate concepts become adequate, the unrelated related, the indistinct distinct, irrelevant relevant, the inapplicable applicable, and the inanimate animate. The student is not limited to think thoughts with thoughts; he thinks actions, facts, events, objects, and the relations of things. The laboratory for the student is like a living dictionary; it vividly defines such concepts as stress, fatigue, tempering, friction, carbon steel, density, oak, numerical control, and torque with a reality that cannot be matched by any grandiose display of words.

According to Alfred N. Whitehead:

> . . . There can be no adequate technical education which is not liberal, and no liberal education which is not technical; that is, no education which does not impart both technique and intellectual vision. In simpler language, education should turn out the pupil with something he knows well and something he can do well. The intimate union of practice and theory aids both. The intellect does not work best in a vacuum. The stimulation of creative impulse requires, especially in the case of a child, the quick transition to practice. Geometry and mechanics, followed by workshop practice, gain that reality without which mathematics is verbiage . . . . The connections between intellectual activity and the body, though diffused in every bodily feeling, are focused in the eyes, the ears, the voice, and the hands. There is a coordination of senses and thought, and also a reciprocal influence between brain activity and material creative activity . . . . Our goal is to see the immediate events of our lives as instances of our general ideas. What the learned world tends to offer is one second-hand scrap of information illustrating

> ideas derived from another second-hand scrap of information. The second-handedness of the learned world is the secret of its mediocrity . . . . Concreteness is the strength of technical education . . . . To obtain a concrete proposition immediate intuition of a truth concerning particular objects is requisite . . . . In order to obtain the full realisation of truths as applying, and not as empty formulae, there is no alternative to technical education. Mere passive observation is not sufficient. In creation only is there vivid insight into the properties of the object thereby produced. If you want to understand anything, make it yourself, is a sound rule. Your faculties will be alive, your thoughts gain vividness by an immediate translation into acts. Your ideas gain that reality which comes from seeing the limits of their application. (46: 74-83)

If industrial and technical education is to be distinguished as a dynamic, educational force in the development of adequate, meaningful, and functional concepts in relation to industry's tools, machines, machine systems, instruments, materials, and processes, laboratory problem-solving activities must involve the student in observing, diagnosing, applying, discovery, verifying, testing, creating, constructing, embodying, and conceptualizing. Such laboratory activities are mandatory within the study of the areas of technological specialization.

THE TEACHER AS A MANAGER

Within the teaching and learning activities of the industrial technology laboratory, the teacher is a manager; he is a manager of men, materials, tools, machines, instruments, systems, and processes. Thus, within these activities lies a challenge to the genius of the teacher to creatively integrate principles, concepts, materials, machines, and manpower in effecting optimum teaching and learning experiences. As the teacher skillfully provides for and implements the production of meaningful and challenging learning experiences, he becomes the teacher-manager. As such, he finds himself planning, organizing, actuating, supervising, and controlling teaching-learning activities in the attainment of desirable educational goals. He sees himself motivating, directing, and guiding the efforts of students in relation to integrating themselves with principles, concepts, materials, machines, instruments, and men in their quest for satisfactory solutions to pressing problems. As a teacher-manager, he becomes cognizant of the fact that inspiring educational experiences for students demand high levels of integration through mutual cooperative interaction. To effectively evolve this type of behavior within teaching-learning activities, the teacher-manager becomes not only aware of the need for ingenuity, foresight, technical knowledge, technical skills, and an understanding of the basics of teaching and learning, but perceives a need for the comprehension of the fundamental principles of management and human relations. For the skillful application of the knowledge of human relations is requisite to the creation of a spirit of mutual cooperative interaction between the teacher-manager and his students. The expert teacher-manager is one who causes students to willingly perform the tasks required of their problem-solving activities, to freely interact with their learning environment in the application of knowledge, and to effectively work together in the production of common solutions to problem-solving activities. He is a teacher, but also a manager. As he exhibits excellence in teaching, he skillfully manages the teaching-learning process. His managerial ability coupled with his powers of perception, knowledge, and skills, enables him to bring about a "totality" of integration within the teaching-learning activities that result in meaningful and inspirational learning, that achieve desirable behavioral changes in students.

Within the third quarter of the twentieth century much attention has been given to the development of the "science of management." The rapidity of expansion and the increasing complexities of modern technological advances have developed a dire need for technically competent persons in positions of management. (12: 212) If people with a technical and human relations background are needed by industry to deal competently with managerial problems in the more sophisticated technological phases of industrial technology, is it not plausible to assume that the industrial and technical teacher who is grounded in the principles of management and human relations would be able to achieve greater excellence in teaching? Efficiency with the teaching-learning process mandates that industrial and technical teacher education create teachers who are knowledgeable in the art of managing human behavior within the problem-solving activities of the laboratories of industrial technology. These teachers must be able to skillfully extract and realize the maximum educational potential from students in their interaction with materials, tools, machines, instruments, systems, and processes. This requires that the student be enabled to bring to bear freely his intelligence upon the teaching-learning environment. Such activity is a direct function of operational thinking in the wise use of managerial techniques, thinking that defines and relates the principles of management and human relations to problem-solving events. Herein, the principles of management and human relations are seen as instrumentalities in the achievement of educational goals.

THE TEACHER AS AN INDUSTRIAL TECHNOLOGIST

As the scientific revolution of the past few decades has caused American industry to place a tremendous emphasis on science, automation, and management, the technological revolution has caused, particularly, the constuction and mechanical industries to place unprecedented demands on educational institutions to prepare graduates to meet occupational needs in the areas of design and refinement, production and manufacture, field service and product utilization, distribution and sales, and education and training. (11: 18) Therefore, educational institutions are responding to this demand through the establishment of curriculums in industrial technology that provide a foundation for the development of professional efficiency in these specified areas. Is it not conceivable that teacher education programs should parallel such programs? Is it not herein that teacher educators need to begin to study and analyze the content for possible inclusion in the teacher education programs? Does not the major source for the development of technical sciences and the human relations in teacher education curriculums lie within the problem-solving activities of previously specified areas of industrial activity? How can the teacher adequately convey and properly assist students in the formulation of modern and functional concepts in regard to materials, tools, machines, machine systems, instruments, and processes without the depth of technological study of the industrial technologist? How can the teacher help students to design, to experiment, to test, to discover, to maintain, to construct, and to embody ideas in effecting solutions to problems that truly radiate the nature of industrial activities, if mathematics and physical sciences are not the bases for perceiving and doing within the areas of technology? How does the teacher adequately interpret industrial elements within the construction and mechanical industries without the knowledge that will enable him to perceive?

Industrial and technical teacher education of this and future decades cannot limit itself to the narrow confines of past programs. In this age of exploding technological advancement, the work benches of craftsmen have given way to the control panels of sophisticated systems, the machine operators of single-axis machines are being rapidly replaced by monitors of multi-axis machines within computer-controlled machine centers, and the traditional materials, methods, and processes are being outmoded by contemporary innovations emanating from new scientific knowledge. Today, it is neither appropriate for teacher educators to be obsessed with a craft or trade skill approach to the study of industrial technology nor is it fitting as an approach to be engrossed in promiscuous design and problem-solving activities that are unrelated to structured course content based on the underlying scientific principles of the technologies. The industrial and technical teacher of the last quarter of the twentieth century needs to have a technological background that will not only permit him to grow and adapt easily to technological change, but to effectively manage the teaching-learning activities such that students meaningfully interpret materials, tools, machines, machine systems, instruments, and processes. A technological background confined to the crafts or to the skills of the trades is insufficient; it limits the teacher's ability to cope intelligently with present and future technologies. For problem-solving activities within these technologies demand that the technological background of the teacher parallel that of the industrial technologist. In fact, the teacher will be an industrial technologist within tomorrow's leading industrial and technical education programs.

As an industrial technologist, the teacher is a college graduate who has competency in the principles of the communication arts, mathematics, physical sciences, behavioral sciences, and the educational and managerial sciences; he also has an extensive background in technical theory and applied problem-solving techniques within a field of technical specialization and closely related fields as well as mechanical and manipulative abilities necessary to the establishment of high level, laboratory experiences. As an industrial technologist, he has the ability to effectively integrate human relations and technical sciences in teaching-learning activities of educational institutions and construction or mechanical industries.

The teacher as an industrial technologist is further characterized by the following capabilities:

1. Has the ability to direct, guide, and motivate students and to coordinate their efforts in the pursuit of problem-solving activities.
2. Exhibits competence in effecting human relations and applying managerial principles.
3. Has the ability to make wise decisions based upon critical and creative thinking in relation to known factors.
4. Has the ability to apply scientific concepts and principles to effect meaningful teaching-learning situations in his technological field of specialization.
5. Has the ability to analyze, interpret, and transmit information, concepts, and principles graphically, orally, and in writing.
6. Exhibits integrity, adaptability, dependability, openmindedness, and other qualities of professional personnel.
7. Has ability to create high levels of mutual cooperative interaction within the teaching-learning process.
8. Has the ability to apply democratic principles to teaching learning situations.
9. Has the ability to plan, organize, administer, supervise, and evaluate the teaching-learning process.

The teacher as an industrial technologist is vitally concerned with carrying out the following duties in relation to excellence in teaching and learning:

1. Defines and develops course studies in relation to contemporary culture.
2. Provides thought-provoking problem-solving activities that demand understanding and vision of basic principles.
3. Provides challenging opportunities to apply basic principles within the judicial and creative problem-solving activities.
4. Creatively plans, organizes, administers, and supervises the teaching-learning process such that meaningful learning occurs within the student.

5. Develops instructional materials as related to problem-solving activities.
6. Defines and applies the most optimum methods of teaching in relation to elements peculiar to the particular teaching-learning situation.
7. Interacts with the student such that he is a stimulant to the student's thought processes and a catalyst of learning.
8. Interviews, selects, and counsels students.
9. Constructs and applies an effective evaluation system within the teaching-learning process.
10. Develops a provocative teaching-learning environment.

OBJECTIVES

Industrial and technical teacher education programs must necessarily be composed of activities of high caliber if they are to prepare teachers to radiate excellence and professionalism in teaching. Colleges and universities have a primary responsibility to provide qualitative teacher education programs in industrial and technical education that will prepare teachers who can enhance the proficiency of learning within human beings. If teacher education programs are to accomplish excellence in teaching, they must lead to something more than the development of manual virtuosity or verbal diarrhea. These programs need to focus on the development of prospective teachers who will have the potential for effecting individual growth in students in the form of critical qualities of the intellect and durable qualities of character that will better enable the individual to be a constructive participant in the family, community, and nation. Major emphasis must be placed on the development of qualities and talents needed for excellence in teaching and for wholesome living in a democratic society. Succinctly stated, the dominant goals of teacher education are:

1. To provide a foundation for the development of professional efficiency in teaching.
   a. Develop ability to apply the basic principles of teaching and learning.
   b. Develop ability to recognize and apply mathematical and scientific concepts and principles.
   c. Develop ability to identify and utilize fundamental principles of a technological field of specialization and related fields.

d. Develop mechanical and manipulative abilities.
e. Develop ability to apply basic principles of management and human relations within a democratic framework.
f. Develop communicative ability.
g. Develop ability to critically analyze and to creatively synthesize solutions to technical problems.
h. Develop qualities of behavior such as curiousness, independency in thinking, creativeness, flexibility, cooperativeness, initiative, responsibility, integrity, selflessness, et cetra.

2. To provide for the development of a comprehensive understanding of citizenship that will enable man to live more intelligently and harmoniously in a democratic society.
   a. Develop a sense of need for free inquiry and the pursuit of truth within a framework of intellectual responsibility.
   b. Develop a sense of personal values, goals, and social responsibilities which will aid in making constructive contributions to mankind.
   c. Develop an understanding of democratic ideals.
   d. Develop skills in community service, social interaction, and professional leadership.

CURRICULAR COMPONENTS

To achieve the goals of industrial and technical teacher education, there must be provisions in the curriculum for study in human relations and in technical sciences. Such a curriculum has the potential for realizing excellence in teaching. This is verified by an analysis of the characterization and functions of the teacher as an instructor, a manager, and an industrial technologist.

The two major divisions of human relations and technical sciences are indicated on Chart 2, Sources of Content for Curriculums in Industrial and Technical Teacher Education. (11: 23) These divisions are composed of curricular elements that emanated from an analysis of the duties performed by the industrial technologist within the industrial technology functions of industry. (11: 7-17) Within the concept of the teacher as an instructor, a manager, and an industrial technologist, the curricular elements expressed on the Chart are also definitely applicable to the development of programs in industrial and technical teacher education. The analysis is a rational and functional basis for defining modern teacher education curriculums that are attuned to present and future technologies. A further analysis of these major divisions follows.

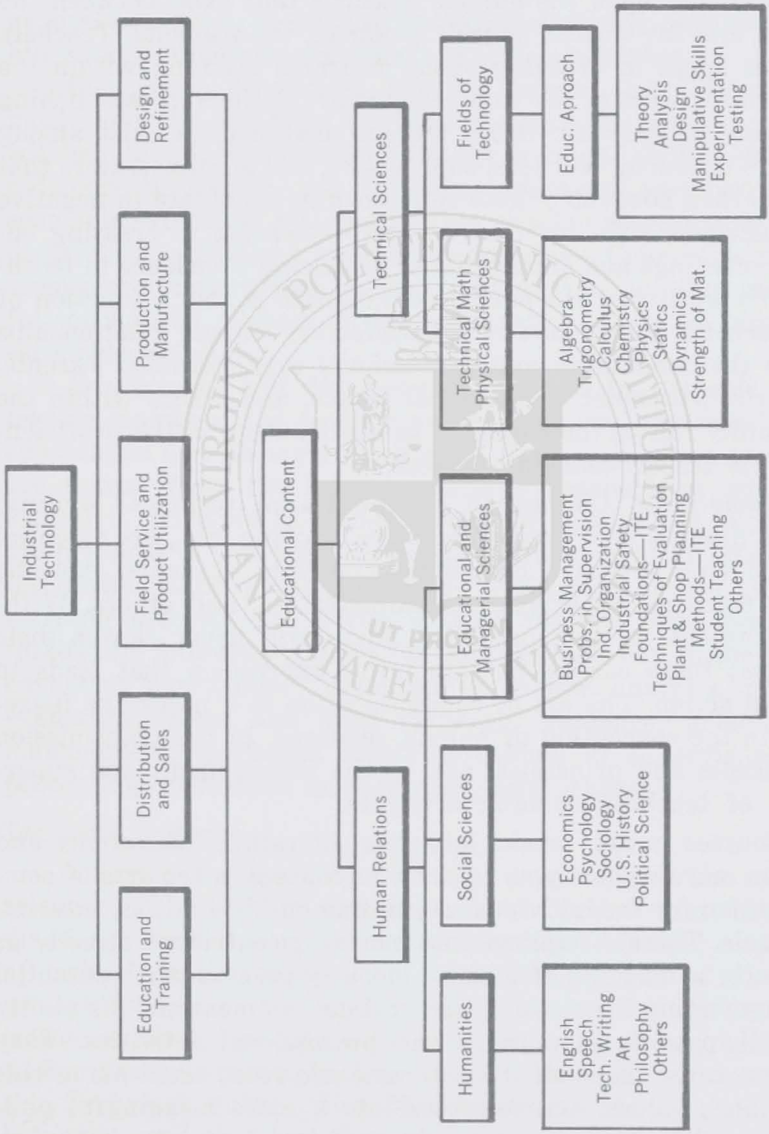

Chart 2. Source of Content for Curriculums in Industrial and Technical Teacher Education

Human Relations

The human relations division consists of humanities, social sciences, and educational and managerial sciences. A strong background in human relations is essential to excellence in teaching. Many opportunities for effective teaching and learning are dependent upon the human relations that exist between the student and the teacher as well as among the students. Teachers who are adept in bringing about desirable learning within the learner are aware of the value of human relations in establishing efficiency in learning. Often human relationships exist among teachers or among teachers, supervisors, and administrators that are less than adequate; these relationships eventuate in negative and improper attitudes that become deterrants to creating enriched offerings and detriments to producing excellence in teaching. The totality of the educational climate is also a function of the teacher's ability to create satisfactory human relationships within the community and professional organizations. Parents, industrial personnel, professional people, and others within the community can be instrumental in contributing to the proficiency of the teacher-learning process.

Humanities. Courses in composition, technical writing, speech, discussion principles, creative drawing, etc., are essential to producing effective communication with students, parents, fellow teachers, supervisors, administrators, and others. Without technique in communication, ideas will never flower their message; there can be no intelligible expression that leads to rational action. The art of communication is a necessary ingredient in the conception of human relations, in the transmission of concepts and principles, and in the management and supervision of teaching-learning activities.

Courses in art, music, language, literature, philosophy and religion may be equally as valuable as courses in the arts of communication for the individual depending on his abilities, interest, and goals. These disciplines may not only contribute directly or indirectly to teaching efficiency, but may possess much potential for augmenting the student's general development and his ability to participate in community and professional activities. They also may cause the student to examine and reconstruct his morals and ethics, values, and purposes into a more meaningful philosophy of life.

Social Sciences. As the teacher assumes his occupational and civic responsibilities, there can be little doubt as to his need for an understanding of human behavior, both individual and group behavior, in effecting desirable social interactions. Courses in general, applied, social, and industrial psychology aid him in understanding problems in individual behavior while courses in general sociology, industrial sociology, and race relations assist him in comprehending problems in group behavior.

Courses in economics, political science, and history have much potential value for the teacher. A knowledge of economics will help him to better understand the economic structures within a democratic society, and to better understand and evaluate the economic effects of his decisions in relation to occupational, industrial, and civic and community activities. Courses in political science and history that aid the individual in building meaningful concepts in relation to the democratic way of life are of inestimable value.

Educational and Managerial Sciences. In the role of the teacher-manager, the teacher needs to be well grounded in the educational and managerial sciences. Courses in these areas that are taught from the human relations approach in which the learner is conceived as a human being of dignity and importance are priceless for the teacher. For the efficiency of an educational institution is no greater than the efficiency of the teaching-learning process. The duties defined for the teacher-manager justify the following courses for possible inclusion in the teacher education curriculum: Foundations, course analysis, methods, evaluation, plant and shop planning, guidance, principles of management, industrial safety, problems in supervision, data processing, personnel management, and others.

Technical Sciences

The second major division of the curriculum is the technical sciences. This division may be further divided into three subdivisions: technical mathematics, physical sciences, and fields of technological specialization. Technical sciences is a very essential division of the teacher education curriculum because it is the rational foundation for studying, perceiving, and doing within the fields of technological specialization.

Technical Mathematics. Mathematics is simply a numerical language used as a tool through which scientific principles are expressed and communicated. It has enabled man to express concepts and principles in the abstract with a high degree of precision of which verbal expression has not been able to parallel. The conception of the principles of mathematics seems to be a necessary condition for understanding science in all its aspects. (21: 23) Analytical geometry and calculus is requisite to the apprehension and the application of many scientific principles, to the graphic solutions of numerous technical problems, to the programing of numerical control equipment, etc.

Technical mathematics is more appropriate for students in industrial technology than is theoretical, abstract mathematics. The approach is applied. Fundamental principles of mathematics are taught not as entities unto themselves but are made meaningful to the student through relating and applying principles to problems within the fields of technological specialization. When mathematical principles are presented in relation to technological applications, students develop a better understanding of the mathematical concepts needed to solve technological problems.

Physical Sciences. Because scientific principles are basic to the development, embodiment, and comprehension of material forms that define tools, machines, machine systems, instruments, gauges, and other industrial products, it is essential for the teacher of industrial and technical education to have a thorough knowledge of the physical sciences. Industry's highly complex mechanical systems reflect man's genius in his ability to integrate voluminous amounts of knowledge in expressed material forms. To man, these systems can only contain a large degree of novelty unless he can intelligently read the systems. Chemistry and physics are invaluable to satisfactory technological problem-solving activities; for the teacher, they are a must. The physics course should require trigonometry as a prerequisite; it should be inclusive of units in mechanics, heat, sound, electricity, light, and atomic physics. Depending on the particular field of technological specialization, subjects such as statics, dynamics, strength of materials, thermodynamics, fluid machanics, and solid state physics should be requisite to many of the upper level courses. Depth in problem solving demands depth in study. These courses must be an integral part of the teacher education curriculum if teachers are to understand the industrial and technological world they are to interpret.

Fields of Technological Specialization. The approach to the study of the fields of technological specialization is different from that used in traditional industrial education. The underlying scientific principles of the technological fields of specialization are the basis for the development of courses in technology rather than the manipulative skills of the tradesman. The technologies primarily focus on theory; analysis; design of industrial materials, processes, and products; experimentation; testing; and construction of testing and experimental devices and products of creative design. Emphasis is placed on the development of manipulative skills as they are a function of basic laboratory activities. The application of basic scientific principles in relation to the forementioned laboratory activities is the basis for developing manipulative skills.

Although the teacher as an industrial technologist does not need to develop a high degree of proficiency in manual skill compared to the tradesman, he does need a qualitative skill that will better enable him to construct prototypes, mathematical and scientific models and industrial models; to properly diagnose malfunction problems; to set and adjust mechanical products for satisfactory performance; and to operate and service instruments, tools, and machines for peak operation. Qualitative and manipulative skills help the individual to visualize the limits of the application of basic principles as well as the capacities and operating conditions of equipment.

The technology phase of the curriculum must provide for both breadth and depth. It must provide the student with an opportunity to major within a field of technological specialization as well as to study in closely related fields. For example, a student majoring in engine power technology not only needs to be able to accomplish extensive study in this field, but he should be able to study in related technological fields such as electricity and electronics, fluid power, materials, and graphics. He should be afforded an opportunity to study in the related fields that will enable him to better understand his major field. In addition, the technology phase of the curriculum must provide for both theory and laboratory experiences. The fundamental principles within courses in theory must be rooted in basic mathematics and science. These principles must be further studied in their application to various types of laboratory problem-solving activities that lead to enriched meanings for students. Appropriate laboratory experiences require activities that will demonstrate the procedures and practices of contemporary industry in the application of theory.

Optimization

If teacher educators in industrial and technical education are to optimize curriculums for the preparation of teachers of excellence, they can no longer simply ignore the salient implications of industrial technology within contemporary industries. Curriculums must be contemporary and possess integral, curricular components that have the potential for creating teachers who are skilled in the implementation of the teaching-learning processes that cause learners to achieve at great heights. Within the teaching-learning process, the teacher is the key to such achievements. For it is the teacher who is instrumental in the functional integration of the elements of the teaching-learning process and in the unlocking and releasing of latent talent of human beings, democracy's most precious resource. Therefore, curricular components need to be integrative; they need to possess the potential for developing teachers who are blessed with the arts of communication, who are knowledgeable in the fundamental principles of mathematics and science, who have comprehension of and ability to apply the basic principles of human relations and educational and managerial sciences, and who are competent in the fields of technological specialization. A teacher education curriculum in industrial and technical education based on an analysis of industrial technology has the potential for creating these teachers. Such teachers should possess the competency to skillfully direct and guide students through meaningful problem-solving activities in which understanding and application of fundamental principles and practices of contemporary industrial activities are requisite. They are indispensable within these activities. If future industrial and technical education programs are to adequately provide for these activities, teacher educators need to construct curriculums that will effect the optimum in the development of such teachers.

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CHAPTER THREE

A Comparison of the Four-Year Industrial Technology Program with Engineering and Industrial Arts Programs

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Confusion often results when the terms industrial technology, industrial arts, and engineering are mentioned in pairs or all together. This may be due to the newness and diffuse image of industrial technology. One of the goals of this chapter is to delineate the boundaries which generally separate the three programs. Another goal aims to generate in the reader a degree of familiarity with the philosophies, content, and conduct of the programs and with the functions of the graduates. Another aim concerns programs which are not B.S. degree curricula of industrial technology but which are sometimes confused with more advanced upper division study. Since the AA degree programs tend to cloud the deliberations of this chapter, the services of the community junior colleges, their technical educational programs, and the Associate in Arts (AA) or Associate in Science (AS) degree all must be set in the proper perspective and orientation as they relate to the bachelor's degree programs under consideration. Then comparison may begin with industrial technology and the industrial arts program from which heritage it evolved and which helped it grow. Finally, comparisons may be constructed with engineering from whose heritage some aspects of industrial technology evolved.

Industrial technology has been compared with the structure of engineering programs prior to World War II, though many differences must be considered. Divergence can be traced through the World War II period and succeeding decades as engineering concentrated more on the physical sciences and mathematics, leaving gaps in the supply of personnel which industries require to staff the production management, facilities management, cost analysis and estimating of the enterprise. The gaps in knowledge left by changes in engineering education promoted industrial technology programs. The new engineers are rather research-and-development oriented, concerned with conceptual design, systems engineering, systems analysis and engineering-and-materials science. Civil engineering retains more of the older emphases on applications of the sciences.

Far different emphases characterize the emergent industrial technology curriculum. Technical education in junior college or in lower division work provides the foundation upon which are built the business management, production development and management-and-humanity emphases. At the same time, upper division specialties in a technical field are developed in considerable depth. On-site studies of appropriate industries are accomplished in field trips. In some institutions, students are required to serve an internship in industry at a responsible level to qualify for the baccalaureate degree.

Junior college trade and technical education leads to the Associate in Arts or Associate in Science degree with qualification for entry into the skilled trades or the skilled technician occupations. Greatly accelerated by the National Defense Education Act of 1958 (NDEA), the critically short supply of technicians has been somewhat altered, but schools now furnish only a quarter of the number required to relieve engineers of the more routine duties burdening our equally short supply of engineers.

Technical education in the two-year colleges qualifies for transfer into industrial technology programs in the upper division baccalaureate degree programs with only minor losses of credit, or often none, if the program has been well planned. Some management emphasis is usually included.

Trade education in post-secondary education fares less well in transfer, since it is usually involved in skill development with minimum amount of theory. Usually only a small part of the drafting, welding, technical illustration, auto mechanics, cabinet-making or other trades is accepted in transfer toward the baccalaureate degree.

As in trade and technical education at the lower division level, advisory councils help keep the industrial technology curricula timely and continually adapted to the needs of industry, and also help arrange supervisory internship positions for students.

Comparison of industrial arts with engineering is very tenuous and indistinct, because industrial arts aims its professional service at secondary teaching of a technical subject at the secondary level. Its purpose is to transmit the industrial heritage, to discover skills and aptitudes and to enhance occupational selection in pupils of junior high school and senior high school ages. The courses termed "professional" in the industrial arts curricula are aimed toward development of teaching proficiency. There is essentially no relationship between engineering and industrial arts.

When considering non-teaching industrial arts curricula, one must remember that the courses available aim at secondary education, not research in materials or processes in modern industry, nor do they develop appreciable management skills. However, graduates have been termed generalists educated in the "liberal arts of industrial education." Generally they are required to complete several teaching courses. They may study in greater depth in mathematics (through college algebra and trigonometry) and physics or chemistry than they would in the teaching major. But their background in mathematics, physics and chemistry ordinarily will be much weaker than that required for industrial technology and far below that of engineering. Nevertheless the non-teaching industrial arts graduate is in demand and industry has provided many excellent positions to such graduates, much to the consternation and detriment of industrial arts teaching, whose graduates are in critically short supply.

Trends of the fifties continue today with only slight change. The outlook for the future of industrial technology is for rapid growth, improved image and status, and continued change to serve the needs of the students, their employers, and the institutions providing the educational services. Today there are approximately eighty programs with many more planned.

COMPARATIVE PHILOSOPHIES

This yearbook opened with a setting of the stage so that industrial technology could be pictured clearly to everyone. The first chapter disclosed the soul of industrial technology in its philosophy and objectives. This section will borrow some thought from the previous effort, to be combined with other philosophies relevant to a comparison of programs at the bachelor's degree level.

Comparisons presented here are only of programs of the bachelor's degree level; limits of this study preclude consideration of two-year technician programs leading to the A.A. or A.S. degrees except as feeder programs permitting transfer into upper-division bachelor's degree industrial technology programs. Also beyond the scope of this comparison are programs aimed at meeting a need for persons holding the B.S. degree in *Engineering Technology* and educated to assist engineers, as industrial technology is not engineering oriented.

Engineering

Engineering curricula lead to the bachelor of science degree in engineering providing broad education for professional careers in the engineering sciences or a qualification for continuing academic work leading to advanced degrees in the engineering sciences.

Options include civil, electrical, materials, and mechanical engineering, and in some institutions, aeronautical engineering, chemical, industrial engineering and others. Many inter-disciplinary degrees have developed in recent years such as bioengineering, ocean engineering and medical engineering.

A rigorous foundation in mathematics, physical and chemical science is required. This has implications for high school preparation and ability level, for a student should begin to prepare himself by the time he enters the tenth grade. Counseling to this effect needs far greater emphasis.

Engineering aims toward professional services in research and development, and toward design of the devices and systems which implement our highly technical civilization.

Many engineers move into management position, particularly in companies whose product is the result of engineering design and construction or production. Utilities, heavy industrial manufacturers, aircraft, and research and development companies are typical of such companies. Although the usual engineering curriculum provides little or no course work in management, an engineer is not expected to terminate his education after obtaining a baccalaureate degree. Those with a management objective continue their education in that area while serving what might be termed an "internship" as a technical engineer for several years before reaching sufficient maturity and familiarity with their organizations. Some companies employ engineers directly out of college specifically for managerial positions and provide special training programs extending over several years.

It is dangerous to generalize about engineering education in view of the diversity of curricula and philosophies. However, not too many educators would challenge the statement that its primary objective is to provide the student with a background of problem solving in applied physical sciences. While it is true that the problems may range from the purely mathematical to the practical, the student has had ample experience in analyzing a situation, and, by employing his theoretical background, arriving at a solution.

Even though engineering has been fragmented into many options, the tremendous breadth of activities available today in practice dictate that each option be comparatively broad rather than directed towards one of the many specialties one reads in the want-ads in the newspapers. The curricula provide the graduate with the tools and an apprenticeship in problem solving; it is left to the employer to mold these qualifications to his specific needs.

Prior to World War II, considerable factual information was presented in a majority of the courses. Today most of this has been eliminated in a formal sense, although the educator with practical experience does impart some of this type of knowledge to his students. The major remaining part of the curriculum which is designed to equip the graduate with tools which are of immediate use to the employer is laboratory instruction. The majority of the engineers entering the field of research and development are expected to spend a considerable portion of their time in the laboratory. Consequently, a number of laboratory courses are required which not only complement the lecture but expose the student to modern instrumentation and measurement techniques.

Although it is not a part of the curricula, the student gains considerable insight into professional opportunities, engineering ethics, and latest developments not found in textbooks by participation in professional societies. Each discipline has its appropriate professional society which usually supports a student branch on the campus. This affords the students an opportunity to meet and learn from practicing engineers who are conversant with the state-of-the-art. The contributions of such contacts to the student's overall capabilities is of major proportions and is recognized by educators and employers alike.

Industrial Arts

Industrial arts curricula aspire to meet the needs of various groups of college students preparing to qualify for teaching the basic facts and implications of industrial life to pupils in elementary, secondary, vocational-technical and trade schools, and to workers in industry.

Industrial arts also provides knowledges and skills for students who do not wish to teach, but plan to enter industry in various technical activities.

Many industrial arts courses are valuable electives for students pursuing majors in other academic subject fields. Examples would include students in engineering, physics or business, who elect courses in machine shop, automotive or general metals.

In the schools, industrial arts forms an important part of general education; discovering aptitudes, promoting creativity, forming desirable work habits, developing favorable attitudes, establishing ideals, developing skills and character traits, and imparting knowledge of the tools, materials, processes, productivity and human relationships of industry. Thus industrial arts consists of instructional laboratory work centered around present industrial and technical life. Opportunity is provided for exploratory experiences facilitating the choice of an occupation.

Industrial arts college teaching programs often include the master of arts degree for students showing strong academic abilities. This should provide further specialization if possible and may include industrial technology courses for increased depth and breadth.

Industrial Technology

Industrial technology curricula aspire to meet the occupational needs of students and provide graduates with broad literacy in the physical, chemical, mathematical, political and social sciences, business administration, history and humanities with appropriate theory and laboratory courses. The program of studies provides graduates with a skill in synthesis and evaluation of problems likely to arise in their supervisory occupations. Exercise in solution of such problems is provided during the later stages of education.

Industrial technology curricula also aspire to meet the needs of the industries which employ their graduates. Programs gain impact and timeliness through the use of highly qualified experts from industry who teach on a part-time basis, and by virtue of their deep and extensive industrial experience do much to augment the faculty.

Curricula are kept timely and of proper breadth with the aid of industrial management advisory councils, direct industry-faculty contact, and follow-up studies of graduates. Suggestions of graduates pursuing master's degrees in business administration help articulation with the industrial technology program.

Though the education of the industrial technologist is very broad, an area of concentration or specialization (such as electronics) is pursued in depth. Specializations are often termed "options" which suggest a family of industries within each of which the technologist can exercise his specialty. Within each company, a family of occupations exist from which the graduate may select positions suited to his aptitudes.

The foregoing philosophy may suggest that some uniformity of programs exists, but such is not the case. The great diversity of offerings has added confusion to the recent studies attempting to completely define industrial technology.

THE ROOTS OF THE THREE PROFESSIONS

Engineering

A dissertation study at Pennsylvania State University in 1962 traced the engineering profession from its birth to 1836. Dr. Stachiw found "chronologically between the journeyman and the professional engineer were the mechanics." Renssalaer School was the first to confer the distinguishing mark, the degree, in 1836; the birth of the engineering profession. Civil engineering was the first option. (11)

An 1850 report stated—"There has existed for the last twenty years a great demand for civil engineers. Has this demand been supplied from our colleges? We assume the single academy at West Point, graduating annually a smaller number than many of our colleges, has done more towards the construction of railroads than all of our one hundred and twenty colleges united.—" (12)

The Morrill Land-Grant Act of 1862 responded to the need for engineers which became acute because of changes brought about by the Industrial Revolution. Also, some politicians frankly admitted that the Act was needed to supply officers and engineers for the Civil War effort.

Engineering education evolved naturally until 1955, when the "Grinter Report" emerged, catapulting the term "Engineering Science" into prominence. The report had immediate and deep impact on engineering education reflecting the philosophy of a science-and-analysis related curriculum. Fortunately these changes anticipated the "Sputnik" situation of only a few years later. The philosophy of the Grinter report, of President L. E. Grinter of the Engineer's Council for Professional Development, was reaffirmed in 1967 in the "Goals Study" of the American Society for Engineering Education. (5: 43)

Industrial Arts

The first curricular area resembling modern industrial arts was established in Washington University of St. Louis under direction of Calvin Woodward and taught by Noah Dean beginning in 1870.

In 1876 John Runkle, President of Massachusetts Institute of Technology, introduced manual training into the engineering curriculum, under a plan evolved from the Russian exhibit of Della Vos in the Philadelphia exposition of that year. (1: 34)

Growth of the high school movement expanded manual training which evolved into the term "manual arts." Later this was changed into "Industrial Arts" and was relegated a place in the area of general education for everyone.

Concern for the best education of industrial arts teachers led to the establishment of an annual forum called the "Mississippi Valley Conference." This had its beginning in 1913 and is still very active today. One of its concerns during the 50th conference was the area of Industrial Technology.

Institutions providing education for industrial arts teachers have made available special programs for students not wishing to enter the teaching profession. In recent years non-teaching industrial arts graduates have been serving industry effectively in sales, training, maintenance, production and many other capacities. However, with the advancing sophistication of industrial systems, a need for greater depth of knowledge and skill in mathematics, chemistry and physics has become increasingly evident, along with a need for various management techniques. The result is the evolution of the industrial technologist.

Industrial Technology

Bradley University of Peoria, Illinois opened the first industrial technology program in 1923, and still offers it today under the term "Applied Sciences" continuing through the Master's degree. Charles Bennett was the principal innovator at Bradley University. Dr. Beryl Cunningham carried the program on to his retirement in 1967. At Bradley, industrial technology is termed applied science and is a part of the School of Engineering and Technology.

Though highly successful from inception, the idea of industrial technology bore little fruit until after World War II and principally since 1950. Today more than 73 industrial technology programs can be identified and more are planned. (2: 11) Most programs evolved in industrial education departments of colleges and universities in response to the needs of industry and of students who did not intend to teach or who were dissatisfied with engineering offerings. Some programs evolved in response to recognition that many students of technical institutes have both the ability and interest to continue their education in courses of university rigor. In fact, Holland Boaz reported fifteen programs of industrial technology which offered the upper-division level courses allowing students to transfer from a two-year curriculum of technical level, with little or no credit loss. (2: 33)

With regard to engineering withdrawals, Max Hansen found that many highly capable students were not being trained in technology as they tended to develop new interests in such majors as business administration, mathematics, physics, sociology, political science, accounting, or economics. Had industrial technology been available, many students could have succeeded in a program more fitting to their interests. Hansen concluded that "There is a crucial need for a degree curriculum in industrial technology at the University of Nebraska," and "Degree curricula in industrial technology are broad in scope, highly successful, and dynamic in the institutions which were investigated."

(7: 197) He constructed an idealized curriculum which he proposed to the faculty. This included three options and suggested two others for future development.

Today industrial technology is advancing resolutely on a broad front. As Harold Foecke stated:

> From the point of view of preserving the traditional engineering technology schools, there may not be much time left to ponder and achieve this transformation because, to employ a military metaphor, they are being outflanked by the emergence of four-year technology programs growing out of the industrial arts heritage. It is certainly true that their nature and purposes are quite different from the ECPD accredited technology programs, but this may not be eminently clear to the potential student. I do not wish to imply that some programs are better or worse than others; the fact remains that they are different. Although the aggregate enrollment in these programs is relatively small, there are perhaps four dozen (sic) such programs in existence already (most of which have emerged since World War II) and their potential drawing power is probably very large. (6: 37)

COMPARATIVE OBJECTIVES

Engineering

Engineering education aspires to provide students with knowledges and abilities qualifying them for responsible professional service in government, industry, and military activities concerning research, development and design. Although many engineers ultimately find themselves in managerial positions, few undergraduate programs provide an appreciable amount of course work specifically directed towards this goal. Engineering education also provides the baccalaureate degree foundation for studies leading to advanced professional degrees through the doctorate.

Students graduating from engineering education with bachelor of engineering or bachelor of science in engineering degrees are qualified to pass the engineer-in-training examinations, then the professional examinations leading to registration as professional engineers in the state, or states, of residence and service.

Industrial Arts

Industrial arts education aspires to prepare teachers for their professional roles in teaching the industrial arts to pupils of the secondary schools, and to prepare others who do not plan to enter the teaching profession for their occupational roles in industry with broad knowledge of the industrial arts and a specialization in one or more of the areas of industrial arts.

Industrial arts education leads to the bachelor of arts degree which serves as the foundation for advanced degrees in either industrial arts or education.

Industrial Technology

Industrial technology aspires to provide students with knowledges, skills and abilities qualifying them for responsible professional service in industry in positions of production management or related service and dealing with the economic, legal, social, political, aesthetic, and cultural constraints on industrial activity and aspects of safety, producibility, productivity, cost and value, quality and reliability, servicibility and functional improvement of products and productive systems of industry.

Industrial technology education leads to the bachelor of science degree which serves as the foundation for study leading to advanced degrees in industrial technology, applied science, business administration, or aerospace management.

CURRICULAR COMPARISONS

Among engineering, industrial arts, and industrial technology it is difficult to find areas of commonality within such diverse disciplines. One area having some similarities may be found: electronics, in which some degree of approach may be noted. Comparisons of other options are tenuous and hardly valid.

For purposes of comparison, the catalogue statements of a California State College follow: (10: 77-9, 83ff)

Engineering

The division of Engineering offers a four-year curriculum leading to the bachelor of science degree in engineering and provides a broad training for a professional career in engineering or for continuing academic work towards an advanced degree. The total program includes a minimum of 132 semester units and provides opportunity in the upper division to specialize by options in the areas of civil, materials, mechanical or electrical engineering. For administrative purposes the School of Engineering includes departments of civil, mechanical and electrical engineering. The options in civil, mechanical and electrical engineering were accredited by the Engineer's Council for Professional Development in 1963. The other option, materials engineering, was a new option offered for the first time in the fall of 1966. Many of the engineering courses are available in evening or Saturday classes primarily for those employed.

The high school student planning to enter engineering is advised to pursue a strong program in pre-engineering subjects. These subjects should include biology, physics, chemistry, advanced algebra, trigonometry and one year of industrial drawing in addition to the general requirements for admission to the College. A deficiency in any of the above areas will result in an extension of the time required to complete the program in engineering.

The curriculum is also designed to accommodate students transferring with pre-engineering training from other colleges such as the junior and liberal arts colleges. Transfer students should note and follow where possible, the appropriate curriculum as outlined in later sections.

Engineering Advisory Council. The Advisory Council for the Engineering Division consists of outstanding engineers and executives from industry and government in the service area of the college. Its function is to afford a liaison between the College and industry and to keep the administration and faculty informed of modern engineering practices. This will insure that the curricula are kept abreast of the times. It will also advise on placement opportunities before and after graduation.

Industrial Arts

The industrial arts curriculum is designed to meet the needs of the following groups of students: (1) those preparing to enter the teaching profession in the field of industrial arts who need the Standard Teaching Credential; (2) those who are teaching industrial arts and who desire work to further their professional growth; (3) those who desire to broaden their experiences, but who do not plan on entering the teaching profession; and (4) those who are vocationally qualified and who desire to qualify to teach industrial arts subjects in their special areas.

Courses in industrial arts also are designed for students completing majors in other subject fields and desire to take elective units in this area.

Course offerings in industrial arts have been selected so that the student can qualify for (1) technical training leading to the baccalaureate degree; (2) a teaching major or minor in industrial arts to qualify for a teaching credential, and (3) the master of arts degree with a major in industrial arts.

Industrial Technology

The program in industrial technology is designed for the student who through screening based upon evaluation of previous educational work, job experience, testing and counseling, clearly demonstrates his aptitude and promise for high level technical work with related administrative responsibility. The following student groups are usually served by this program:

1. Promising high school graduates interested in an applied science curriculum.
2. Transfer students from the junior colleges who desire to earn the bachelor of science degree in their area of specialization.
3. Students who desire a change of objective from other occupational curricula.
4. Personnel currently employed who desire additional training and/or to qualify for the bachelor's degree.

Industrial Technology Advisory Council. The advisory council, composed of leaders actively engaged in areas of technology with which the program is concerned, continually provides information and guidance about industrial developments in methods, materials and techniques so that the program reflects the best of current practices. In reference to the above, they examine various aspects of the program and make recommendations for changes in course content, methods and/or facilities. A current on-going program mandates the utilization of a strong advisory committee. This should also represent all the technical options within the program.

Course Requirements

Tabulated here are course requirements for the baccalaureate degrees indicated. These curricula are offered at California State College at Long Beach and are listed for comparison.

Electrical Engineering
132 semester units, B.S.

Social Science	6
Biological Science	3
Physics	12
Chem., Inorganic	10
Math (Par. Dif. Eq.)	15
Literature, Phil.	6
Art	....
English Comp.	3
Speech	3
Psychology, Gen.	3
Health & P.E.	4
Economics	3
Intro. Engineering	1
Graphics	3
Engr. Activities	0
Engr. Acon. & Ad.	3
Thermodynamics	4
Dynamics	3
Particle Mechanics	3
Electric Circuits	4
Computer Methods	1
Circuit Analysis	3
Electron Devices	3
Engr. Electronics	4
Electrical Fields	3
Circuit Analysis II	3
Engr. Electronics II	4
Electromagnetics	4
Control Systems	4
Elec. Engr. Electives	12
Mech. Engr. Electives	3
Total	132

Industrial Arts
124 units, B.A.
(Electronics)

Social Science	9
Biology	3
Physics or Chemistry, Gen.	4
Math (Trig)	6
Literature, Phil.	3
Art Studio	3
Comp. & Tech. Report	6
Speech	3
Psych, Gen.	3
Health & P.E.	4
Economics	3
Orientation	1
Indus. Drawing	2
I. A. Design	2
Curric. Methods	3
History of I. A.	3
Dev. Ind. & Tech.	2
Gen. Metal	2
Gen. Electricity	2
Wood Shop	2
Graphic Arts	2
Automotive	2
Photography	2
Safety Ed.	1
Org. & Mat. Facil.	2
Vacuum Tubes & Circuits	3
Semi-Conductors	3
Circuit Analysis	3
Audio Systems	2
Theory TV & FM	2
Amateur Radio Lic.	2
Adv. Tech. Studies	4
Special Problems	2-4
Electives to Total	124

Industrial Technology
128 units, B.S.,I.T.
(Electronics)

Social Science	6
Biology	3
Physics	8
Chemistry, Gen.	4
Math (Calc.)	8
Symbolic Logic	3
Industrial Design	2
Comp. & Tech. Writing	6
Speech	3
Psych, Gen. & Indus.	6
Health & P.E.	4
Economics	3
————	
Indus. Drawing	3
Accounting	3
Marketing	3
Job Analysis	3
Kinematics	3
Machine Shop	3
Mat. & Processes	3
Ind. Safety	2
Supervision	3
Circuit Analysis	2
Testing & Troubleshooting	2
Transistor Theory	2
Production Analysis	2
Proposal Writing	3
Bus. Adm. & Control	2
Computer Circuits	2
Elec. Automation	2
Prod. Techniques	2
Transfer Technical	24*
Electives to Total	128

*Note: Transfer technical units in industrial technology, electronics option, may include:

Direct Current—Lecture and Laboratory	5 units
Alternating Current—Lecture and Laboratory	5 units
Vacuum Tubes and Semiconductors—Lecture and Laboratory	5 units
Circuits and Systems—Lecture and Laboratory	5 units
Measurements—Laboratory	2 units
Drafting (except Electronic)	2 units
	24 units

While typical, the transfer technical background shown may have variations to be evaluated in consultation with an electronics option counselor.

Inspection of the curricula compared on the previous page reveals the differences in depth of coverage in mathematics, physics, chemistry and electronics, with industrial technology intermediate to industrial arts and electrical engineering. Industrial arts includes education courses even for non-teaching graduates. Industrial technology goes deeper into electronics, and adds psychology, accounting, business administration, communications and production courses. Electrical engineering specializes in electromagnetics and electronics and electrical systems in depth.

THE PRODUCT FUNCTIONS

Engineering

It is nearly redundant to point out the astounding progeny of our expanding technology, such as space exploration vehicles, worldwide live telecasting, and communications with telemetry devices through tens of millions of miles. All of these depend on engineering.

However, it may not be as generally appreciated that each major activity is supported by numerous engineering departments requiring vast numbers of engineers working as teams. Few would argue against the premise that no major new developments could occur without engineers. Today our engineers are applying the developing theories of physics and other sciences with systems methods to create our next generation of products.

Engineers combine the principles of the sciences to meet a conceptual need and design the system with its major details. Thus are created the advances of today that become the production of tomorrow. Then the engineers and their aides construct and assemble their prototypes, test and adjust, tune and refine until the concept reaches a thoroughly satisfying level of function. Quality and reliability are specified, maintenance and repair programs determined and the design released for production.

Engineers need managing, and engineers are most qualified for the task after developing the necessary skills. Further practice and skill in management often leads engineers to the top of their companies and industries.

Conversely, due to shortage of aides and to urgencies, some engineers often are forced to perform in roles more appropriate to technicians.

Oftentimes engineers leave engineering horizontally, into personally intriguing activities in entrepreneurship, sales and distribution, producability and manufacturing research or production.

Industrial Arts

It is of interest to note the specialties in which industries have special interest in the non-teaching industrial arts graduate. In general, these comprise options in which few or no industrial technology graduates are available.

The automotive industry attracts a large number into its production, service coordination, training and supervision programs. This option permits development of unusual depth and the graduate is in great demand. The lumbering and forest products industries also attract many industrial arts graduates of non-teaching programs who are specializing in the woods and crafts options.

In these industries the industrial arts graduate functions at all levels and positions of supervision and management. His function derives from his strong interest and self-improvement efforts.

Industrial arts graduates, like diemakers, can reach the presidency of large companies, and go beyond, when personal drive has enough acuity.

Industrial Technology

John Dykstra, former diemaker and recent president of Ford Motor Company has described the functions of the industrial technologist in the following terms:

> He may develop a special machine to manufacture a newly improved automobile part. Or he may design the entire layout for a huge food processing plant. Or he may plan and coordinate all the production operations in a factory turning out electronics equipment for space flight.—
>
> Our nation's leadership of the free world depends quite literally upon productivity. We must *produce* for defense, *produce* to compete successfully with communism in the market places of the world, *produce* to keep our own economy moving in high gear.—

To his hands, his brain, and his vision is entrusted the task of developing America's industrial and economic might to its fullest possible strength.—

Thus it is clear that this broad engineering field actually is not a *job* at all but a *function,* not a single task but a great many tasks that converge upon his one vital duty—*get it made and made right.*—

Maintain production efficiency. He chooses the correct tooling and processing that will make a product to exact specifications hour after hour, month after month, and on schedule.

Maintain the peak of quality at all times. Excellence cannot be inspected into a product. It must be built into it, and the engineer has to know how.

Play a creative role in improving the whole of the manufacturing process. At our company, we have a group of men in advanced manufacturing development who live more in the future than they do in the present! For example, they are now working with methods that will in time produce gears 25-50 times faster than machines we have now. Significant creative work lies ahead for the manufacturing engineer in automation—machines that run themselves—the use of new metals, electro-chemical machining, computer technology and other marvels.

You can readily see that a great number of different jobs are involved in carrying out the manufacturing engineer's basic responsibility. Here are only a few of the specific areas in which manufacturing engineers at Ford Motor Company are currently working:

They create new tools, processes and equipment. They help plan and create complete production systems. They lay out whole factories. They plan production flow. They make time and motion studies to reduce waste effort.

I should cite some cautions. A manufacturing engineer cannot expect to work short hours. At the plant level, he may get calls in the evening to rush down because something has gone wrong. He must be ready to get himself begrimed from head to foot as he tackles an unruly machine. He must discipline himself to be a student of engineering throughout his entire life to keep abreast of technical advances in his field.

The personal satisfactions of the profession are on a level with its high importance. There is great satisfaction that comes from the knowledge that you are serving humanity with a good product you helped to create. I know that feeling and consider it one of life's great blessings.

There is also deep pride because you are, in a very real and practical sense, contributing to the future of your country and the free world. There are few more important goals to which you can devote a lifetime." (4)

OVERVIEW AND OUTLOOK

The preceding sections of this chapter have clarified each segment but have not affected any valid comparison: the trichotomy of technical education remains.

Engineering and non-teaching industrial arts are unrelated, even when the common option of electronics is selected. Thus the only comparable learnings are in some aspects of general education, but they are common to all students in four-year institutions.

Engineering and industrial technology have little relationship, as engineering is more research and development oriented while industrial technology is production supervision and productivity-reliability oriented. Due to its great breadth, industrial technology occasionally encroaches upon minor fringe functions of engineering. Such encroachment is not due to curriculum approaches, however, but develops in response to exigencies of the work situation.

The third comparison, of non-teaching industrial arts with industrial technology shows only tenuous relationship. Industrial technology *is* technology and as such has strong foundation in mathematics, physics and chemistry which differs markedly from that in industrial arts. On the other hand, the industrial technologist may know very little of graphic arts or have few woodworking skills. Preparation in management is as divergent.

PROSPECTS

In 1952, Dean Hollister of engineering at Cornell University pointed out that an apparent turning point has been reached in the engineering profession as the "percentage of the population available to be made into engineers is no longer increasing despite the accelerating need for engineers in our economy." (8: 8)

In 1963 manpower experts estimated that we must graduate more than twice the current 35,000 engineers each year to meet expanding needs.

In March, 1968, Dean Ingersoll of engineering at the University of Southern California observed "despite a growing demand for engineers, the supply has remained almost constant during the last ten years with about 35,000 graduating at the bachelor's level each year throughout the nation."

"Although more freshmen are enrolled in colleges and universities, the proportion qualified for engineering who select that field has declined steadily," Dean Ingersoll said. "This fact troubles both engineering educators and industrialists." (9: 3)

Various efforts to improve guidance and mathematics instruction at the secondary level may help to release a supply of qualified students to engineering studies.

Industrial arts non-teaching baccalaureate degrees are encouraged by industrial education departments. The demand for graduates remains high and continues to increase.

Industrial technology curricula have been dynamic and growing the two decades or less comprising most of their history. Hansen found an exuberance for technology curricula in each institution he visited, and all the programs he investigated were changing in response to perceived needs. The void formerly being left in the preparation of persons for the operational levels in industry is being filled by industrial technology programs. Hansen found the state university to be the logical institution for industrial technology curricula. On the state university campus he studied, concerning withdrawals of capable engineering students, he found "a crucial need for degree curricula in industrial technology at the University of Nebraska." (7: 191-7) Boaz concurred, saying "—it seems reasonable to conclude that the programs are needed and will continue to grow and the curricular offerings will continue to expand." (2: 125)

Coordination of the expansion of industrial technology will help guide orderly growth to meet the perceived objectives. The national Industrial Technology Association formed in 1968 at Kent State University under Charles Keith's direction should help coordinate growth along proven lines. (3: 35)

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CHAPTER FOUR

Two-Year Associate Degree Programs Compared with Four-Year Industrial Technology Baccalaureate Degree Programs

PAUL L. KLEINTJES

Any attempt which proposes to compare must be based on the assumption that what is to be compared, can be. In addition there must be general agreement on criteria to be used, evidence which can be applied to these criteria as a basis for judgment, and a rational consideration of the evidence so applied to permit the drawing of reasoned conclusions.

INTRODUCTION

The review of the literature in the initial stages of this study revealed that while much had been written about both associate degree and baccalaureate programs structured to prepare persons for entrance into industry, there was much confusion in terminology and wide divergence in aims of the authors involved. Most authors of the works cited had drawn valid conclusions from scholarly research, but few of these were directly applicable to the problem at hand. Most frequently, materials of greatest value to this paper were incidental to their theses.

The basic problem of this chapter is to compare two-year associate and four-year baccalaureate degree programs. The immediate discernible secondary problems are the definition of terms, and the determination of bases on which such comparison could be made. The scope of this chapter is, therefore, limited to: the proposal of criteria which can be used as a basis for comparison; the definition of terminology used which seem to be generally acceptable; the presentation of evidence applicable to these criteria within the framework of terms as defined; and finally the preparation of conclusions which may aid in the ordered development of both two- and four-year programs which prepare for entrance into industry.

Methods of research were limited to a review of articles in professional journals, summaries of seminars, reports of committees, theses and dissertations, publications of government and learned societies; follow-up studies of graduates of two- and four-year programs and personal interviews with industrial recruiters and training personnel.

An initial listing of plausible criteria was examined and, by reason of availability of data pertinent to the problem and the significance of each item, was reduced to these as being both significant and documentable.

Objectives, proposed, purported or assumed
Faculty, preparation, academic and service
Students, achievement levels and goals
Graduates, position and salary on initial placement
Program, technical requirements
  science and mathematics requirements
  general education requirements

The definition of terms was the most obvious and immediate confrontation.

The Technician

Almost immediately, on beginning a review of the literature in search of a definition of the technician, one is struck by the amazing consistency of incoherence that exists in both industry and education. McCord and Schaefer state the condition so succinctly it is cited as an introduction to this phase of the problem.

> The man of the hour, the technician, continues to elude and spread havoc in the circles of those who profess to define him. State and national meetings glibly discuss the all-important individual and his role in modern technology only to have confusion of definition run rampant through the audiences. Educators, it seems, almost delight in their diversity of opinion on the subject and much time and effort has been lost in "taking sides" at state and national levels. Great concern has been voiced over the wording of federal legislation, jurisdictional implications, and the adequacy or

> inadequacy of certain facets of the educational profession to carry out programs of technical education. Meanwhile, the urgent need to educate more technicians, however they may be defined, continues at an alarming rate. (31: 3)

Other scholars seem to concur on the problem of definition. Emerson, after discussing the difficulty of defining the technician because of the wide variety of duties and payroll titles involved, offers this as a broad and general definition.

> The technician is a person who works at a job which requires applied technical knowledge and applied technical skill. His work in this respect is somewhat akin to that of the engineer, but usually narrower in scope. His job also requires some manipulative skills, those necessary to handle properly the tools and instruments to perform the technical tasks. In his special field he has considerable technical knowledge of technical-industrial processes, and in the field he knows how to apply the necessary principles of the physical sciences and mathematics. In general, he uses instruments in contrast with tools. His contribution is mainly through mental effort in contrast with muscular exertion. (14: 1)

Hansen (16: 22) found that no one is quite sure what a technician is, or is there complete agreement on who should train him. He concludes, "at present it (technician) may refer to the washing machine repairman or to a person supporting physicists." Dr. Jerome Moss in an article entitled "Will the Real Technician Please Stand" appearing in the October 1962 issue of *Industrial Arts and Vocational Education* presented a bibliography of twenty-five references on defining the technician. Schill and Arnold contend that the definition of a technician cannot be based on some past concept of occupational classification. They write, "The technician is not necessarily a modified or unsuccessful engineer, nor is he necessarily a re-educated craftsman. He is a new and unique part of technological society." (27: 5) They accepted for purposes of their research project the following:

> The engineering or scientific technician is usually employed in (1) research, design, or development; (2) production, operation, or control; (3) installation, maintenance,

or sales. When serving in the first of these functional categories, he usually follows a course prescribed by a scientist or engineer but (may or) may not work closely under his direction. When active in the third category, he is frequently performing a task that would otherwise have to be done by an engineer.

> In executing his function, the scientific or engineering technician is required to use a high degree of rational thinking and to employ post-secondary-school mathematics and principles of physical and natural science. He thereby assumes the more routine engineering functions necessary in a growing technologically based economy. He must effectively communicate scientific or engineering ideas mathematically, graphically, and linguistically. (27: 5)

Venn cites one government definition of a technician as:

> All persons engaged in work requiring a knowledge of physical, life, engineering, and mathematical sciences comparable to knowledge acquired through technical institute, junior college, or other formal post-high school training, or through equivalent on-the-job training or experience. Some typical job titles are: laboratory assistants, physical aides, and electronic technicians . . . and not men such as machinists and electricians. (39: 132)

He goes on to say:

> This is a limiting definition that identifies certain semiprofessional workers in fields related to science and engineering (fields in which this distinguishable middle-level occupation was first recognized). But our developing technology includes "technical occupations" with such titles as data processor, construction estimator, marketing specialist, technical secretary, illustrator, structural draftsman, production control supervisor, dental assistant, flight engineer, radiation technician, cartographer, technical photographer, color television monitor, practical nurse, food service manager, government safety inspector, and so on. Many of these titles are new, an indication of the tremendous growth of employment opportunities in new technical fields. Indeed, progress into the technological age, accompanied by greater

> demands on professional people, will emphasize that those in the professions spend too much time doing what someone with a shorter, more specialized education could do just as well. (39: 132)

The citations given serve to show the lack of unanimity of opinion that exists and it would be presumptous in this short study to attempt to create a new and generally acceptable definition.

For purposes of this study the term technician will be used to describe the person who is qualified for entry into a technical position in industry as the result of successful completion of an educational program terminating in an associate of arts degree in a technical curriculum.

The Technologist

This term is somewhat new in the list of occupational classifications. There seems to be no agreement as to the origin of the term except that it evolved over the past few years and serves as a useful device in describing a newly realized occupational category. Unlike the limitless categories and descriptive boundaries applied to the technician there is some evidence of agreement on both definition of the term and the scope and educational requirements of the position described. This may be due in part of the recency of conception of the term. The phenomena is so new that educators and industrialists have had insufficient time to confuse the issue. In all probability it is due to the scholarly approach to the development of programs to fill a need in industry and the careful definition of terms involved.

In the "Progress Report for Four-Year Technology Committee for the American Vocational Association" the industrial technologist is described as follows:

> The technologist is a college graduate who is associated with managerial and scientific activities in the industrial field. He has a solid background in mathematics, physical sciences, and human relations with extensive educational experience in technical theory and manipulative abilities in a field of specialization as well as in closely related fields. He is able to work with scientific personnel and contribute to their ideas as well as to supervise and manage people and to coordinate their efforts in the utilization of ma-

terials and machines for producing and distributing industrial products. (1: 2)

Cunningham, in his study on "Applied Sciences in Education and Industry", after discussing various technologies, as construction technology, electronics technology, machine design technology and others writes:

> A student who successfully pursues one of the industrial technologies as a field of specialization along with approved courses in other technical sciences and in human relations . . . humanities, social sciences, educational and managerial sciences, . . . is an applied scientist.
>
> The applied scientist is a college graduate who is associated with managerial and scientific activities in the industrial field as well as in the educational field. He has a solid background in mathematics, physical sciences, and human relations with extensive educational experiences in technical theory and manipulative abilities in a field of specialization as well as in closely related fields. He is able to work with scientific personnel and contribute to their ideas as well as to supervise and manage people and to coordinate their efforts in the utilization of materials and machines for producing and distributing industrial products. (9: 23)

Hansen writes that representatives of North American Aviation, Rocketdyne Division indicated job opportunities for technology graduates are unlimited. They said:

> There is a wide range of occupational outlets for the four-year technology graduates. These include supervision, management, supporting positions for engineers and scientists, quality control, time and motion analysis, computer work, and liason between the home company and the subcontractors. (15: 89)

In interviews with some twenty-three industrial representatives, Hansen (16: 65-75) found supervisory and management positions were considered as likely entry levels for four-year technology graduates.

These findings are corroborated by the author's follow-up studies of graduates of the Industrial Technology Program at California State College at Long Beach. Returns from approximately sixty percent of the graduates, (about 135 replies) over the past five years were analyzed. These indicated that nearly ninety percent occupy positions of a professional, supervisory or managerial level. Industrial recruiters, when questioned by the author mentioned the supervisory-management potentialities of four-year industrial technology graduates as the prime focus of recruitment interest. One of the better summary definitions of the industrial technologist is Keil's paraphrasing of Weber's description.

> *Industrial technologist.* A college graduate who is associated with technical, supervisory or managerial activities in an industrial field. He is management oriented, rather than engineering oriented, in his approach to technical, scientific or human relations problems. The industrial technologist's background is broad and general rather than specialized; he has had a solid foundation of courses in mathematics and the physical sciences; he has had a variety of experiences in shops and laboratories designed to give him insight into how goods are produced; he has had some courses in business administration designed to give him insights into the problems of management, distribution and economics; and he has had general education courses designed to equip him with communication and human relations skills and an ethical foundation for making decisions. (20: 12)

Throughout the literature, various diagrams were found attempting to show the relationship of the various occupational levels to the how and why aspects of industrial occupations. Figure 1 is an adaptation of these graphic presentations with the industrial technologist superimposed to provide a graphic summary of the search for definition.

For purposes of this study the term (industrial) technologist will be used to describe the person who is qualified for entry into a technical supervisiory or management oriented position in industry as the result of successful completion of a four-year educational program terminating in a baccalaureate degree. He is a technically qualified, management oriented person.

With the purpose presented, several terminological suppositions proposed and the research methodology outlined, two other facets of the study must be examined as preparatory work for

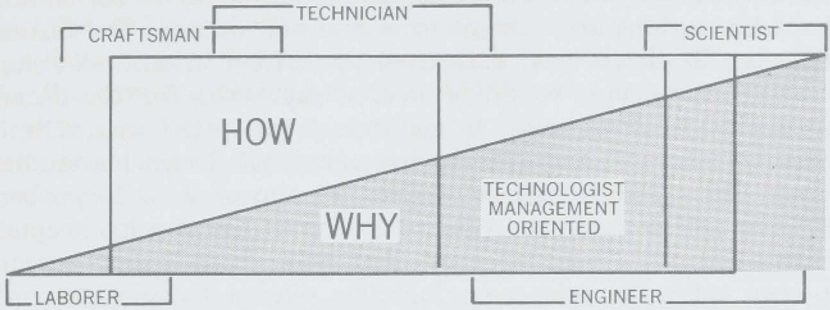

Figure 1. The technologist, his occupational level

the major matter—the comparison. These involve a brief review of personnel requirements of industry and some of the educational requirements of selected occupations. Though summary, they will provide further insight into the complexity and confusion existent in the problem.

INDUSTRIAL PERSONNEL REQUIREMENTS

One subject continually headlined in the newspapers and periodicals and most often the topic of discussion of business, labor and education groups is concerned with employment, manpower and technology. Here again the picture is bright or gloomy, impossible of solution or a simple matter of training or retraining, depending on who has the floor.

In commenting on the report of the National Commission on Technology, Automation and Economic Progress, *Product Engineering* (25: 67) notes the calmness with which the Commission approaches technological progress and the ambitious programs of training and retraining it suggests. They find the Commission holds that automation does not have a dire impact on the work force, but that it admits of a faster rate of technological development. The Commission predicts by 1975, for all manufacturing, a 14% increase in employment to 19,740,000 jobs. During the same time, however, in the manufacturing sector, manpower requirements will decline from 41% to 37% of all jobs while the service sector will grow from 59% to 63%. Based on an annual work force growth of 1.7 million and an assumed annual unemployment rate of 3% (actually closer to 5.5%), training and retraining alone would be no mean task.

Studies indicate that manpower shortages in many of the middle-level occupations are already acute and will worsen. The Bureau of Labor Statistics (24) estimated that 67,800 science and engineering technicians would be needed each year for the decade from 1960 to 1970 simply to maintain a ratio of .7 to 1 of technical to scientific and engineering personnel. From his studies, Venn (39: 133-5) sees a need of a ratio of 2 to 1 or about 200,000 new technicians a year because of the developments in technology. He finds, however, that only about 50,000 persons a year enter the science-engineering related technical occupations. He further emphasizes the educational problem when he writes:

> The problem is not simply one of numbers. It is one of quality. Though unplanned routes may lead to eventual employment designated as "technical," what kind of technicians do these sources produce? Their training in most cases has been narrow and lacking in rigor and their education is marked by large gaps, so that their future productivity and citizenship effectiveness are necessarily limited by the nature of their education. The technical occupations today form a vital and responsible part of science and engineering, and they demand personnel with the background and education increasingly possible only through organized technical education curricula within the educational system. (39: 134-5)

He summarizes the problem when he states, "In short, the need in the semi-professional, technical, and highly skilled occupations is for (1) more people, (2) the right kind of people who are (3) well trained and (4) well educated. Only through education can these ends be accomplished." While the increase in jobs of a technical nature is obvious, the problem of re-educating persons displaced from their jobs by automation and related advances must also be considered. Curtis, writing on automation, warns:

> Probably the reality most often overlooked is that the displaced worker frequently is not the one best suited to be trained to take on the newly-created job. The obsolete jobs tend to be considerably inferior to the jobs newly created by automation. Furthermore, the jobs going begging today are jobs which demand skills higher than the

> national average of skills. The process of training for the high skills in demand usually requires that a person holding down a good job upgrade his skill in order to prepare for the new and better job. (10: 21)

Clague, writing on the occupational outlook in the scientific and technical occupations, emphasizes the disproportional growth in manpower requirements in these fields as to that of general manpower needs increases. He writes:

> Manpower requirements in the scientific and technical occupations are expected to increase much more rapidly than the group as a whole. About 2.4 million engineers and scientists may be needed by 1975, about twice as many as currently employed. Need for some specialties within this group will grow faster than others. Mathematics, electrical engineering, and physics will be among the fastest-growing fields. The largest scientific fields, chemistry and biological sciences, will also grow rapidly. Growing expenditures for research and development programs, and the increasingly important role of engineers and scientists in the planning and production of our rapidly changing and increasingly complex defense and space equipment as well as the expanding needs of a growing and changing economy, are major factors in the rapid growth of demand for the scientific and technical occupations. Along with the rising demand for engineers and scientists, an increase in needs for technicians will take place. This is due at least in part to the increasing complexity of modern technology, which has created a need for workers who have some basic scientific and mathematical knowledge and also specialized training in some aspects of technology. The demand for these workers may be intensified if the supply of scientists and engineers remains below demand. (8: 39)

Keil (20: 4-6) found that the literature is replete with articles and reports indicating the increasing demand for various types of technical manpower. He reports that a particular need has arisen for persons with technical background qualified to staff the management positions emerging in the intermediate ranges of technical employment. He further points out that while in the past many of these positions were filled by graduates of professional engineering schools the picture has changed. Engineering education, regardless of field, rests on an ever-increasing foundation of mathematics and science and the engineer does not have time to perform many of his previous functions. Engineer schools graduate about 35,000 engineers each year. The needs of industry are placed at 70,000 new engineers each year. It seems improbable this need can be met. In summary Kiel writes:

> It has become apparent that if a readjustment of technical manpower is to be made, special attention must be given not only to the training of engineering technicians, but also to management-oriented professional personnel who have the additional managerial and human relations skills necessary to complement their technical qualifications. (20: 5-6)

In interviews with industrial recruiters, Hansen, this author, and others found a unanimity of opinion that technically trained persons with additional work in management oriented studies were in great demand. Industry representatives also emphasized the importance of the baccalaureate degree for both its status and promotional aspects.

The sources cited are but a small fraction of the materials studied, all of which were in general agreement that the critical increasing personnel needs of industry are centered in the technician-technologist-engineering triangle. There also seems to be sufficient corroborating evidence that these needs are not going to be met by existing educational resources in the forseeable future. The relationship between personnel need and the education qualifications of these personnel is worthy of some scrutiny.

As the personnel requirements of industry have changed greatly over the past decade, so have the educational requirements for entry into these positions changed. Venn points out:

> A high school diploma is a minimum requisite for most production workers, and a bachelor's degree, often in engineering, may be a requisite for the foreman or supervisior. A college education is the only ticket for entry into the professions, with graduate study often a necessity for advancement. The technical, skilled, and semi- professional occupations all demand substantial amounts of post-secondary

> education for entrance. In the accelerating job-upgrading process of technology there is a steady increase of higher education and skills needed for entry and retention. Education has become the crucial ladder to the reward positions in society. (39: 16)

He continues:

> Now, technology has advanced many occupations on the technical, skilled, and semiprofessional levels to a point where they require higher levels of specializiation and related knowledge that are best learned and taught within educational frameworks. Manifestations of this upward push are to be found, for example, in engineering, where the two-year engineering technology curricula of today compare in rigor and breadth with the four-year engineering curricula of twenty-five years ago. As engineering continues to become more complex and specialization is delayed, graduate study will become a must for the engineer, and, by the same token, it is probable that within the present decade the bachelor's degree will become a must for many technical occupations. Similarly, the skilled crafts are now making their appearance on the junior college level. (39: 16)

Figure 2 shows the relationship of educational requirements and careers in electronics. This is typical of most technologies.

In addition to statements of general training requirements for various occupational levels, some studies have been made which show the relation of specific subject matter areas to various technical occupations. Table 1 shows the relationship of selected subject matter to some occupations in civil and highway technology. (34: 15) One would not have to search far for documentary evidence of what is already obvious. Space limitations dictate the inclusion of only the several cited. Man's accumulation of technological 'know-how' has been increasing logarithmically with time. Educational requirements for service in the technological world must of necessity also increase.

With the preliminaries of definition of terms and of examination of industrial personnel educational requirements reviewed, it is now appropriate to look at the programs which will help provide for some of the personnel needs of industry.

TABLE 1
Training Requirements Analysis Form— Civil and Highway Technology

Subject Matter areas required (Instruction to be included in the application of science and mathematics to the technology)	Occupation Titles Symbols: A—Advisable E—Essential							
	Constr. eng.	Draftsman, arch.	Estimator	Highway eng.	Instrument man	M'plex-proj. topographer	Surveyor	Surveyman
MATHEMATICS:								
Algebra through quadratic equations	E	E	E	E	E	E	E	E
Trigonometry of the right and oblique angle	E	E	E	E	E	E	E	E
Analytical geometry and mathematical analysis	E	E	E	E	A	E	E	E
Plane geometry	E	E	E	E	E	....	E	A
Structural computations and estimating	E	E	E	E	....	E	A	E
Introduction to calculus	A	....	....	E	....	....	....	....
SCIENCE:								
Physics:								
Heat and fluids	....	E	....	E	....	....	....	....
Sound and light	....	E	....	E	....	....	....	....
Statics	A	E	....	E	....	....	....	....
Dynamics	A	E	....	E	....	....	....	....
Chemistry:								
Inorganic	....	....	....	E	....	....	....	....
Soil analysis (chemical and physical)	....	....	....	E	....	....	....	....
TECHNICAL SPECIALTY:								
Highway and structural drafting	....	....	E	E	A	....	....	A
Map drawing	A	....	....	E	E	E	E	E
Surveying	A	....	A	E	E	E	E	E
Structural design	E	E	E	....	....	....	....	....
Technical (auxiliary or supporting)								
Strength of materials	E	E	E	E	....	....	....	....
Roadbuilding materials and methods	....	....	....	E	....	....	....	....
Construction materials	E	E	E	E	....	....	....	....
GENERAL:								
Communications skills	E	E	E	E	E	E	E	E
Human relations	A	E	A	E	E	E	E	E
Technical report writing	E	E	E	E	E	E	E	E

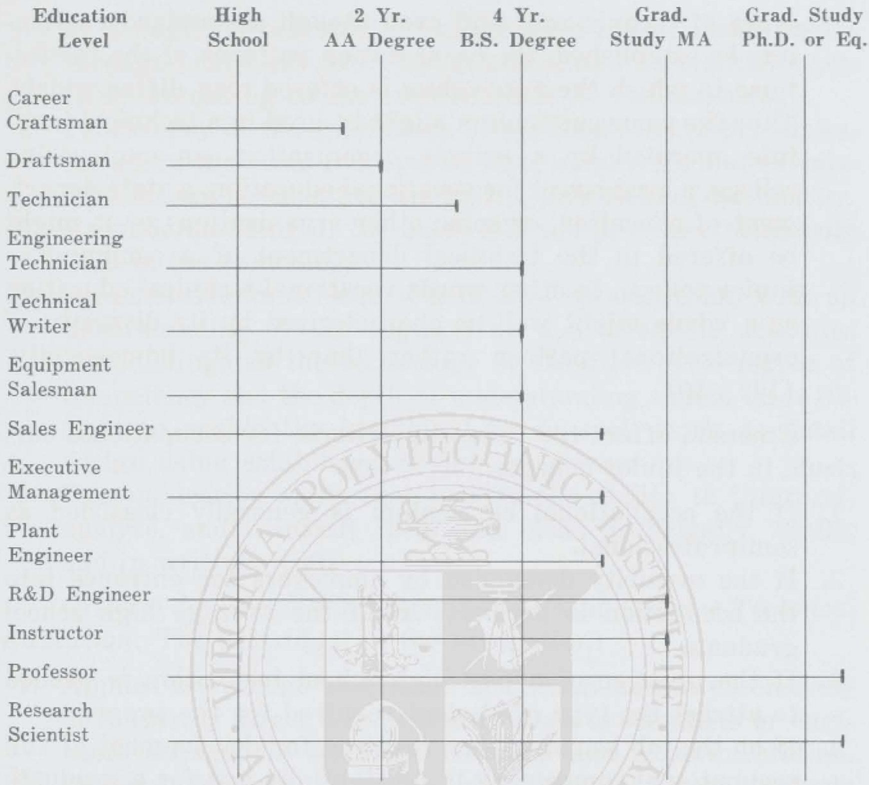

Fig. 2. Educational Requirements for Careers in Electronics (11: 14)

TWO-YEAR ASSOCIATE DEGREE PROGRAMS

As an opening for the discussion of two-year associate degree programs, it is interesting to consider Emerson's statement on institutions concerned with technical education. He writes:

> No single type of educational institution can meet all the varied needs for vocational-technical education. The scope and level of the occupations in this field vary greatly. Different geographical areas of the United States utilize different types of institutions for achieving similar objectives. While it may be practicable to develop relatively standardized curriculums, with accreditation, for specific categories of engineering technicians, the standards used for such programs may well be quite different from desirable standards for programs designed to prepare other

> types of technicians. And even though a standard curriculum be established, the organization patterns of the institutions in which the curriculum is offered may differ widely. Thus the same curriculum might be used in a technical institute operated by a private organization, an engineering college, a local board for vocational education, a state department of education, or some other organization; or it might be offered in the technical department of a community junior college. In other words vocational-technical education as a whole might well be characterized by its diversity of organizational pattern rather than by its homogeneity. (14: 10)

Emerson offers the following criteria for occupational curricula in the junior college.

1. If the occupational curriculum is generally classified as semiprofessional.
2. If the maturity demanded by employers for entrance into the occupation is beyond that of the average high school graduate.
3. If the prestige of a post-high school institution is needed to attract the type of student required for the program.
4. If on-the-job learning time required for development of full occupational competency is substantially less for a graduate of a post-high school program than for a high school graduate in the same field.
5. If the level and type of curriculum requires high school graduation, including the completion of specified courses, as a minimum foundation for undertaking the occupational study.
6. If the state desires to meet the needs of people who went to work after high school graduation with no specific occupational training, and who later want to enter full-time training to prepare for better jobs. (12: 7)

An Office of Education bulletin offers criteria for identifying technician occupations on the basis of abilities required by the individual in the occupation. These criteria are:

1. Facility with mathematics; ability to use algebra and trigonometry as tools in the development of ideas that make use of scientific and engineering principles; an understanding

of, though not necessarily facility with, higher mathematics through analytical geometry, calculus, and deferential equations, according to the requirements of the technology.
2. Proficiency in the application of physical science principles, including the basic concepts of laws of physics and chemistry that are pertinent to the individual's field of technology.
3. An understanding of the materials and processes commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the engineering and scientific 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 do such work as detail design using established design procedures.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing. (36)

Criteria for Identifying Occupations that Require Technical Education: The individual in the occupation:

1. Applies knowledge of science and mathematics extensively in rendering direct technical assistance to scientists or engineers engaged in scientific research and experimentation.
2. Designs, develops, or plans modification of new products and processes under the supervision of engineering personnel in applied engineering research, design, and development.
3. Plans and inspects the installation of complex equipment and control systems.
4. Advises regarding the maintenance and repair of complex equipment with extensive control systems.
5. Plans production as a member of the management unit responsible for efficient use of manpower, materials, and machines in mass production.
6. Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical equipment and/or products.
7. Is responsible for performance or environmental tests of mechanical, hydraulic, pneumatic, electrical, or electronic components or systems and the preparation of appropriate technical reports covering the tests.

8. Prepares or interprets engineering drawings and sketches.
9. Selects, compiles, and uses technical information from references such as engineering standards, handbooks, and technical digests of research findings.
10. Analyzes and interprets information obtained from precision measuring and recording instruments and makes evaluations upon which technical decisions are based.
11. Analyzes and diagnoses technical problems that involve independent decisions.
12. Deals with a variety of technical problems involving many factors and variables which require an understanding of several technical fields. (36)

The abilities required of technicians vary not only in type, but in degree with the particular technology served. This wide range of skill and understanding requirements taxes the ability of training programs to provide both width and depth of educational experiences. Even a precursory examination of the literature convinces one of the difficulty of the project. It is not surprising to find innumerable programs with variations in content to meet specific needs equally numerous.

While there are many variations in both programs and content, there are factors which are common to all. Emerson summarizes the characteristics of good technical training programs as follows:

1. Programs are directed toward the development of technical skills—defined as the ability to apply technical knowledge—in specific fields of technology, with emphasis on problem-solving abilities.
2. The objectives of the programs are clearly defined in terms of the knowledge and understanding, skills and abilities, attitudes and appreciations required for the effective entrance of graduates into employment in the specific occupations or clusters of occupations toward which the programs are aimed.
3. Programs are rigorous in character, and aim for immediate productivity on completion of the training.
4. The overall programs make adequate provision for different levels of technical occupational life within industry, through appropriate curriculums, student selection, and instruc-

tional methods, and provide opportunity for persons of all suitable age levels and background to obtain desired preparation for technical occupations appropriate to their abilities, including adults and post-high school youth.

5. The age- and grade-levels of the programs are in keeping with the practices of industry with respect to hiring age, maturity needed, and the like; and with the total length of full-time school attendance or opportunities which the State provides for a high proportion of its citizens.
6. Curriculums are based upon accurate and up-to-date analyses of the needs of the industries where graduates may expect to find employment.
7. Curriculums provide opportunity for the development of the manipulative skills appropriate to the technician jobs for which they provide training as well as for the development of the technical skills needed.
8. Some specialization in the technology of the field is introduced at an early point in each curriculum.
9. Curriculums include such content in general education, designed to prepare persons as capable citizens in a democracy and appropriate to the age and grade level of the student, as is appropriate in the light of the total needs of the curriculum for basic and applied mathematics, science and technology.
10. Each curriculum provides instruction in oral and written communication appropriate to the field.
11. The instruction places emphasis on laboratory experiences designed for the teaching of scientific and technological principles through application to typical technical tasks.
12. The mathematics and science taught is articulated with the technology of the field toward which the program is aimed.
13. Students are selected on the basis of high motivation, aptitude for the field of training, and intellectual ability of a level commensurate with the rigorous character of the training program. Programs are most effective when designed for persons who have found their bearings through previous or collateral experience in industry, and desire intensive preparation for their chosen work.
14. Graduates of the programs show demonstrably superior achievement in the occupation immediately after entrance

as compared with persons of similar age, aptitude and ability who have not had such training. A high proportion of the graduates find placement in the fields for which they studied, relatively soon after graduation.

15. Programs are kept in phase with technological developments. (13: 5)

A study of most good two-year technician training programs reveals that they successfully reflect all or most of Emerson's characteristics. Content analysis of two-year programs reveals a general subject matter distribution range somewhat as follows:

Major technical specialty	40-60%
Allied technical specialty	15-20%
Basic mathematics and science	20-30%
Administrative and managerial subjects	0- 5%
General subjects	10-15%

Two-year programs are almost always developed in response to local or school service area needs. Several typical programs are reproduced to show the variation and similarity of program content.

A.S. Degree Machine Design Technology Program (9: 52)

Subject	Credit Hours
English Composition	6
Math — through technical calculus	9
General College Physics	6
Speech	3
Introduction to Psychology	3
Economics	3
Physical Education	2
Drafting and Design	11
Machine Shop	3
Welding	3
Metallurgy	2
Heat Treatment	2
Principles of Electricity	3
Mechanics	3
Industrial Safety	3
	62

Mechanical Technology AA Degree (13: 69)

Subject	Credit Hours
Industrial Processes	4
Engineering Drawing	4
Industrial Organization	2
Manufacturing Processes	1
Mechanics and Strength of Materials	6
Production Processes	1
Basic Thermodynamics	3
Machine Design	5½
Metallurgy	5
Metallurgical Laboratory	1
Materials Testing Laboratory	1
Planning for Automation	3
Applied Thermodynamics	3
Mechanical Laboratory	1
Industrial Plant Planning	4
Fundamentals of Electricity	3½
Mathematics	6
Physics	4
Communication Arts and Skills	6
Social Science Electives	9
	73

Technician Education Yearbook (31: 95-100 reports that in 1964 there were 112,000 persons enrolled in technician (2-year) programs in such fields as electronics, electrical, mechanical design, chemical, metallurgical, civil and construction, production, instrumentation, nuclear, and plastics technology and in data processing and computer programming. Enrollments were highest in electronics programs, with mechanical, construction and production next in order. There were 190 junior colleges and 60 technical institutes included in the survey. Average starting salaries for technicians, in 1964 was reported at $5000 a year. Electronics technicians averaged the highest at $5066, and production technicians lowest at $4351 per year.

The Tool and Manufacturing Engineering program offered by Los Angeles Harbor College reflects the combined efforts of representatives of the American Society of Tool and Manufacturing Engineers, an Industrial Advisory Council and the faculties of both Harbor College and California State College at Long Beach. The program, with slight modification, serves as either a terminal or transfer program.

Los Angeles Harbor College, Los Angeles
Engineering Technician, Tool and Manufacturing Engineering

Tool and manufacturing engineering is concerned with the economic production of manufactured goods.

Engineering technicians work as a team with professional engineers in the preparation of drawings, testing of machines and machine processes, making cost estimates, compiling statistics, and preparing technical reports. With sufficient industrial experience and continued education, excellent possibilities for advancement are possible for the engineering technician in the field of tool and manufacturing engineering.

This two-year occupational curriculum offers a transfer option toward a Bachelor of Science degree in Industrial Technology, California State College, Long Beach.

First Semester	Units	Second Semester	Units
T.M.E. 1—Introduction to Machine Tools	4	*T.M.E. 61*—Manufacturing Processes	4
Drafting 50—Production Drafting	4	*Drafting 51*—Tooling Drafting	4
Engineering Technician 25—Industrial Safety	1	*Mathematics 4*—College Algebra	3
Mathematics 3—Trigonometry	3	*Communications Requirement*	3
Communications Requirement	3	*General Education Requirement*	2
Physical Education	½	*Physical Education*	½
	15½		16½

Third Semester	Units	Fourth Semester	Units
Drafting 9—Mechanical Drafting	4	*T.M.E. 5*—Precision Machining Practices	4
History 11—Political and Social History of the United States I	3	*History 12*—Political and Social History of the United States II	3
Mathematics 7—Basic Mathematical Analysis I	5	*Health 10*—Health Education	2
Physics 6—General Physics I	4	*Physics 7*—General Physics II	4
Physical Education	½	*General Education Requirement*	3
		Physical Education	½
	16½		16½

Another approach to technician training is represented by the transfer program taken from the Fullerton California Junior College Bulletin. The core-curriculum for the several technologies is presented. The 29 units of technical electives vary with the technical area chosen.

The program as presented in the Fullerton Bulletin reads:

Industrial Technology

Prepares for junior standing at California State College at Long Beach. Students may choose a specialty in construction, electronics, or manufacturing. This program is designed for the student, who, through screening based upon his junior college work, job experience, testing, and counseling, clearly demonstrates his aptitude and promise for high level technical work with related administrative responsibility. Four years are required for completion of the B.S. degree. (See also Industrial Technology —two-year program.)

Normal High School Preparation: four years of college-preparatory mathematics, mechanical drawing (junior or senior year), chemistry or physics recommended.

First Year	Units 1st S	Units 2nd S	Second Year	Units 1st S	Units 2nd S
Physical Education	½	½	Physical Education	½	½
1AB Reading and Comp.	3	3	3A Calculus	4	
27 U.S. History	3		2AB College Physics	3	3
10 Biology		3	3AB College Physics Lab	1	1
48 Careers in Engineering	½		1 American Government	3	
*Electives	9	10	2 Elem. Chemistry		3
			2L Elem. Chem. Lab. and Quiz		1
			1A Gen. Psychology		3
			35 Personal Health		2
			*Electives	6	4
	16	16½		17½	17½

*Determined by specialty—construction, electronics, or manufacturing and placement in mathematics.

Among the numerous curricula for technician training, the following are most frequently found:

Air-conditioning technology
Architectural technology
Automotive technology
Aviation technology
Building construction technology
Civil technology
Computer technology
Design technology

Drafting technology
Electronic technology
Inspection technology
Instrumentation technology
Mechanical technology
Technical illustration technology
Tool technology

Since the Florida Legislature established the Division of Community Junior Colleges as a unit of the Florida State Department of Education in 1957, twenty-five junior colleges have been established. Of the many two-year degree programs offered, technical is the largest area.

> These technical programs include several technology fields—aeronautical, architectural, chemical, civil engineering, electronics, industrial laboratory, instrumentation, marine, mechanical, mechanical production, mining chemical, mining industrial, printing, and radiological health—and computer programming; data processing; drafting and design; electrical, engineering aide; flight training; highway engineering; mortuary science; municipal and sanitary; quality control and reliability; and surveying and mapping. (30: 13)

With very few exceptions, programs are developed after careful surveys of the needs of industry in the area with the assistance and guidance of advisory councils. The membership of these councils represents a cross section of the industry to be served and the trades or crafts involved. As a result, they are practical, sound, and up-to-date.

FACULTY

The problems of recruiting and retaining faculty for technical programs is becoming increasingly acute. The academic requirements for educators at all levels are constantly being raised. The technical instructor must not only meet these certification requirements, but have industrial experience as well. Many junior college instructors enter into teaching on a part-time basis from industry with a minimum of academic preparation. Credential requirements vary from state to state, but all set a high enough standard to assure adequate preparation of instructors. Tenure and salary increments are often tied to work beyond the baccalaureate degree with the M.A. often cited as a requirement for tenure. The Office of Education bulletin on teacher competencies in technical education states that the education and experience of the technical instructor must include in addition to the regular pattern, all of the following:

1. Trade analysis and course construction.
2. Methods of teaching industrial subjects.
3. Development of instructional material.
4. Shop organization and management.
5. Vocational curriculum instruction. (24: A)

The requirements for teaching in Florida Junior Colleges is generalized:

> To receive certification in Florida, those who teach in the technical fields must hold a bachelor's or master's degree; have two years of experience as a technician, engineer or scientist in a technical or technically related field; and have completed six semester hours of course work in the philosophy of technical education and methods of teaching technical subjects. Persons who have special qualifications but do not meet the requirements as outlined may, upon request of a junior college president, receive special certification without making up any deficiencies. (30: 15)

In a summary report on the preparation of trade and technical teachers in California, Barlow (3: 17-21) indicated that 15% held the master's degree, 30% the bachelor's and over 25% had taken resident college courses. Depending on the age group, from five to fifteen percent worked for degrees while teaching. He further stated that about fifty percent of teachers had from five to fourteen years of industrial experience. A study of the catalogs of two-year colleges in addition to current literature on the subject indicates adequate preparation for teaching on the part of the junior college technical subjects instructor.

The report of the National Commission on Technology, Automation and Economic Progress provides a good general summary on the community college and its role. They report:

> As a terminal vocational education program the community college makes its most immediately direct and obvi-

> ous contribution to preparation for employment. In considering this aspect, terminal programs in the community college and area vocational schools should be compared to determine the differences in and advantages of each program. Comparisons will be made in terms of possible rather than currently existing programs.
>
> The terminal vocational education program in the community college, like the area vocational school, should concentrate on preparing students at the skilled-worker and technician levels. The potential of the community college is especially high for training its students as skilled technicians and semi-professional workers.
>
> In the first place, high level technical training involves post-secondary school preparation in basic academic disciplines as a concomitant to acquiring specific job skills. With a competent staff of academic personnel already in the college transfer part of the curriculum, the community college appears to be in an ideal position to offer this high quality technician training.
>
> Second, it may be reasonably expected that relatively more of those enrolling in community colleges will aspire to becoming true technicians than would normally be found in the area vocational school. That they choose to attend a "college" rather than a vocational school may be significant.
>
> Third, the community college has a pool of potential students for technician training among those who find the college transfer program incompatible with their interests, values, or abilities. Since such students are already in the setting, and often in the same building, movement from a college transfer to a technician training program could be made with maximum ease. (23: 98-9)

The two-year associate degree program has a vital role in the preparation of qualified technicians for entry into industry. It has a secondary role, no less important, of providing a transfer technical program for those persons capable of four-year college work and who have leadership and managerial potential. Technical programs are varied to meet local needs and kept up-to-date with continued review and guidance from advisory councils. The faculty is well prepared for the task. The problem of faculty recruitment and retention is acute.

FOUR-YEAR TECHNOLOGY PROGRAMS

The four-year technology program owes its emergence to these developments.

The change in emphasis in engineering curricula. Increasing emphasis on mathematics and science in the engineering curricula to cope with the complex advancements in technology has gradually eroded the course offerings in shop or skill subjects and left little room for managerial- and personnel-related courses.

The increased enrollments in two-year technical programs of persons capable of continuing in four-year programs. This has brought about a demand for "transfer" type courses in the technical programs. Out of this development has emerged an articulation in which the greater portion of the skills are handled in the two-year program with emphasis on advanced techniques, supervisory and management offerings, and the rounding out of general educational experiences associated with the baccalaureate degree.

The continually increasing demand by industry for supervisory and management personnel and persons with a combination of technical and general education characteristics to take over areas no longer compatible with modern engineering preparation.

The reasons just advanced for the emergence of four-year technology programs are reflected in the findings of the Four-Year Technology Committee of the American Vocational Association. In this preliminary report they wrote:

> A review of industrial technology curriculums indicated that they were oriented more toward training for supervisory and middle management positions than for occupational specialization, such as in engineering or in the two-year technician program. It is presumed that graduates of a four-year program of industrial technology will be employed in positions requiring leadership qualities and a broad knowledge of those supervisory and administrative functions which result in the efficient operation of an industrial organization. The training includes a basic knowledge of some engineering and management principles, a broad knowledge of industrial processes and the operation of machines and equipment, in addition to applied technical and

> practice skills. The chief asset of the training is that the graduate of such a program is provided with a broad background of training which makes him flexible and adaptable to almost any kind of an industrial organization with a reasonable amount of in-service or job orientation training. (1: 6)

They continue:

> Since the end of World War II there has been an increase in emphasis on the four-year technology program at the college and university level. This has been brought about by a need for degree people in the field of applied science or technology. Industry has been placing more emphasis on degree requirements for promotion and retention.
>
> Industry needs an increasing number of men whose formal technical education extends beyond the basic two years of college. These men must be equipped to use the complex tools and processes of modern industry; to coordinate construction or production and at the same time, to adapt themselves quickly and effectively to the changes in techniques now developing with bewildering rapidity. The men must also assume positions of administrative responsibility entailing the supervision of both men and facilities. (1: 10-11)

In relation to transfer curricula, they write:

> The two-year programs, if properly designed, can be the primary source for students in the four-year program. There should be close articulation between these two so that the transfer students are not penalized. In those cases where two-year programs are not available, the primary source of students for the four-year program is the high schools within the area. Again it is imperative that close articulation be done. (1: 12)

In his study "Industrial Technology and the Engineer Withdrawal," Hansen sums up his findings on the nature and scope of four-year technology programs as follows:

> A perusal of land-grant college and university catalogs reveals a great diversity of industrial-technical offerings among the various institutions. Many different kinds of programs are available under a variety of titles. Some

schools have extensive two-year terminal curricula as well as four-year baccalaureate technology curricula. Some of these programs are found in the college or school of engineering, others may be found in the college of agriculture, and many technical curricula are located in the industrial education departments of teachers colleges.

Technical programs are listed in the catalogs under such titles as industrial engineering technology, industrial supervision, industrial distribution, construction technology, manufacturing technology, metallurgical technology, aircraft technology, engineering technology, and mechanical technology. Some titles are listed as technical curricula in specific areas: electronics, graphics, automotive, chemistry, journalism, metals, woods, industrial illustration, and production control.

In both terminal and four-year programs, technical courses are built on a foundation of mathematics and the physical sciences. In general, the mathematics requirements range from college algebra through calculus, and in most programs, one year of general physics and one year of general chemistry is included. In all curricula, attention is given to the liberal arts with varying requirements in the social sciences and humanities. In some technical programs, general technical courses may be found. These include industrial safety, time and motion study, industrial supervision, production management, and manufacturing processes. Among the liberal studies may be included the related fields of industrial sociology, industrial psychology, and labor economics. In some technical curricula, use is made of such business administration courses as accounting, business law, personnel management or training, labor problems, and introductory business administration. Courses in journalism, technical or business writing, and art or illustration may also be included.

Introductory statements in the catalogs illustrate the diversity of industrial-technical curricula. Some programs seem to be highly oriented toward vocational goals while on the other extreme, the programs may be very general in nature. Statements are made to the effect that the curricula prepare students to enter industry at the intermediate level

—as draftsmen, engineering aids, laboratory technicians, inspectors, production technicians, estimators, maintenance personnel, distribution personnel, and in various phases of the operational and production end of industry. Personnel work, sales, administrative, managerial, and construction and contracting are also mentioned as occupational outlets. (16: 48-9)

Weber in his conclusions proposes that industrial technology programs have the following characteristics:

1. Purposes are management oriented rather than engineering oriented.
2. Curricula are broad and general in nature rather than specialized.
3. A variety of courses in laboratories or shops is required.
4. Requirements for graduation are similar to other four-year college programs. (40)

Keith in his study undertook, among other things, to determine the common goals of four-year industrial technology programs; to study programs in other colleges; and to develop criteria for the programs. From the findings, some of his conclusions are offered:

1. The teaching staff should have had two to five years teaching experience, 15 to 30 semester hours of professional preparation, 18 to 40 semester hours in special allied courses and at least a Masters Degree.
2. Proficiency in teaching is essential and important.
3. The scholastic level of students in the program should be equal to or above that of other programs of the school.
4. The physical plant should provide sufficient space and appropriate up-to-date equipment to meet the requirements of the program.
5. An advisory committee composed of employers, graduates of the program, parents and educators should participate in the development and operation of the program.
6. Staff members should be active in professional, educational and industrial organizations. (21)

Keith also listed the following objectives for Industrial Technology programs as those most often accepted: (1) provide instruction in the technology of a specific industry, (2) prepare for managers and supervisors in industry, (3) prepare for industrial positions that do not require engineers, (4) give a broad general background, (5) familiarize students with basic tools, materials and processes used in manufacturing industries.

Schill and Arnold in their study *Curricula Content for Six Technologies* offer several suppositions which differentiate the baccalaureate in technology from the two-year program. These are namely (27: 90): (1) additional depth is needed in a technical specialty, (2) broader knowledge of technology, business and/or industry is required, and (3) non-vocational interests and attitudes must be developed through courses in the humanities. The education of the baccalaureate-holding technologist must contribute to his ability to advance to more responsible positions in his company. There are currently some eighty colleges and universities offering baccalaureate programs in technology.

Hansen summarizes catalog statements from twenty-two colleges. Typical of his summaries is Auburn University:

> *Auburn University* has a Department of Building Technology in the School of Architecture and the Arts which offers courses in structural design of buildings, design of mechanical and other equipment for buildings, the practical application of building material, estimation of costs, methods of construction, and field erection procedures. This is a degree program leading to a Bachelor of Building Construction.
>
> General requirements include mathematics through calculus, physics, English, economics, engineering accounting, history of building, scientific reasoning, industrial relations or labor problems, military science or physical education, and electives from the humanities, social sciences, and business.
>
> Technical courses include introduction to building, drawing, materials and construction, sheet metal, woodwork, mechanics of structures, cost control, welding, surveying, construction methods, and building equipment. (16: 50)

It is possible in this short study to outline but few industrial technology programs. Some examples follow. Hansen, as a result of his study proposed the following:

Industrial Technology (16: 198-9)

General Requirements	Sem. Hrs.
English Composition	6
Technical Writing	2
Algebra	2
Algebra and Trigonometry	4
Statistics	3
General Chemistry	7-9
General Physics	10
General Economics	6
Industrial Sociology	3
Business and Professional Speech	3
Elementary Psychology	3
Industrial Psychology	3
Humanities or Social Sciences	6
	58-60

Technical Requirements	
Engineering Drawing	6
General Metalworking	2
Machine Shop	2
Welding	2
Machine Woodworking	3
Industrial Materials	3
Applied Electricity	2
Internal Combustion Engines	4
Manufacturing Processes	4
Production Engineering	3
Management Engineering	3
	34

Distribution	
Marketing	3
Advertising	3
Salesmanship	3

Business Requirements	Sem. Hrs.
Introduction	3
Business Law	3
Personnel Administration	3
	9
Military Science or Physical Education	4
	18-20

Options

Production	
Plant Layout	3
Time and Motion Study	3
Industrial Safety	2
Data Systems	3
Data Processing	2-3
Production Coordination	3
Quality Control	3
Statics and Mechanics	3
Engineering Materials	3
Surveying	3
Production Management	3
Industrial Design	3
Engine Maintenance	4

Note: 18 to 20 hrs. selected with consent of the adviser

Supervision	
Plant Layout	3
Time and Motion Study	3
Industrial Safety	2
Production Coordination	3
Production Management	2
Systems and Procedures	3
Data Processing	2-3
Production Management Control	3
Industrial Relations	3
Human Relations	3
Labor Economics	3

Note: 18 to 20 hrs. selected with consent of the adviser

Cunningham offers the following as typical:

APPLIED SCIENCES (9: 50)

Industry Education Program — B.S. Degree

Typical Machine Design Technology Program

Freshman Year

Eng. 101 Composition	3	Eng. 102 Composition	3
*T. Math 119 College Algebra	3	*T. Math 120 Trig & Slide Rule	3
*MDT 111 Mech. Drawing	2	MDT 115 Des. Drafting	2
Elec. 150 Prin. of Electricity	3	Speech 103 Basic Speech	3
Metal 227 General Machine Shop	3	Metal 235 Welding	3
P. E. Service Course	1	P. E. Service Course	1

Sophomore Year

Phys. 205 Gen. College Physics	3	Phys. 206 Gen. College Physics	3
T. Math 225 Tech. Calculus	3	T. Math 226 Tech. Calculus	3
Elec. 170 Electronics Prin	3	MDT 211 Machine Details	2
A.C. 225 Industrial Plastics	3	Art 167 Basic Design	2
Psy. 101 Intro. to Psychology	3	Econ. 100 Intro. to Economics	3
		Elective (Humanities)	3

Junior Year

T. Sci. 316 Mechanics	3	T. Sci. 317 Strength of Mats	3
MDT 311 Adv. Machine Dr	2	Metal 315 Heat Treament	2
Metal 305 Metallurgy	2	Metal 301 Processes in Metal	3
I.T.E. 350 Motion & Time Study	3	T. Sci. 318 Dynamics	3
Soc. 101 Intro. to Sociology	3	MDT 336 Cams and Gears	3
C.B.A. 300 Law in Society	3	Elective (Humanities)	2

Senior Year

MDT 342 Mechanical Design	4	I.T.E. 344 Industrial Safety	3
G.B.A. 342 Business Management	3	I.T.E. 372 Anal. & Organ	2
Psy. 407 Ind. & Personnel Psy	3	MDT 436 Tool Design	3
MDT 411 Machine Design	3	G.B.A. 344 Collective Bargaining	3
Metal 358 Meas. & Insp	3	MDT 331 Sheet Metal Drafting	2
		Elective (Humanities)	2

*Students with adequate background in drawing or mathematics will start with more advanced courses in these areas, thereby making it possible to take courses in chemistry, industrial electronics, patternmaking, collective bargaining, electronic data processing, digital computer technology, or personnel management.

Stout State University (28: 3) offers programs leading to the bachelor's degree in what they call concentrations. These are: manufacturing engineering, product development, technical sales and service, plant engineering, packaging, electronics, graphic arts, building construction, and technical writing. The program requires 130 credits for graduation. Specific course requirements and concentrations are:

Required General Courses	Cr.	Required Technical Courses	Cr.
English and Writing	9	Manufacturing Engr.	16
Speech	4	Drafting	2
Psychology	3	Hydraulics	2
Personnel Management	3	Electronics	2
Economics	3	Metal Processes	2
Sociology and Government	9	Cost Analysis	3
Health and P.E.	3	Engineering Ec.	3
Chemistry and Physics	20	Indus. Management	2
Statistics	2	Production Processes	3
Computer Programming	2	Chemistry of Materials	3
Mathematics	10-15	Series—Field Experience	2-10
Basic Shops	13-14		
Industrial Organization	2	**Selected Academic Courses**	
Production Management	3	(11 credits minimum)	
Quality Control	2	Technical Writing for Industry	3
Time and Motion	2	Educational Psychology	2
	93-98	Audio Visual Education	2
		Advanced Computer Planning	2
		Differential Equations	3
		Physics-Mechanics	3
		Chemistry of Materials	3
		Speech for Business and Industry	2
		Sociology of Work	3
		Managerial Economics	3

Many schools offer two-year programs in addition to four-year baccalaureate programs.

The program at California State College at Long Beach is somewhat unique. This program offers no lower division work. The technical concentration, in one of three options (construction, electronics, manufacturing) is taken at a junior college. The number of units in the technical areas offered at the two-year college varies, but 24 credits in a technical area are transferable, i.e. 24 units in either electronics, manufacturing or construction. The student meets the junior college requirements for the associate in arts degree by completing specified courses in communications, mathematics, social studies and the sciences. The student can transfer a total of 70 credits to the state college. At the college he completes the program for the bachelor of science degree.

Since the state college serves over twenty-two two-year colleges, articulation and flexibility must go hand in hand. At this writing, there are 620 majors enrolled in the two years at Long Beach. 300 of these are in the electronics option with the remainder about equally divided between construction and manufacturing. The program for the electronics option is shown in the following outline.

Electronics Option — Industry Technology

	Sem. Units		Sem. Units
Basic Electronics	24	History	3
Graphics	2	Political Science	3
Machine Shop	3	Economics	3
Accounting	3	Logic	3
Mathematics, including Calculus	8	Gen. Psychology	3
General Physics	8	English	3
General Chemistry	4	Speech	3
Biology	3	Health & Physical Education	4

The above are most often completed at a junior college; those below at the four-year college, junior-senior years.

All of the following: Related Technical

Materials and Processes of Industry	6 units
Production Analysis	2 units
Production Technology	2 units
Kinematics	2 units
Industrial Safety	2 units
Foremanship and Supervision	3 units
Industrial Proposals and Specifications	3 units

General Related

Technical Report Writing	3 units
Industrial Psychology	3 units
Statistical Inference	3 units
Job Analysis	3 units
Industrial Design	2 units

Electronics 13 units selected from

Circuit Analysis
Testing and Troubleshooting
Transistor Circuits (advanced)
Computer Circuits
Electronic Systems
Advanced Communications
Microelectronics
Automation
Electronic Production Techniques

From the few examples shown, it is quite obvious that four-year technology programs are about as alike as are the two-year technician programs. Studies indicate, however, that graduates from all programs are well accepted by industry.

A Stout State University survey of initial positions of graduates is summarized in Table II.

Table II

The Number and Percentage of Graduates in Each Classification of Position Years 1959 - 1966

Position Classification	No.	Percent
INDUSTRIAL TRAINEE	23	13.21
PRODUCT DEVELOPMENT	30	17.24
Product Design	21	12.07
Test Engineering	9	5.17
MANUFACTURING	81	46.57
Material/Production Control	16	9.19
Methods/Works Standards Engr.	41	23.56
Product Supervision	11	6.36
Quality Assurance	6	3.45
Plant Engineering	7	4.01
MARKETING	32	18.39
Sales	12	6.89
Service	14	8.05
Technical Writing	6	3.45
INDUSTRIAL RELATIONS	5	2.87
DATA PROCESSING	3	1.72
TOTAL	174	100.00%

Since the data summarized above are the graduates' initial positions over a seven-year period, they do not in all cases reflect trends in graduate placement. The changing curriculum and needs of industry have caused shifts over the last few years in graduate placement. The manufacturing area seems to be taking the greatest number of graduates.

Table III shows the range of entry job titles of some 217 graduates from the California State College, Long Beach Program based on follow up studies.

Table III

Entry Job Titles of Industrial Technology Graduates California State College at Long Beach

Associate Industrial Engineer
Electronic Test Engineer
Manufacturing Engineer
Test Equipment Engineer
Applications Engineer
Facilities Engineer
Electrical Engineer
Contract Specialist
Process Analyst
Methods Analyst
Quality Control Engineer
Electrical Shift Foreman
Operational Analysis Engineer
Engineering Supervisor
Manufacturing Design Engineer
Project Engineer
Design Engineer (Electrical)
Field Engineer
Manufacturing Planner
Associate Civil Engineer
Tool Engineer
Production Engineer Sr.
Associate Programmer
Industrial Engineering Specialist
Engineer Computing Analyzer
Systems Engineer
Transmission Engineer
Associate Engineer
Supervisory, Production
Associate Staff Engineer
Staff Engineer
Electronic System Engineer
Materials and Process Engineer
Engineer in Training
Equipment Engineer
Design Engineer Jr.
Customer Engineer
Buyer
Design Engineer Sr.
(Mechanical & Electrical)
Supervisor — Ingot Engineering
Methods & Standards Engineer
Product Engineer
Marketing Representative Trainee
Estimator
Design Engineer
Industrial Engineer
Management Trainee
Test Engineer
Technical Marketing Trainee
Integrated Circuits Specialist
Employee Relations Representative
Industrial Engineer Assistant
Plant Engineer
Administration Assistant to
Manufacturing Manager
Quality Control Manager
Research Engineer
Maintenance Officer
Job Supervisor "B"
Programmer, Manufacturing
Associate Technical Publisher
Product Reliability Analyst
Electronic Engineer
Sales Engineer
Quality Analyst
Manufacturing Methods Engineer
Quality & Waste Supervisor
Production Manager
Circuit Engineer
Product Line Specialist
Quality Engineer
Plant Layout Engineer
Maintainability Representative
Engineer Scientist
Quality Assurance
Member of Technical Staff

The Placement Office at California State College at Long Beach reports entry salaries paid to industrial technology graduates ranged from $685 to $875 per month with the average about $725.

The importance of the four-year technology programs as a part of American education may find summation in this statement on the role of colleges and universities as preparation for employment:

> The crucial and vital role of colleges and universities in preparing students for employment is, in some ways, too obvious to need mentioning. In other respects, it is so complex that it defies definitive discussion in a document such as this. However, some brief remarks are essential if American education as preparation for employment is to appear in proper perspective.
>
> Much of the impetus responsible for the current rapidity of change in our occupational society comes from colleges and universities. Individuals dedicated to formulating and transmitting new knowledge are highly concentrated in colleges and universities, and their progeny are most likely to continue developing this new knowledge in the employment setting as leaders and workers. Colleges and universities are perceived not only as places where individuals can acquire occupational skills, but also where the desire to acquire and produce new knowledge and the capability for reasoning is developed to the highest possible degree. There are developed the leaders who will direct the job activities of many others. It is a setting in which the greatest possible freedom of choice is provided to students in recognition of the major responsibilities they are expected to assume in utilizing their skills and their talents. The colleges and universities represent, therefore, the portion of our formal system of education which calls for the highest levels of ability and which has the potential to produce individuals most likely to make meaningful societal contributions. (23: 99)

COMPARISON IN SUMMARY

An effort has been made to examine material readily available which would give insight into the educational areas of two- and four-year technology programs. Citation have been necessarily limited but those made seem to be typical of material available on the subject.

Both programs are in fact existant, both are consistent in their inconsistencies. Terminology, program titles, program content vary greatly from school to school and region to region.

The findings of this study in a summary comparison of the two programs follows:

Two-Year Associate of Arts Programs	Four-Year Baccalaureate Programs
Objectives	
To prepare persons for entry into industry in a specific area of technology at a high skill level. To prepare persons for continuing technical education at a four-year college.	To prepare persons for entry into industry at a level above the technician level. Emphasis is placed on supervisory and management potential of technically qualified persons.
Students	
Most students initially have a two-year terminal objective, are mechanically rather than theory oriented and are often not academically inclined.	May come direct from high school, some are transfers from the more theoretical engineering programs, many are graduates from two-year programs, are management oriented, most are academically as able as students in other disciplines.
Placement and Salaries	
Find ready placement in jobs for which they trained. Industry is familiar with their capabilities. There is a wide range in pay scale from $2.00 per hour in woodworking industries to $6.50 per hour in aerospace operations.	Industry is just becoming acquainted with the potential of these persons. Most positions lead to supervisory or management status. Salary scale varies with region and industry starting salaries of $800 per month not unusual.
Program Content — Technical	
Varies with the technology, 20-40 credit units typical. High skill outcome emphasized, concentration in a specific area typical.	More breadth, more emphasis on why, reasonable skill levels expected, problem solving emphasized.
Program Content — General	
Mostly limited to English, speech, psychology, history and political science, sometimes an art course.	Broader in scope with additional communications, humanities, logic psychology; background for human relations aspects.

Program Content — Math Science

Mathematics often called technical or applied. Some calculus for electronic majors, applied algebra and trigonometry most common. Applied or technical physics common. Chemistry not a common requirement.

Some programs accept technical mathematics. Most require regular college math, in either case most require a first course in calculus. General college physics and general chemistry required. Some organic chemistry and biological science.

Program Content — Related

Industrial safety becoming general, materials and processes, mechanics some interest in time and motion becoming more evident.

Industrial safety, management and supervisory courses, production and quality assurance, costing, industrial psychology, accounting, technical writing, labor relations.

Faculty

Well qualified technically, new emphasis placed on academic qualifications. B.S. or credential required. Many have Master's degrees. Those with added education move into administrative positions or four-year college teaching. Industrial experience required, generally more than for the faculty of four-year programs.

Minimum academic requirements in most instances is M.A. or M.S. in a technical or industrial education area, industrial experience required, those with advanced degrees move into administration. Many faculty come from two-year institutions.

Facilities — Equipment

Usually representative of that found in industry, tend to have many of one kind of unit for depth of skill development.

More general, more variety, smaller than equipment for two-year programs. Objective to show capabilities and characteristics rather than develop skills.

This review was not intended to be an exhaustive study of the problem. Interested persons should consult the bibliography for further details and complete expose of topics but briefly touched in this paper.

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CHAPTER FIVE

Laboratories and Equipment

NORMAN W. RISK

The availability of funds for construction of technical educational facilities and laboratories under the Educational Acts of 1963 and 1965 has provided a breakthrough for states which seek to provide technical programs of high quality, realistically offered in the light of actual and anticipated opportuities for gainful employment.

At the present rate of construction and evaluating projected needs throughout the country, there will be by 1975 a nation-wide system of technical programs readily accessible to persons of all ages in all communities of the United States. Whether these dramatic developments culminate in the existence of a superiority of technical excellence in America largely depends upon the quality of planning and invention done now.

Technical excellence cannot be attained without an exchange of basic planning information and relevant communications between industrial spheres of the community and technical education resources in the community. Such forms of communication stimulate innovation directed toward viable technical learning programs.

Grant Venn states in *Man, Education and Work* that the new technology besetting social and economic institutions of industrial nations can be impersonal, nonideological, relentless and possibly overwhelming. (7) To avoid this state, intervening plans and redefinitions of purposes, continuously conscious of the human dignity of man in relation to his work, must be accomplished. The educational planner in a democratic society counters systematically the effects of negative impact by educational facilities designed to insure the integrity of skills as well as the integrity of the individual.

There is a serious gap between the adequacy of traditionally-built technical educational programs and facilities and the demands of new industrial technologies. The opportunities for the technician with limited potential are rapidly diminishing. New knowledge requires him to perform tasks involving the use of complex machinery; to diagnose and solve problems; and to communicate both orally and in writing his ideas, solutions and directions to others. The young technician has to have competency in basic fundamentals in several fields. For example, maintenance men must now have a background of physics, mathematics, electricity, electronics, hydraulics, and the theory of instrumentation to order their complex controls. Draftsmen and designers see their skills altered as a result of new methods of automating design developed in conjunction with numerical control. Since during the lifetime of a technician, his job may be obsoleted several times, it is necessary for him to acquire new skills. The retraining need is continuous.

What does business and industry expect from technical education and what does this infer for laboratories and facilities? A United States Office of Education research project discloses that business and industry want technical education program leaders to consider the following criteria in planning development.

1. To encourage the technician to acquire a knowledge and technical skill in basic fundamentals of a specific technical area.
2. To stress technical-industrial principles as more significant than mere applications.
3. To increase the technician's ability to communicate through drafting, sketching, composition, and report writing.
4. To develop a keen, accurate observation of objects and processes.
5. To develop the technician's ability to analyze and to synthesize, based on his careful observations. (3)

It appears that what industry and business expect from technical education is a predictable level of achievement in problem solving, communications, and personal responsibility.

NEW CONCEPTS IN PLANNING FACILITIES

The President's Manpower Report in March of 1966 describes the future as a time when education and training will be a permanent bridge between learning and human development. Even as new uses and new facilities for technical education are developed, it must be recognized that people grow stale unless there is a continuous renewal of their knowledge, an enrichment of their skills, and development of their talents.

New concepts in planning facilities are necessary. Any ordering and securing of new concepts is, however, complicated by the continuous climate of *change*. Change is, undoubtedly, our most certain working principle. Further, the rapidity of change is not constant, but exponential. The knowledge that buildings, designed to house today's program and those of the future, will remain with us for many years emphasizes the need for *flexibility* and *adaptability* within each planning stage. Tools of the art and science of technology have been and will continue to be augmented by technological developments in data processing, system analysis, and simulation. As aims and objectives are continuously subject to revision, the educational planner must be ready to deal with these contingencies of man, nature, and things. He must structure facilities as means rather than ends, and demonstrate his full worth by testimony that adaptability and flexibility can be gained through architectural planning. His gravest challenge is, therefore, to insure flexibility while still maintaining the quality of construction. At the same time the educational planner-architect is committed to a search for ways to decrease, if possible, building and maintenance costs.

The dollars available for laboratories and equipment will also find themselves competing with budgets for tools of teaching and learning. It is a truism, of course, that school laboratories and facilities should not get in the way of teaching-learning — that they not interfere with educational programs. However, much more than neutrality will be expected of technical facilities in the future. Facilities will not only "house" the program and the learners, but will be expected to provide, in addition, a type of social and psychic "home" for both.

J. Lloyd Trump stresses that educational facilities in the future will be characterized by their positive contribution to educational goals. (5) Findings from the field of social psychology propose, for example, that group instructional rooms should be circular in shape, with domed ceilings that push the group psychologically together. Air conditioning, controllable lighting, and soundproofing are modern contributions which support the educational program by establishing a positive and productive climate.

Areas for independent study and for research are important trends to be considered in the design for technical education facilities. An increasing number of technical authorities consider independent study the heart of the program, and define independent study as what students do when their teachers stop talking! Through independent endeavor students, individually and in small groups, cover the subject, learn what teachers want them to learn, and often go on to make their own creative inquiry. It is predicted that future students in industrial-technical programs will spend as much as forty percent more time engaged in such study as they have in the past. The implication is that forty percent less time will be spent in large group instructional settings.

Other trends affecting planning of technical facilities include the projection that there will be less mass movement of student traffic which requires large halls and stairwells, and more movement of individuals and small traffic groups. Noise will occur as students who have worked independently choose to get up at unscheduled times and go to another space area in the building to hold a conversation, take a break, or to simply interact socially with their peers. Reduction of noise by acoustical treatment of a variety of types will be necessary.

Other planning projections clearly indicate that there will be an extensive year-round, 24-hour-a-day use of technical laboratories and facilities. Such intensive use means temperature and humidity controls are necessary. The need for high- and low-intensity lighting, appropriate to the purpose going on in the physical plant, is equally certain.

Too few educational planners have been concerned with beauty and the aesthetic quality of technical facilities. Often factors of efficiency, economy, and flexibility have been overriding. Future trends, however, will tend to consider the aesthetic tastes and values of those who work and learn within structures and will strive to make the educational milieu aesthetically satisfying.

PLANNING FACILITIES

The planning for and provision of a structure to accommodate any technical education program is vital to the success of the operation. The uniqueness of the technical education program imposes a distinct design challenge upon the architect. Special shops, laboratories, storage spaces and a wide range of equipment necessitated by the objectives of the programs demand specialized treatment. Special planning of facilities must acknowledge that each area has specific requirements which must be met. Thus, the building design is an expression of how well program planning has been solved.

The approaches to problem solving in building design should, therefore, be systematically pursued. It is recommended that planning teams begin with the development of a long-range plan, proceed to a short-range plan, and, finally, determine an immediate action plan.

The factors to consider in developing the long-range plan for the future are:

1. Consideration of the potential number of students coming into each phase of the technical program over a *twelve* year period.
2. Consideration of educational policies affecting the nature of the programs offered and policies affecting the site, size, location and nature of laboratories and equipment installations.
3. Consideration of financial support available at present and at predicted future periods.

The development of the short-range plan is based on projected needs within a defined, fixed period. Enrollment figures and the program of instruction to be housed within a *six*-year period are considered. The immediate action-planning steps are those which can be implemented within *twenty-four months*.

The purpose of the long-range plan is to serve as a "universe" within which short-range and immediate planning are undertaken. Figure 1 illustrates the nature of this relationship. The point is that any planned projects undertaken now should not prevent the realization of a long-range plan and are, in fact, part of it.

The cone model is conceived as a viewer with an aperture at its apex. By looking through the aperture, the short range plan cannot be viewed except against the background of the

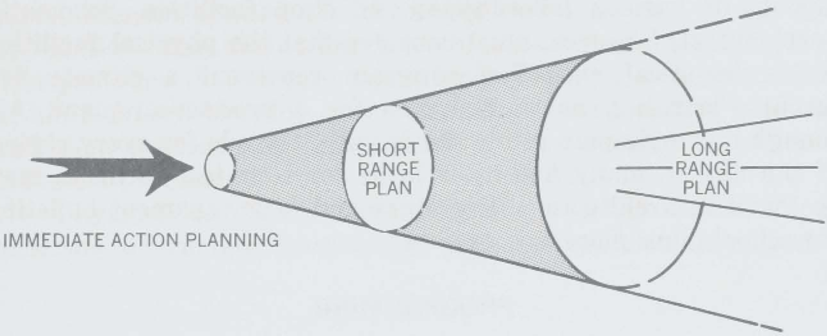

Figure 1. Cone Projection of Planning Steps

long range plan. Further, the immediate action plan cannot be viewed without seeing it within the limits imposed by both the long-range and the short-range plans. Even though the long-range plan may be the least crystallized, it serves as the overall background for immediate planning. Continuous study of the three basic factors of planning — student population, educational policies, and financial support — underlying the long-range plan is the planner's best guide to reconstruction.

The long-range plan may be reexamined, whenever necessary, but should be reevaluated periodically on a six-year basis. This is, generally, the effective period of the short-range plan and serves as a convenient time for reappraisal of the long-range plan. Each time the long-range system is reexamined, a new short-range system should be developed and a new immediate action plan designed within the constructs imposed by the short-range plan.

Major consideration should be given to the program or content of the curriculum, as well as to the staff and student requirements in determining facilities for the technical programs of the future. All are interrelated to the extent that it would be impossible to separate one from another. Planning technical education facilities is an inclusive act and must take into account all knowable human factors. This phase of planning should be a cooperative venture among educators, administrators, and architects.

The educators' first responsibility is to develop educational specifications that fulfill the requirements for programs planned. There is always a need for schematic development of physical layouts of various laboratories and shop facilities. Schematic development, however, must consider that the physical facilities for a technical education program represent a climate for teaching-learning, not a floorplan for a production plant. Although no single plan meets the design demands for every region of the nation, many fine basic ideas for technical facilities may be found in architectural literature and in government bulletins for school plant planning. (6)

PROGRAMMING

Irrespective of the proposed schematic plan devised by the educational planner, it is proposed here that such a plan be subjected to a yardstick of credibility and effectiveness. An acceptable evaluation devise is heavily weighted toward efficacy in the development of human values, attitudes, and skills, rather than toward effectiveness of productivity or quality of product. Any facility which meets the approval of the educator should be conceived of as a human system of interaction and activity with the highest regard for the interpersonal transactions, rather than for the resultant product. It is hypothesized, however, that the greater the satisfaction of the learner in his involvement, the greater the quality and the quantity of the product at some projectable point in time. Figure 2 demonstrates basic interrelationships within the programs of industrial technology. The design for laboratories and facilities is based upon Bloom's *Taxonomy of Educational Objectives* and is concerned with the cognitive and affective domains. The two domains are conceived as mirroring each other. (1)

In Figure 2 observe how the learner's entry into the industrial-technical system is accomplished through the larger open system. Broad instructional facilities provide him with frequent opportunities for acquiring knowledge and for extending his comprehension of knowledge. Social interaction with peers and faculty is made possible within a technological learning society, while premature specialization is discouraged. Broad-base programs orient him to the principles of observing, knowing, problem solving, and analyzing, which will later be applicable to specific technical areas interlocking within the broader system.

If this theoretical position is to be implemented, then it is vital that equipment and facilities be designed as teaching structures oriented toward the theoretical with the introduction of application and evaluation introduced concomitantly. It is a first principle that the student initially orders the commonalities of his technical learning experience, acquires its unique language and then proceeds to differentiate out the specifics of discrete technical practices.

Physical facilities which can catch the thought of Guilford's ordering of mental functioning, progressing from cognition to

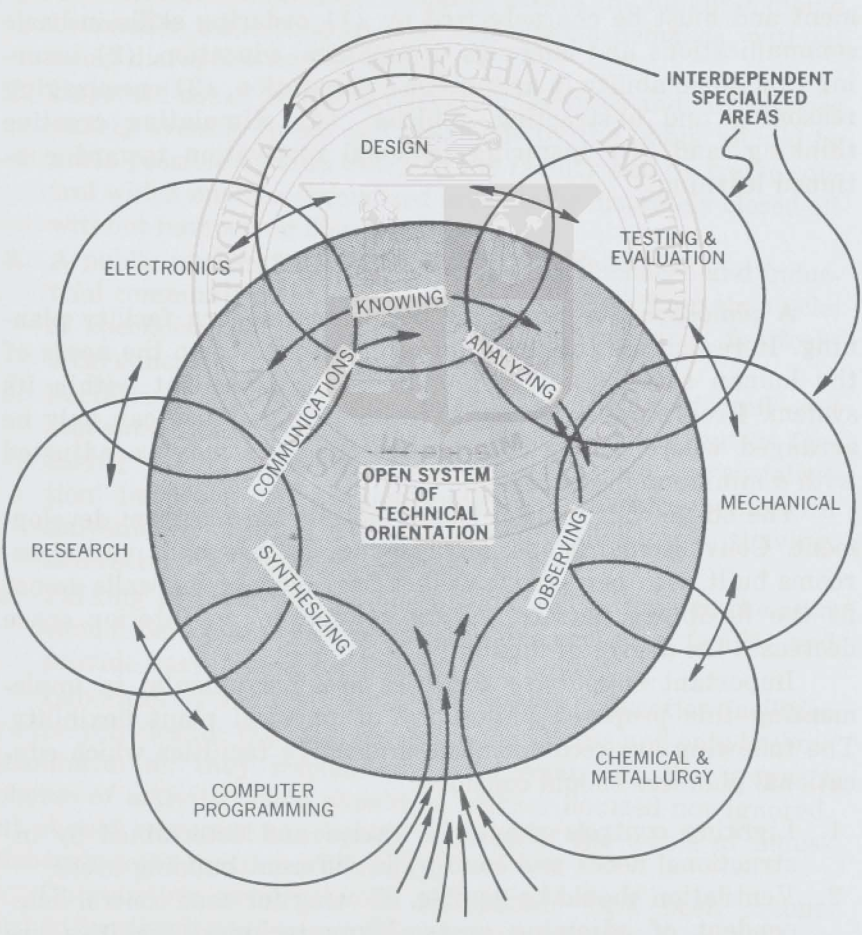

Figure 2. Relationships of Industrial Technology Programs

memory, through divergent thinking and convergent thinking to judgment and evaluation, can lead students, as a result of the educative process, to maximum skill attainment in both basic and specific technical knowledge. (2: 469-79) The layout of physical facilities for the technical program may either promote or deter the educative process.

Training for specific production jobs may have its advantages for business and industry, where the worker is molded to fit like a "T", but in-company type training is not broad enough to serve educational standards. Technical education, broadly based, enables the student to continue his career development and must be characterized by (1) ordering skills in basic communications and language of technical education, (2) insuring functional ability in arithmetic computation, (3) encouraging reasoning and abstracting abilities, (4) stimulating creative thinking, and (5) inspiring personal motivation toward continued learning.

SUPPORTIVE FACILITIES

A philosophy of flexibility permeates modern facility planning. It recognizes the importance of adaptation to the needs of the human systems interacting and interdependent within its system. Programming students to obtain flexibility can only be arranged where course content and facilities may be adjusted with a minimum of confusion.

The static-wall concept should not curtail program development. Conventional shops, laboratories, lecture halls and classrooms built with permanent weight-bearing interior walls do not fit the flexibility pattern. Every column in an interior space decreases the degree of flexibility.

Important supportive facilities are instrumental in implementing this proposed philosophy of physical plant flexibility. The following are recommended supportive facilities which educational planners should consider:

1. Lighting controls should be varied and determined by instructional needs and comfort in different building areas.
2. Ventilation should be flexible, allowing for zone control independent of adjoining areas. Many technical facilities are completely air conditioned for year around use.

3. Acoustical treatment should be given to walls, ceilings, and floors to control sound transmission from shops and laboratories to offices, classrooms, and rest areas. This frequently includes carpeting of hallways, lobbies, and offices.
4. The design for central storage and delivery of materials should enable greater space utilization in laboratories and shops, where designs for tool units are highly flexible and allow for a variety of arrangements and uses.
5. Audio-visual and closed circuit television facilities should be conveniently located and easily directed to shops, laboratories, galleries, and classrooms.
6. Sensitive communication systems within the building should be readily responsive to staff and system demands, without being disruptive and irritating.
7. Expected use of technical education facilities and laboratories during evening hours and weekends by the public should be made possible by easy entry to the facility and by traffic control which enables specialized areas to be discretely closed off without hampering flow to major areas.
8. A public nucleus, devised for use by the business and industrial community, should be encouraged apart from the nuclei of specialized learning centers designed primarily for technical education instruction.
9. Facilities directed at the physical well-being of staff and students should consider installation of canteen centers featuring vending services, provide areas designed for "socialization" purposes, and replace "gang" toilet arrangements with conveniently located bathrooms where showering, shaving, and resting facilities are made available.
10. Parking facilities for students, staff, and visitors to the area should be a planned component of the technical facility and provide easy access for loading and unloading.

Laboratories and equipment for technical education facilities are the vehicles for the teaching-learning process and only become meaningful as they implement and compliment the program spheres of activity. They should be neither lionized nor ignored, but should represent an organic element of the whole of industrial-technical educational planning.

Outstanding programs of instruction have been accomplished by devoted personnel in meager surroundings and dismal programs can be observed in truly admirable facilities. The key to creative industrial-technical education programs has been and will continue to be the result of broad economic support for buildings and facilities, the enthusiastic self-direction of students, combined with the motive forces of imaginative and skillful teachers and administrators.

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CHAPTER SIX

Faculty Selection and Qualifications

CHARLES W. KEITH

The quality of an educational program is dependent to a large degree upon the quality of the faculty. Since the Industrial Technology programs are of college level, it is obvious that the faculty should have an educational background comparable to those faculty teaching in other instructional areas. Faculty members in Industrial Technology should have the minimum of a masters degree and, if possible, a doctors degree. They should possess a strong background in a technological field of specialization and in related fields of the technical sciences, have a minimum of five years of work experience in industry in a variety of positions related to the field of specialization and a comprehensive understanding of the several areas of human relations.

Faculty members need to have a definite interest in teaching and have a mechanical inclination. An academically trained person without industrial experience and without a knowledge of the application of human relations and technical sciences to industrial problems will likely have difficulty in relating his knowledge to these problems. Likewise, people who graduate from present-day engineering programs or those who are vocationally oriented do not usually make the best technology teachers unless they understand and believe in the educational concepts of the technology program. The successful teacher has a thorough understanding of advanced technical education, is familiar with and sympathetic toward its objectives, has an intense interest in teaching in the specialized fields of industrial technology, and is appreciative of the professional status of the industrial technologist and of the diversity of positions he fills in industry and in education.

Faculty members in this academic area experience difficulty in keeping up with the rapid changes and new developments occurring in industry and education. They should be encouraged to participate in in-service activities in order that their programs and instruction can be kept current. One of the best devices for keeping up with changes is through in-service education. Some of these activities recommended for the professional improvement of the faculty are:

1. Participate in technical and professional programs.
2. Work in industry and in research.
3. Study the literature dealing with their technological fields.
4. Take college courses in areas that will improve their teaching in industrial technology education.
5. Attend industrial and professional meetings.
6. Attend industrial seminars and take courses given by industry.
7. Engage in individual research problems.
8. Study new scientific developments and become familiar with how these developments affect industrial practices.

The process of instructing and teaching is one of the most important facets of the industrial technology program. If the programs are staffed with unqualified personnel, they cannot thrive nor can they produce the product so essential to today's technology. One of the most serious problems within the program is the procurement of enough adequately qualified instructors. This becomes more difficult as the field of technology expands and changes with the new developments in industry.

Consideration of the type of faculty involved in the teaching of industrial technology programs throughout the country prompted a study (1: 1) to be made to gather data for evaluating program needs. The findings of this study resulted in the following descriptive material with respect to the faculty, so essential in the preparation of future graduates in industrial technology.

FACULTY PROFILE

The average faculty member appears to be middle aged, has completed the minimum of a baccalaureate degree program, is either a registered engineer or has a masters degree in engineering, or has some form of professional education with several years experience in industry. It is also noted that the individual must be adept in the use of communication techniques, both spoken and written. The faculty member is specifically interested in the teaching responsibility which has been assigned to him and somewhat less interested in his opportunities and contributions to the community in which he resides. He is an individual who is not particularly desirous of doing research work or advanced study in research, but is definitely interested in young people and their goals and aspirations. He is also a person who can identify with today's youth in a very real sense, has some knowledge of the changing culture in which we find ourselves within the world today, and is also at ease discussing and conversing technically with representatives of the manufacturing and industrial community. This faculty member is a person who is dynamic in action, is impatient with the usual slowness in the development of curricula and facilities and all other aspects which go with such developments on the normal college campus. He is extremely sociable and is usually involved in the non-professional activities within the campus faculty while at the same time being primarily interested in the day-by-day activities of his teaching responsibility.

The industrial technology faculty member is an individual who is not stereotyped by previous experiences, is not afraid to speak out, has his feet on the ground, and can still move and change as the times change. He can adjust to change as it develops, can fit in with new developments, and can orient and reorient himself as the press of time and change imposes its limitations and challenges upon him. This faculty member is a person who can by nature and example build into the students with whom he associates changes in attidude and changes in development. He must be able to analyze industrial problems and relate these to his students making them cognizant of industry's needs and problems. Based on these factors, it becomes imperative that the faculty involved in the preparation of industrial technology graduates be carefully screened and selected.

Preparation: Industrial

A recent survey (1: 1) of approximately 47 colleges and universities preparing industrial technology graduates having degree programs either in industrial technology or industry preparation indicated that there was a wide range on the faculty with regard to the industrial experience of individual staff members. This range extended from 12 months to 108 months with approximately one-half of the schools surveyed indicating that the staff had received 30 or more months of such experience. This industrial experience was specifically oriented in approximately 25 institutions with respect to the individual teaching area.

The most disturbing facet of this study was that 29 schools reported a mean of only one staff member per school had received all or part of his work experience in the past 2 years. Since change has been so rapid in industry and technology, all institutions should have staff members who have had experience in industry, at least to some degree, within the past 2 years. Another disturbing factor in this study was that the range of industrial experience in all 47 institutions was from no recent industrial experience in 14 schools to one school in which 8 staff members had work experience within the last 2 years. Although it was assumed that the institutions reporting had staff that had received recent work experience, some of the data were quite to the contrary. When the relationship of industrial experience of the instructors to their teaching assignment was ranked upon a five-point scale, some facts became evident. Six schools indicated a high degree of relationship (a rank of 5) between recent work experience and the staff member's teaching area. The mean measure on the scale was 3.5 with 10 schools indicating a ranking of 3. This data could be interpreted as meaning that slightly more than half of those instructors teaching in industrial technology programs had industrial work experience with immediate relevancy to their teaching disciplines. It is obvious that staff associated with the technical areas in industrial technology programs must have not only sufficient professional preparation in their areas of expertise, but must also have had rather recent experience in industrial activities. Only by this means can we in the profession provide adequate degrees of preparation for our students going into industry. It is also apparent that it is vital to have immediate experience and knowledge of industry from a first-hand point of view to maintain our status with respect to other disciplines in higher education.

Preparation: Professional

Data about professional education courses taken by industrial technology instructor were obtained from 24 institutions. The mean number of semester hours was 32 with a range of from

10 to 60 semester hours. This data suggests that the staff members were reasonably well prepared technically; and professionally. The mean was 31 semester hours with 25 schools reporting. This indicated that most faculty members were adequately prepared for their work. Data received from 12 schools showed that a mean of 3 staff members per school held only the bachelors degree. The range of staff per school with only this degree was from one to 9. Reports from 27 institutions indicated a mean of 4 staff members per school who held the masters degree. The range of staff per school with this degree was from one to 7. This collected data suggests that it might be concluded that the kind and number of degrees held by the staff compares favorably with staff members of other disciplines of the colleges surveyed. There was, however, a lack of staff members holding the doctorate degree. Apparently supervisors and chairmen of these programs throughout the nation have concluded that the doctorate degree is not a vital necessity but that rather the individual should have the appropriate masters degree with associated industrial and teaching experience.

A survey of institutions concerning part-time staff (those who taught less than a one-half load) with respect to earned degrees disclosed a somewhat different ratio. Eighteen schools indicated a mean of 3 staff members per school with only the bachelors degree. The range of part-time staff per school with this degree was from one to 7 staff members. Twelve schools indicated a mean of 3 staff members per school with a masters degree. The range of part-time staff per school with this degree was from one to 13. While there were no doctorates teaching part time, the number holding masters and bachelors degrees compared favorably with those on the regular full-time faculty. In addition, they contributed a practical approach to the problem due to their close contact with industry which constitutes a worthwhile contribution.

Instructors involved with industrial technology curricula must have thorough preparation in formal education relevant to their teaching area, with a minimum of 15-20 semester hours undergraduate preparation. These individuals should have at least 10-15 semester hours in mathematics and physics and at least 8-10 semester hours in chemistry. They should have at least one good course in technical writing, a course in speech or public speaking, and an understanding of computer science. A masters degree is essential and should be obtained preferably in the applied sciences, engineering or industrial technology. The doctorate degree is not essential at the present time. Industrial experience is more essential. With the emergence of appropriate doctorate studies in technology, acquisition of this degree will become more important.

Registration and Licenses

A recent study (1: 1) of programs of industrial technology throughout the nation indicated that 9 schools did have registered engineers on their staff, two of these having 3 registered engineers and 7 schools having one registered engineer. The specific area of registration was omitted in all cases since engineers are registered in a job category nationwide. One school designated having 2 graduate engineers on the staff; however, they were apparently not registered. Types of licenses or registration held by staff members as reported in this recent survey were as follows: FCC license in Radio; First Class FCC license, Radio-Telephone; First Class FCC license, Marine and Broadcast; Commercial Pilot's license; A and M license; FAA A & E license; Journeyman Machinist; Journeyman (General); Master's license, General Contractor; Master Electrician; Licensed Electrician; Certified Magnetic Inspector; Marine Navigation license; Certified and/or Licensed Welder; Licensed TV and Radio Repair; Licensed Auto Mechanic; Journeyman Printer; and Registered Surveyor. This listing indicates that the largest number of licensed staff was in the electrical-electronics areas. In this survey there was no indication whether these staff members were regular or part-time. In any event, they were undoubtedly able to make a practical contribution to the program. Staff involved with the program must have the appropriate registration and/or license membership. Availability of numerous organizations in the electronics field may account for the large number of memberships.

TEACHING EFFICIENCY

One of the most difficult problems in all education today is the ability to determine and ascertain efficiency of instruction. There are obvious checks and balances which can be employed in this regard; nevertheless, in the final analysis the efficiency of instruction can only be judged by the success which program graduates have in life. This success, in many instances, is colored by factors other than the influence of the instruction received at the particular institution. A survey of 29 schools having industrial technology programs suggested that there was a certain degree of emphasis placed upon the teaching efficiency of the staff. The difficulty in judging this efficiency appears to be in the methods used to observe it. This survey suggested approximately five methods as a basis for judging teaching efficiency of the staff. In rank order of importance these methods are as follows: (1) lack of student criticism, (2) observation of grades granted the students in respective class sections, (3) keeping up with the "State of the Art" on the part of the instructor, (4) student success in employment or on the job, (5) other methods including observation of the instructor's work by his immediate supervisor, comments coming to the supervisor from employers of graduates, observation of the instructor by fellow associates, and self-evaluation of the instructor's work on an annual or semi-annual basis. A survey of program graduates at one school indicated they were taught less effectively in the industrial technology courses than in the departments of physics, mathematics and chemistry. Means for current evaluation of staff performance must be developed if we are to produce any tangible results in faculty evaluation.

WRITING FOR PUBLICATION

Discussions and correspondence with program chairmen at a number of institutions throughout the country suggests that these individuals are not particularly concerned with the extent of textbook or article writing accomplished by their staff members. There is, however, a great concern that the staff be involved with the writing of technical reports and the type of communication directly applicable to their expertise areas and to the courses in which they are particularly involved. At the 1965 (2: 1) and 1966 (3: 1) conferences on Industrial Technology in American Higher Education, there was considerable evidence on the part of industrial participants concerning a definite need for graduates who can communicate adequately with associates in the industrial world. This communication takes the form of verbal, graphic, and written expression. Discussions with a number of personnel directors throughout the country suggests that it is imperative that the graduates of the industrial technology programs have an adequate understanding of the concise form wherein reports are structured. Such concern, therefore, should be counteracted through the activities of appropriate writing techniques on the part of the staff involved with industrial technology. The staff usually is adequately prepared in graphical communication, namely engineering drawing, technical drawing, and similar courses, but has had little contact with technical report writing and with verbal techniques of presenting material.

A study of 27 schools of industrial technology indicated that approximately 40 percent of their staff have written books, textbooks, or informative volumes. There is little evidence to suggest that staff members have written for research or have been involved in research activities. Program chairmen throughout the country have indicated some concern in this regard. It is apparent that instructors associated with these programs must have experience, knowledge, and expertise in technical report writing. Since much of the communication in our technical society today is involved in the realm of manual preparation, it is also important that this type of communication be emphasized and taught by associated staff. There is little evidence that staff associated in today's industrial technology programs has had any experience with the structuring and writing of technical manuals or technical manual preparation. Writing reflects the technical and professional competencies and is the vehicle whereby the "State of the Art" is recorded. This ability must be developed by all instructional staff members.

ORGANIZATION MEMBERSHIP: EDUCATIONAL, PROFESSIONAL, TECHNICAL AND OTHER

A recent survey (1: 1) of industrial technology programs throughout the country indicates that a major portion of the teaching staff associated with these curricula are members of educational associations. Teacher-type organizations such as the American Industrial Arts Association, American Vocational Association, and the National Education Association predominate. A study of 27 schools indicates the following types of organizations listed in rank order with the highest number of responses being placed at the top of the list. American Industrial Arts Association, American Vocational Association, National Education Association, American Society for Engineering Education, American Society of Tool and Manufacturing Engineers, American Society for Metals, American Welding Society, Society of Automotive Engineers, American Society of Training Directors, American Council of Industrial Arts Teacher Education, National Society of Professional Engineers, Phi Delta Kappa, American Association of University Professors, and Iota Lambda Sigma. Staff members are also associated in several service organizations throughout the community, namely: Lions, Rotary, and Exchange Clubs.

Since the curriculum in industrial technology has technical subjects as its major interest, it is imperative that the staff associated with the curriculum have first-hand contact with those appropriate organizations directly identified with these technical areas. Each member of the teaching staff should be involved and directly associated with that appropriate technical society which represents his field of expertise. Only in this manner can the instructor become fully acquainted with recent developments as well as projections relative to his sphere of knowledge. This membership should receive primary attention on the part of all faculty members. It is also urged that since the "State of the Art" is changing so rapidly in technical fields, each member in this regard should make every effort to attend all annual and semi-annual meetings of his appropriate organization. It is imperative that wherever possible the staff member should contribute to these association meetings by reading papers and by giving reports of applied research with respect to his area of competence. The last three Annual National Conferences on Industrial Technology in American Higher Education indicated that industry and industrial representatives attending were deeply concerned with respect to the fact that the graduates of industrial technology programs have an adequate understanding of today's needs in industry.

SUMMARY

The selection of qualified faculty members is vitally important for the continuation of a healthy and current program in industrial technology. All associated with the administration of these programs must make every effort to obtain the type of teaching staff who will be current with the needs of today's industry. This staff must have knowledge of the current techniques

and applications of technology, as well as some ability to adjust and adapt to future trends and directions. This staff must also have an understanding of the mathematical and scientific principles as applied in industry and as needed in these areas of expertise. This knowledge must include a thorough understanding of the use of computers and computer applications in today's world and there must be an understanding of numerical control machine equipment and the method of programming these units. The faculty member must have direct relationship with the industry and educational leaders in his field and his geographical area and must be able to identify the functions of today's youth in an everchanging world.

The challenge to this curricular area today is to find and identify those individuals throughout our society who can most readily transmit the technical knowledge needed in today's everchanging world. The instructor must be able to do this efficiently and effectively with as much dispatch and cohesiveness as possible. The traditional teacher must change and adapt to the new innovative teaching techniques which surround us today. Formal courses as we have known them in the past will, undoubtedly, be restructured and will become more identified with the applications which are on the immediate horizon. Traditional course structures as we have known them will have to be regrouped. Many will be discarded and many new ones will be added. Symposia, seminars, workshops and other similar types of continuing education programs must be developed. Instructional staff requirements must change. The total rate of obsolescence in this nation is greater than the present ability of the nation's technical schools, colleges, and universities to provide up-to-date graduates. Students must be often reminded that continuing education after graduation is a must to maintain their technological skills in a viable, effective state of readiness. This is, indeed, a challenge which faces all of us and can only be met through the use of outstanding faculties in industrial technology.

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CHAPTER SEVEN

Selection of Technology Students

ADAM E. DARM

This chapter is concerned with the selection, retention, and follow-up of students in the four-year technology curriculum. Hereafter, the curriculum will be referred to as industrial technology (IT), the title a majority of the institutions use to identify the program. (4) The information presented will reflect the present procedure used to enroll prospective students in industrial technology. It will also describe the student population with respect to previous schooling and biographical data. Case histories of typical students will be found later in this chapter. The academic success of students will be indicated along with suggestions for screening potential IT students.

TYPICAL ADMISSION REQUIREMENTS

Most colleges and universities use some form of standardized entrance test for predicting success and classifying students at the time of enrollment. Some institutions require not only the standard ability entrance tests, but also mechanical abilities and interest tests. (6) These institutions have established norms for their school which do a creditable job of determining academic strengths and weaknesses of the prospective students. However, predicting success or failure by using tests is usually effective in measuring only the extreme ends of the scale.

Another form of admission requirement is the grade point average. High school grade point average is generally considered to be one of the better predictions of college success. It is used as a prerequisite to enrollment at many colleges and universities. In California, for instance, only students in the upper one-third of the high school graduating class may enroll at the state colleges. (2) Students not in the upper third must seek admission at junior colleges who accept "any high school graduate, or any person over 18 years of age who seems capable of profiting by the instruction offered. (11) After completing two years at the junior college and earning a "C" average, the student may transfer to institutions of higher learning. (2) Therefore, it would seem useful to consider grade point averages of previous school work and standardized tests as criteria for admission to the institution and acceptance to the industrial technology department.

There is one other admission requirement which should be seriously considered. The previously mentioned requirements are college policy requirements which apply to all prospective students. However, the interview may be an additional valuable tool for admission. During the faculty interview with the prospective student, the student's interest and appearance can be observed. Further, his transcript of previous school work is reviewed. On this personal basis the student can gain a better understanding of the program and the requirements which he must meet. The faculty member in reviewing the student's transcripts can better advise the student of academic problems which he may face. Sometimes the low grades earned by the student may not reflect his true abilities, as the subject and extenuating circumstances may have caused him to earn the low grades. Usually the level of maturity of the student has a great deal to do with his grades. There are many students who are "late bloomers" and show their academic strengths later in life. These and other factors may be determined in the short interview.

If students do not enter directly from high school into the IT program, but transfer from other institutions of higher learning, the department should establish basic admission requirements, requirements in addition to those established by the college. For instance, the number of credits and types of courses which will provide a better qualified and academically well-rounded student should be considered. The transfer student may have just enrolled in subjects in which he has shown some strength, and ignored other subjects which would have given him a broader educational base. The courses and credits should be established by each program keeping in mind the standards the department wishes to maintain. If students usually transfer from junior colleges, some agreement should be articulated between the institutions allowing each institution to teach what they can do best. The IT department at the State College at Long Beach, California, will accept up to a maximum of 24 technical units which have been articulated with all of the junior colleges transferring students to the program. (5)

SCHOOL POPULATION INVENTORY

The primary source of students in the technology program appears to be from two-year technical programs. (8) These include junior or community colleges, technical institutes, various technical-vocational schools and apprentice training schools. Usually the student is a graduate of the program from which he transfers. Wherever the two-year institutions are not available in a geographical area, the students will come directly from high schools. Some four-year institutions only offer the upper two years because of the predominance of junior colleges and technical institutes in their locale. Those students coming from technical or occupational high schools with a good command of mathematics and the physical sciences would have an advantage over those who graduate from a liberal arts program. The consensus of opinion from various IT departments is that a good student is one who likes mechanical things and has interest and ability in the technology field. (6) Of the students who do enroll in technology programs directly from high school, most come from public supported schools. (1)

In addition to those students who enroll from junior colleges and high schools, some transfer from programs at other four-year institutions. Sometimes they transfer from these programs because of academic failure or because they have moved from the geographical area of the school. Usually the former problem is brought about by a lack of motivation, or by being counselled into too rigorous a program. The latter situation results from corporations transferring students who are working full or part time to other locations before they can complete their academic requirements. Interestingly enough though, many IT departments report that large numbers of engineering drop-outs do not enroll in industrial technology programs. The departments have reported percentages under 10 percent. However, Boaz reported 34 percent of the students in his sample came from engineering curricula. His data was collected from 219 respondents who graduated during 1954, 1959, and 1962 from 29 departments nationally.

At that time many programs had not been in existence long enough to have many graduates; while other departments had no graduates for the years cited. (1) The large percentage of former engineering students used in this study may be accounted for because of the sample and distribution used. Industrial arts students in meager amounts transfer to technology programs, usually because of the higher pay offered by industry for a technology graduate.

A prediction of the success of students from two-year technical programs can be based on their performance at these institutions. Usually the student who has done well in the advanced courses at these institutions does well in the four-year technology program. In evaluating the two-year college or technical institute transfer student, the counselor should note how well the student has done in subjects outside the technical field, especially in courses requiring qualitative and quantitative reasoning. Students weak in these areas will find difficulty in completing the entire IT curriculum. If the transfer student comes from another four-year institution, the student's academic performance can be compared with that of the present institution.

BIOGRAPHICAL INVENTORY

Another tool for the selection and determining of the retention of students in technology programs is biographical data. The armed forces and industry have used this technique with some measure of success for determining personnel placement. The author has used biographical data information in attempting to predict success in the four-year technology program. (3) Though the information did not lead to any significant results statistically, it did reveal the students' backgrounds.

The following information comes primarily from studies made by Boaz, Keith, and the author. Typically the IT student is between 20-24 years old and unmarried. Most have had no military service experience. The students apparently demonstrate some qualities of leadership because a majority are hired for production management jobs. Most of the students are equalling or bettering their parents' educational backgrounds. In both the author's study and Boaz's study the greater part of the students reported their father's occupation as professional and technical. A majority of the students enrolled in the IT program work, either part- or full-time, in technical occupations primarily centered around drafting or design work. Further, many plan to enroll in graduate programs upon graduation, on a part- or full-time basis. Follow-up of the graduates has revealed this last item to be true in increasing numbers. The student himself feels he is technically and academically competent to succeed. The studies indicate that the IT student has an average to above average achievement record in his academic work.

ACADEMIC PERFORMANCE IN SELECTED SUBJECTS

Technological superiority alone will not determine success in the world of the future. The social sciences and humanities will be important and essential in enabling the individual to adjust himself to a changing society. Therefore, the technology student must be equipped to live in our society. Various studies have shown that there is little or no difference in scholastic achievement between technology students and other college students. The education of the technologist must be broader than technical courses. It must encompass mathematics and the physical sciences. Frequent studies of the students in IT at Long Beach indicate that the physics, mathematics, and chemistry courses are the most difficult for the students to pass. A large number need to repeat these courses. (A "C" grade is passing for the technology students in the mathematics and physical science courses.) However, upon repeating one or more of these courses they do succeed. Generally, failure to successfully complete one of these courses does not impair the student from completing the entire program, whereas students who fail to complete two or more of these courses in combination with other courses are eliminated from the curriculum.

As can be expected, the technology student does well in his "native" field of technical subjects. In fact, as is often the case, many students are "carried" by their technical courses. This "one-sidedness" eventually catches up with the student when he is forced to balance his program with mathematics, physical sciences, and the related subject matter requirements. The student finds himself in a chaotic situation having to learn and understand subject matter to which he is unaccustomed. In related areas, courses in business, logic, and technical writing offer the most difficulty. Again, failing them singly the student may survive, but failing them in conjunction with the mathematics and/or physical sciences, the student is destined to probation and academic dismissal.

Interestingly enough, when it comes to overall scholastic performance, the technology student need not apologize for his accomplishment. He fares as well or even better than other members of his school. Some schools report as little as 15 percent of their students being on probation or having been academically dismissed. In Keith's study, 29.2 percent of his sample dropped out of the program. (6)

CASE STUDIES

As was mentioned earlier, the IT student comes from a variety of backgrounds. The following cases represent some of the typical students enrolled in the technology programs.

A student named Karl, age 25, has four children. He has worked in industry at various levels from fork lift truck driver to technician. His company has a slow down and he is laid off for a while. Karl has been going to a two-year college part-time for several years. Upon termination of his present job, he enrolled in the industrial technology program. His wife works part-time and Karl borrows money to complete his education. Karl's grade point average at the end of two years was 3.75 (on a 4 point scale). Interestingly, Karl's scholastic record at the junior college was just above a "C" grade. Karl, upon graduation, went with a major electronics firm, with the highest salary offered anyone in the program that semester.

A student named Bill, age 30, is a family man. He has worked in industry for a number of years as technician, supervisor, and engineer (title often given to highly skilled technical positions in aerospace industries). Bill completed most of his work at a junior college, earning an Associate of Arts degree in engineering on a part-time basis. He enrolled in mechanical engineering at a four-year institution. His grades were well above average in most subjects. Because of his industrial experience Bill decided that the narrowness of engineering was not what he wanted. He transferred to industrial technology and successfully graduated with an extremely high grade point average. Bill became a technical advisor for a national accounting firm upon graduation.

Another student named Dick was not as fortunate as the two previously mentioned students. Dick was an average student in engineering in his first semester. By the second year in electrical engineering he had to drop out of school because of failing grades. It was perhaps his drive that saved him from complete defeat. Dick enrolled in a two-year community college to raise his grade point average. Upon his improvement scholastically he re-enrolled at the same institution from which he was dismissed. This time he enrolled in the industrial technology electronics program. His grades in this program were average to slightly above average. Consequently it took several years for him to "work out" his previous failing grade point average. Dick succeeded finally and became a successful employee for a large computer company.

Ray is a foreign student, here from Iran on an education visa. He started his technical work at a junior college. His junior college grades were average to slightly above. When he heard about the industrial technology program he wanted more information from an IT advisor. After the program was explained to him he felt this technical approach would be most beneficial to him and his country. He explained that engineers in his country were reasonably plentiful but persons who can get things built were not.

Because of the money exchange problem between the two countries Ray had to work in industry here to support himself. He was employed in a commercial manufacturing industry as a foreman of hourly workers. He did an excellent job.

His performance academically was well above average. He indicated that much of what he was learning in the program was of great assistance to him on his job. Upon graduation, Ray returned to his country where he is now managing the manufacturing operations of an industry in his home town.

Joe is a student who has enrolled in the IT program upon completion of high school. His performance academically is just average. Because of his youth, he also has difficulty finding part-time employment. Most companies also want a person who has something to sell. Joe doesn't seem to be able to sell himself well. The only work he is able to do is a box boy job at a grocery store.

After a couple years Joe doesn't want to leave the grocery because he thinks he's making good money and has some security.

He is unable to be persuaded from his job before graduation. During the last semester of school Joe interviews for several jobs from manufacturing industries. None make him a reasonable salary or position offer comparable to those of his classmates in the program. In his frustration and in desperation he takes a position as a draftsman in a defense industry, a position usually filled by people who have little or no college work.

Jim is a student who did not make it. He came into the program with almost 95 credits, most of which were drafting and carpentry. Jim had never had any courses outside the technical area which could be considered rigorous. His general education courses consisted of U.S. History, Political Science, English — all with below average grades. The science and mathematics were at the technical level taught in the technical department. Upon enrolling in the industrial technology program and being required to take more rigorous courses both inside and outside the IT department, the student went on probation after one semester and was dismissed the second semester. He has been readmitted and dismissed several times since initially enrolling in the program. Jim may never make it through the program.

Perhaps the most common situation is exemplified by this next case. Lanny is a man who has earned approximately $10,000 per year at most of his jobs. Invariably, however, Lanny would reach a plateau in his advancement. His mobility to other jobs was also limited. It was explained to him that the lack of a college degree would be a crippling factor for his job and promotional opportunities. "The college degree is the prerequisite in about 499 cases out of every 500," a placement bureau official told him. Consequently, people without college degrees do not get the best jobs. Lanny does not need nor want an engineering degree, but he does want advancement and with the degree, some security.

The seven cases mentioned are but a few of the hundreds of situations which exist in industrial technology programs. Some students have the ability to complete an engineering curriculum, while others do not. Invariably, it is the plateau in advancement which stifles the man without the degree. If the student has a reasonable amount of ability and is interested in technical things, he can succeed in industrial technology.

THE SCREENING PROCESS

Students enrolling in the IT program need to be able to compete with students of other academic areas in most courses outside the technical curriculum. They have to have a mathematical and theoretical knowledge which will enable them to perform, under suitable guidance, the type of semi-routine detail engineering work that is currently tying up large numbers of graduate engineers. (9) The value of good academic skills is unquestionably one of the tools for success in our industrial society.

Usually, the technical skills come rather easily to most technology students. But it must be remembered that the technologist must understand how, why, and the capabilities of technical equipment. They need not "master" the skill. Their positions in industry will be one of direction and decision making, with very little manipulation of equipment and tools. In other words, because one is a skillful craftsman, this will not necessarily make him a good industrial technology prospect. On the other hand, no one should be eliminated because he's been a carpenter, or a machinist; or has little skill in the manipulation of tools, materials, and equipment. With proper education and development these men make excellent technologists and contribute greatly to industry.

Where and what technologists do will be covered in the next chapter of this book. For the purpose of predicting employment success as a result of the student's performance in the IT program, it might be said that grades and industrial experience are most important. The student needs to be reasonably successful in mathematics, physics, and chemistry, along with having a good command of the English language. He, of course, must excel in the technical and supervision courses if he is to assume the role of technical management in industry. With regard to work experience, the only experience which really aids the student is several years of varied experiences; not the same experience several times over.

To insure greater success for graduates, a standard criterion of success should be established in the program. A student needs to have competence in mathematics, the physical sciences, and the technical subjects. These are the tools he will need in industry upon job entry. Therefore, a minimum of a "C" grade should be required for passing. Anything lower indicates a weakness which needs to be overcome. Requiring the student to repeat the course not ónly helps him, but also raises the scholastic standard of the program.

RECOMMENDATIONS AND CONCLUSIONS

Students expecting to enroll in industrial technology should receive adequate orientation. Perhaps the four steps outlined by Shippen, with a few modifications, can be appropriately used here. (10) These include informing, testing, exploring, and counseling. The student needs an overview of the program. What kind of work do technologists do? What is their future with this degree? What areas of strength do they need to survive in the curriculum? There should be some explanation of the specific courses in the curriculum. Special attention should be given to the mental and mechanical aptitudes which seem to be necessary for success in the program.

Secondly, there should be some form of mental and aptitude testing and these should be explained to the student. Testing should be used as an aid to the student, rather than a selection device. A study reported by McConnell, which this author feels best illustrates why tests should not be used as a selection device, was made at the University of Kansas in 1951. (7) About one-half of the freshmen who were admitted that year scored below the median on the national norms of the American Council of Education Psychological Exam (ACE). Of the 800 that graduated four years later, 200 were in the group which scored below the median on the ACE. What is paramount in this report is that those graduates who were below the median became teachers, engineers, journalists, lawyers, doctors, pharmacists, and graduates of liberal arts and sciences, and business. Had test scores been used as a selection device, 200 students might not have completed their education. Even more important is the critical occupations which these graduates filled. Therefore, tests should not prohibit the student from entering the program.

Thirdly, the student should be given an opportunity to explore the program. This can be done through interviews with the faculty of the department and students enrolled in the program. Faculty should take interest in the student to explain questions which may be pressing to the student. If the department has a student organization, the prospective candidate should be given an opportunity to talk with the representatives of this organization. In this group the student can be free to ask questions concerning faculty, courses, homework, and other problems which students can expect to encounter in the curriculum.

Finally, the student should be counselled in light of his own strengths and weaknesses. In the final analysis, the student should make his own decisions, but should be given wise direction so he can come to a favorable decision for himself. His program should be "laid out" before him so he can see where he is going. It is important that the student select a "balanced" schedule, one which doesn't load him with physics, chemistry, and calculus in one semester while his transcripts show him as an average or slightly below average in previous science and mathematics courses. He's not going to be around long with that program! Important also is that the student's first program include a "bread and butter" course, one which provides him with a basic usable skill. Often this motivates the student in his overall academic effort. Further, if the student needs to drop out of the program for any reason, he has some tangible skill he can use to better himself.

In summing up this chapter, there is not one instrument which can be used singly which will tell you which students will succeed or fail. The best evidence is, of course, previous grades from high school and college. This author feels that the interview in conjunction with previous academic work is most important. However, whatever methods are used, it is essential to follow up the students to see how they are progressing. Course grade analysis and graduate follow-up are effective means for determining the success of your approach.

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CHAPTER EIGHT

Job Placement and Employment Opportunities

ZENON T. SMOLAREK and WESLEY S. SOMMERS

Industrial Technology is now in a decade of decision. Although some programs have existed for many years, Industrial Technology did not become nationally prominent until the 1960's. What happens from now until the mid-1970's undoubtedly will determine whether or not Industrial Technology will emerge as a recognized professional field or will be submerged by competing fields such as Engineering, Business Administration and the two-year Technology programs.

To a large extent the future of Industrial Technology depends on the amount and quality of effort expended by leaders in the field. The recently established National Association of Industrial Technology was created to provide national leadership. In a very real sense the success of this organization will directly affect the future of Industrial Technology.

The most important, and immediate, responsibility of the leadership is to define as clearly as possible what is meant by Industrial Technology. Such a definition must be aimed at the future and must be defined in operational terms: a description of graduate competencies; the positions and responsibilities of the graduate upon entrance into the professional field; the advancement potential; the professional work environment; and the programs to produce that graduate. The present ACIATE Yearbook is an attempt to present the best contemporary thinking related to defining Industrial Technology. Yet, no one would contend that this yearbook represents the complete operational definition of Industrial Technology necessary for eventual survival.

If Industrial Technology is to become an accepted professional field it must fill the very real needs of industry for professional/technical personnel. This chapter presents consideration of two theses: (1) that an operational definition of Industrial Technology must be based on an accurate determination of industry's future personnel needs which can best be filled by Industrial Technology graduates; and (2) that industry's professional/technical personnel needs are most accurately reflected in job placement and employment opportunities.

The term "job placement" is considered for the purposes of the chapter to be concerned with historical information related to the vocational positions assumed by Industrial Technology graduates. "Employment opportunities" is considered to be concerned with the possible future placement opportunities of graduates.

The major concern of program planners is with "employment opportunities" — the future market for graduates. However determination of employment opportunities is dependent upon many inter-related factors: economic trends and employment levels; changing needs for technical and management personnel; development of educational programs seeking to fill similar industrial positions; changes in Industrial Technology programs; and, the current and future trends in industry's utilization (initial placement and promotion) of Industrial Technology graduates.

Most of the factors from the preceding list are being studied and reported by various governmental and professional organizations. However, one factor — job placement of Industrial Technology graduates — falls uniquely within the responsibilities of Industrial Technology. It is on the basis of primacy to determining the future of Industrial Technology that this chapter focuses on the area of "job placement." Sufficient accurate information related to job placement is not now available for Industrial Technology graduates — a first order of business is to provide that information.

The initial focus of this chapter was on actual job placement with an attempt to project employment opportunities. A preliminary survey was made of several leading Industrial Technology programs to determine the amount and the kind of placement information that is now available throughout the country. The results of that preliminary survey clearly indicated that current and past records of Industrial Technology graduate placements are insufficient to present any concise picture of national placement of Industrial Technology graduates. Therefore, the focus of the chapter was changed to: (1) identify the types of data needed to obtain a clear picture of job placement and assist in projecting employment opportunities for Industrial Technology graduates; (2) stress the need for obtaining such data in order to develop the definition of Industrial Technology required to establish it as a valid professional field; and (3) present some data concerning job placement that can be used to illustrate the analysis and interpretations related to such information.

The remainder of the chapter will present an over-view of the type of information that could be collected and analyzed on a national basis. Since such information cannot be obtained for any significant number of schools, data from Stout State University's Industrial Technology program will be used. Obviously, its use will be limited to similarities between programs and regional industrial needs. As one of the largest programs in the country, Stout's Industrial Technology graduate data may have some utility for national thinking and planning. However, the purpose of using this data is primarily to illustrate the type of information that can be obtained and possible use of that information.

UTILIZATION OF JOB PLACEMENT INFORMATION

If one of the theses of this chapter is valid, the purpose of obtaining accurate job placement information is to guide program planners in developing future programs that will uniquely qualify Industrial Technology graduates to meet specific professional/technical personnel needs of industry. Specifically, such information should guide these planners in: developing desired competency descriptions of future graduates; designing specific programs to produce such graduates; and obtaining the necessary faculty, facilities, and other resources to implement the designed program.

The needed job information should answer such questions as: In what positions are our graduates placed? What are the responsibilities of these positions? What are the competency prerequisites for these positions? What are the advancement patterns? What is the level of compensation? What is industry's evaluation of our graduates in these positions? How do these patterns of placement and advancement compare to that of graduates from related educational programs?

The answers to the above, and similar questions, can be obtained from two major sources, the graduates of Industrial Technology programs, and the employers of these graduates. The most complete current information has been obtained through contacts with graduates since graduates are usually the more accessible source. Few college placement offices can collect comprehensive initial employment information, and fewer still can maintain information files beyond initial placement. Therefore, while feedback from employers is necessary for a complete understanding of job placement, the initial thrust probably should be directed toward establishing a comprehensive system of feedback from the graduates.

The following description of the Stout Graduate Surveys is intended to provide an over-view of what is involved in developing such surveys. The Stout surveys are of importance to this chapter because they provide specific data that is used to illustrate information needs and analyses related to job placement.

In 1959 Stout State University graduated its first class from the Industrial Technology program. Not long after this it became apparent that the many questions from students, faculty, and industry about what our graduates were doing could not be accurately answered. A general review of the known successes of a few graduates was not sufficient for any person really concerned with the program. Therefore, in 1962 a group of students undertook the first survey of Stout Industrial Technology graduates.

The first graduate survey clearly showed the importance of formally surveying graduates of a professional educational program; and a second survey was made the following year. As a result of these surveys, extended efforts were made to identify those characteristics of the graduates that seemed important to optimum job placement and job success. Employers and potential employers were contacted for their reactions to graduates and the curriculum. The graduates' responses as well as their placement records were analyzed. Students and faculty were brought together for future planning, together with an advisory committee from industry.

As a result of these efforts, the first substantial revision of the curriculum was made, the first definitive report of graduate placement was made, the first descriptive brochure was developed, a guide book for students was produced, provisions for continued study and revision were established, and advisory groups were organized, both from campus and industry. Perhaps as important as any one of the above results was the establishment of good communications with graduates and industry. The lesson was learned, and a permanent system for surveying graduates was established.

At the present time the Stout graduate survey system operates as follows: (1) Immediately preceding graduation each senior is given a form on which he indicates permanent mailing address and is asked to identify the company and position, if he has already secured employment. (2) During the following academic year an initial survey form is sent to all graduates of the preceding academic year. This form is several pages in length and asks for information, such as initial position, starting salary, employing company, responsibilities of the position, succeeding positions, reflections on the curriculum related to requirements of the job, post graduate education, and methods of securing employment. (3) Annually all graduates are sent a request with an enclosed return card to inform us of changes of address, companies, and/or positions; and (4) A five-year follow-up study of all graduates asks for information concerning position, salary, company, and educational changes or additions since assuming their first position. While no claim is made that this system is complete, sixty-five percent of all graduates have made some kind of return and the resulting data is considered usable for the purposes of program evaluation and future curriculum development.

Two useful categories of information can be obtained from graduate surveys; information which helps to define the most appropriate professional/technical personnel needs of industry that can be met by Industrial Technology graduates, and information which indicates industry's evaluation of the graduates. Specific information related to defining appropriate positions for graduates includes initial position placement, advancement within position categories and transfer to other position categories, and descriptions of position responsibilities. Specific information related to the industry's evaluation of graduates includes level and compensation of entry positions, advancement in responsibility and compensation, and recruiting effort.

It is doubtful that any survey can be designed and implemented which will provide all of the desired information. There are limits to the cooperative spirit of those who must complete the survey instrument, and there are difficulties in classifying and quantifying information so that it can be effectively analyzed and interpreted. Yet, it is quite possible to collect sufficient information to permit useful analysis and interpretation. The following discussion of survey information provides an indication of information that has been obtained and possible interpretation of that information.

PLACEMENT OF INDUSTRIAL TECHNOLOGY GRADUATES

Placement information can provide the most direct understanding of the industrial positions most suitable for Industrial Technology. Such information provides a composite summary of industry's judgment and the graduate's preference. However, a static picture of placement patterns cannot suffice for any professional field, and certainly not for a young and developing field such as Industrial Technology.

As technology, the economy, and industrial management practices change so will the personnel needs of industry change. Moreover, time and experience is needed for graduates and industry to explore the other's potential and make the appropriate job placement judgments. Clearly, trend information concerning job placement is required. Such trend information should include trends in initial placements, as well as advancement trends beyond initial placement.

Industrial Positions Assumed by Industrial Technology Graduates

The question of how industry actually uses Industrial Technology graduates can be partially answered by identifying the positions in which the graduates find placement. In an attempt to identify a national pattern, the placement reports of six Industrial Technology programs (other than Stout) were analyzed using the same categories used in summarizing the Stout information. Table I indicates a national placement pattern similar to that of Stout.

Approximately one-tenth of the graduates are identified as Industrial Trainees; approximately forty-five percent are identified with the area of Manufacturing Engineering; and approximately eighteen percent enter the marketing area. In only one of the major categories did an apparent difference in proportion become evident — a considerably larger proportion of graduates from schools other than Stout entered the product development area. The Stout records indicate that the product development area is closer to the technician category than any of the other major areas. Whether the difference between placement of other schools and Stout in this area is related to differences in curriculum, differences in geographical manpower needs, or simply differences in the categorization of positions, cannot be answered with the existing data.

In interpreting Table I it should be recognized that the data includes all graduates from programs with no reference to time of graduation. The classifications of positions refer to position placement and shows no relationship to the graduates' program concentrations.

The classifications of Table I are those used for summarizing information from the Stout graduate surveys and are not necessarily representative of the categories used by the reporting schools.

Table I

Comparison of Initial Positions of Industrial Technology Graduates of Stout and the Accumulated Data From Six Other Schools

	No. Stout	Percent	No. Other	Percent
Industrial Trainee	23	13	23	8
Product Development	29	17	79	27
Product Design	20	11	68	23
Test Engineering	9	6	11	4
Manufacturing	80	46	127	44
Material & Production Control	16	9	39	13
Methods and Work Standards	40	23	49	17
Production Supervision	11	6	13	4
Quality Control	5	3	16	6
Plant Engineering	8	5	10	3
Marketing	33	19	53	18
Sales	12	7	16	6
Service Engineering	14	8	35	12
Technical Writing	7	4	2	1
Industrial Relations	5	3	5	2
Data Processing	4	2	3	1

*The six other schools include:

1. Fresno State College
2. California State College at Long Beach
3. Southwest Missouri State College
4. Miami University
5. Georgia Southern College
6. Kansas State College

A comparison of the data from Stout's surveys and the information received concerning the graduates of other programs indicates a consistency between the findings of Stout's surveys and the general pattern of national placement of Industrial Technology graduates. It appears that the following discussion based on Stout's graduates is at least somewhat representative of the nation as a whole.

Table II presents the trends in initial positions entered by Industrial Technology graduates over a period of eight years. The most noticeable trends seem to be in the areas of product development and manufacturing. In the area of product development early placements included approximately one-third of the graduates while in recent years this percentage has dropped to about one-tenth of the total graduates going into industry. An interpretation of this drop may be related to the nature of the work done by graduates entering this type of position. From the descriptions of responsibilities it seems that the larger share of graduates entering the product development area have responsibilities close to those of the graduates of technical institute programs. In many cases, advancement in this area is limited because of the necessity of competing with graduates of engineering programs. It is hoped that graduates entering this area have such unique competencies that they can advance more rapidly and further than graduates of two-year technician programs. Also, it is hoped that they are not permanently relegated to a sub-engineering position.

The decrease in percentage of graduates entering product development seems to be offset by the increased proportion entering the manufacturing area. With the proportion of graduates entering manufacturing increasing from approximately one-third to somewhat over one-half (of those entering industry) it would seem that industry is tending to identify Industrial Technology graduates with the area of manufacturing management. There is a strong indication that industry has a large unfilled need for technically oriented college graduates in the area of manufacturing and production management. Apparently this need cannot adequately be filled by engineering graduates or by technicians.

Placement in the industrial category has remained constant over the years studied between 10 and 20 percent. Obviously this category represents entry positions and can only be meaningfully

Table II
Initial Positions of Industrial Technology Graduates 1959-66, Showing Percentages Entering Each Area

Positions	1959	1960	1961	1962	1963	1964	1965	1966
Industrial Trainee	**0.00%**	**14.28%**	10.52%	**16.66%**	**8.69%**	**25.00%**	**4.54%**	**17.24%**
Product Development	**30.00%**	**42.85%**	**15.78%**	**16.66%**	**13.03%**	**14.28%**	**13.63%**	**3.44%**
Product Design	15.00%	28.57%	10.52%	11.11%	8.69%	10.71%	13.63%	3.44%
Test Engineering	15.00%	14.28%	5.26%	5.55%	4.34%	3.57%	0.00%	0.00%
Manufacturing	**35.00%**	**42.85%**	**36.92%**	**27.77%**	**65.20%**	**42.84%**	**54.53%**	**55.14%**
Material and Production Control	10.00%	0.00%	0.00%	22.22%	17.39%	14.28%	4.54%	3.44%
Methods and Work Standards Engineering	15.00%	28.57%	10.52%	5.55%	43.47%	21.42%	27.27%	27.58%
Production Supervision	10.00%	7.14%	15.98%	0.00%	0.00%	3.57%	9.09%	6.89%
Quality Control	0.00%	0.00%	0.00%	0.00%	0.00%	3.57%	4.54%	10.34%
Plant Engineering	0.00%	7.14%	10.52%	0.00%	4.34%	0.00%	9.09%	6.89%
Marketing	**25.00%**	**0.00%**	**15.78%**	**38.88%**	**13.02%**	**14.28%**	**22.72%**	**20.67%**
Sales	0.00%	0.00%	0.00%	22.22%	4.34%	7.14%	9.09%	10.34%
Service Engineering	20.00%	0.00%	10.52%	11.11%	4.34%	7.14%	4.54%	6.89%
Technical Writing	5.00%	0.00%	5.26%	5.55%	4.34%	0.00%	9.09%	3.44%
Industrial Relations	**10.00%**	**0.00%**	**15.78%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Data Processing	**0.00%**	**0.00%**	**5.26%**	**0.00%**	**0.00%**	**3.57%**	**4.54%**	**3.44%**
Total	**100.00%**	**99.98%**	**100.04%**	**99.97%**	**99.94%**	**99.97%**	**99.96%**	**99.93%**

analyzed by use of longitudinal studies identifying the positions finally assumed. Often, industrial recruiters tell the graduates that the training program is specially designed to prepare greatly needed personnel for entry into middle management. Other training programs are of short duration and are designed to acquaint the trainee with specifics of the company's product or methods. Sufficient follow-up data is not available to determine the actual relationship between the stated purposes of a trainee position and the end placement. There is, however, some indication that for some companies the management trainee category represents a stockpiling area from which trainees are placed according to specific personnel needs of the future.

The type of information displayed in Table II yields other possible analyses. The following observations might be made about trends within major category groupings. In the area of manufacturing there seems to be a noticeable upward trend in the placement of graduates in the quality control grouping. Prior to 1964 no graduates entered this area. However, by the last reporting date approximately 10 percent of all the graduates going into industry went into positions labeled as quality control. The data are not adequate to say positively that there is an increasing trend to place graduates in quality control positions, yet this increase corresponds with the increasing stress of industry on quality of the product.

Placement in the methods and work standards engineering category seems to remain somewhat constant, employing approximately one-fourth of all the graduates going into industry. More meaning might be obtained from these data if a greater in-depth study was made of the positions within that category. This category is sufficiently broad to include time-study men (a technician category) and methods engineering (an industrial engineering type of position). Indications are that in the early years a large number of graduates going into these positions were of the time-study variety, while in recent years more of the graduates have been entering methods engineering. However, time-study positions have traditionally been used as training positions for persons going into the general area of manufacturing. Therefore, we are again faced with the need for longitudinal studies to provide a better understanding of how our graduates are placed and promoted.

In the category of marketing a seemingly apparent shift in placement is taking place. In the first year, 25 percent of the graduates going into industry went into the area of marketing. Of this group none entered in the sales area, 20 percent entered service engineering and 5 percent went into technical writing. During the last reporting year, 1966, the total percent of graduates entering the marketing area was 20 percent, with 10 percent going into sales (usually termed sales engineering), 7 percent going into service engineering, and 3.5 percent going into technical writing. Again we have a shift in placement patterns that seems to correlate well with what people from industry are saying is appropriate for Industrial Technology graduates.

The information illustrated in Table II represents the most readily available, and possibly the most useful, data that can be obtained about the placement of Industrial Technology graduates. With sufficiently detailed supporting information (i.e., specific position titles, descriptions of responsibilities, position reporting to, and number and types of employees supervised), it is possible to identify actual placement patterns and trends. Unfortunately, the interpretations that can be made from Table II (and the supporting information) are severely limited due to the relatively small number of graduates included, the confinement of data to graduates of only one institution, and the need to correlate these data with other factors, such as trends in industrial manpower needs, quantitative information concerning the output and placement of related educational programs, and indicators of industrial sales and production.

If Industrial Technology has pretentions to define itself as a distinct professional field, a minimum requirement would be to have a complete picture of the placement of its graduates as suggested in Table II. There is an obvious need for many programs to collect historical data concerning the placement of their graduates. Equally obvious is the need for some central coordinating agency to standardize the collecting and recording instruments and to provide the total analysis and interpretation of the data.

Longitudinal Studies of Industrial Technology Placement

Initial placement information concerning Industrial Technology graduates provides considerable information necessary for defining Industrial Technology and evaluating present and past programs. However, a more complete evaluation of the programs cannot be accomplished without longitudinal placement studies of graduates. It is not satisfactory to simply know what happens to graduates immediately upon graduation. Ultimate evaluation depends on determining how well, and in what areas, Industrial Technology graduates succeed in their professional careers. Such information is considerably more difficult to obtain than initial placement information. It requires regular follow-up studies of the graduates and decidedly more complex methods of analyzing and reporting data. One basic, but frustrating problem, is simply to maintain current addresses of all the graduates. The methods used at Stout of making annual post card surveys has provided help in maintaining a current address file; however as time goes on, increasing numbers of graduates become "lost."

Tables III and IV represent initial attempts to report the changing pattern of placement beyond the initial position. Rather than providing useful information these tables better illustrate the difficulty of reporting findings. There should be no attempts to make meaningful interpretations from the data presented. Sufficient numbers of graduates have not been included since only three five-year follow-up surveys have been made and the analysis and reporting methods are still in the preliminary stage.

Some superficial interpretations from Table III indicate, as one would expect, a considerable movement out of industrial trainee positions. It can be assumed that all persons in this category would eventually be changed to another category.

When comparing amount of change, based on the total population, we see relatively small shifts between the major groupings: slight increase in graduates changing to Product Development, a slight decrease in changing to Manufacturing, a slight increase in those changing to Marketing. However, a closer analysis is necessary for interpreting trends. For example, twice as many graduates shifted into the Quality Control area of manufacturing as shifted into Product Development; the largest number shifting out of Manufacturing were from the Methods and Work Standards area; and, the increased change to Marketing came entirely from shifts to Technical Writing positions.

Table IV represents another attempt to analyze follow-up information concerned with changes of graduates between position groupings. Because of the lack of sufficient numbers of grad-

Table III

Changes of Positions of Stout Industrial Technology Graduates 1959 - 1966

	Initial Positions (100%)	Moved Out of Position	Moved Into Position	Result of Moves	Amount of Change
Industrial Trainee	23	57%	9%	52%	— 48%
Product Development	29	41%	55%	114%	+ 14%
Product Design	20	30%	50%	120%	+ 20%
Test Engineering	9	67%	67%	100%	0
Manufacturing	80	49%	40%	91%	— 9%
Material & Production Control	16	63%	38%	75%	— 25%
Methods & Work Standards	40	45%	28%	83%	— 17%
Production Supervision	11	45%	36%	91%	— 9%
Quality Control	5	0	140%	240%	+140%
Plant Engineering	8	75%	50%	75%	— 25%
Marketing	33	30%	45%	115%	+ 15%
Sales	12	25%	58%	133%	+ 33%
Service Engineering	14	43%	36%	93%	— 7%
Technical Writing	7	14%	43%	129%	+ 29%
Industrial Relations	5	40%	120%	180%	+ 80%
Data Processing	4	50%	25%	75%	— 25%

Table IV

Changes of Position Areas of Industrial Technology Graduates 1959 -1966

	Product Development	Manu-facturing	Marketing
Initial Positions	29	80	33
Number of Changes (100%)	16	36	10
Change to Product Development	63%	19%	0%
Change to Manufacturing	25%	69%	30%
Change to Marketing	16%	11%	70%

uates in the various areas, this table only presents information related to changes occurring in the areas of product development, manufacturing, and marketing. The table presents such a small percent of actual cases that any interpretation would not be valid. It is presented as an example of another possible treatment.

The data presented in Tables III and IV presently have limited value in identifying trends. The graduates represented are largely, but not entirely, from the first few graduating classes since the bulk of the data came from the five-year follow-up study. As such, we have little idea of "position change" patterns for graduates from the revised curriculums. However as more data are collected, and by comparison with Table II, rather significant placement patterns related to changing industrial needs and changing curriculum should emerge.

Initial Salaries of Industrial Technology Graduates

Of considerable interest to anyone attempting to identify industry's evaluation of Industrial Technology graduates is the amount of money that they are willing to pay for those graduates' services. While such information is of interest, there are many difficulties in obtaining valid salary information and interpreting that information once it is obtained. The most obvious problem in collecting the information is its reliability. Companies are not always consistent nor cooperative in reporting actual salaries paid to the graduates they hire. In addition, with approximately one-half of the graduates finding employment through personal contact, it becomes exceedingly difficult to obtain this information through any other source than the graduates themselves. It can be suspected that some graduates might inflate the salaries reported.

Salaries must be reported in a meaningful way. The term "meaningful" depends on the intended use of the data. If the concern is with industry's evaluation of Industrial Technology graduates in terms of what it is willing to pay for those graduates, then comparative salary information may be desired — salary increases compared to some meaningful norms, such as per capita income increases, consumer price index increases, changes in purchasing power of the dollar, and increases in salaries of graduates from other related degree programs.

The data available indicates that, with the year 1959 as a base, starting salaries for Industrial Technology graduates from the Stout program increased 39 percent. Over the same period of time, the per capita income increase was 24 percent. In other words, while the average income increase for the country over the given period of years was 24 percent, the increase in starting salaries for Industrial Technology graduates was 39 percent, or over one-half greater than the average. This can be interpreted to mean that over the period of years included, industry's evaluation (in terms of initial salaries paid) was significant and positive.

Perhaps a more meaningful comparison would have been to relate the starting salaries for Industrial Technology graduates with those of graduates from related programs. Such information is not currently available; however, in a 1966 study of engineering graduates' salaries, the reported averages ranged from $658 to $682 per month. For "non-technical" graduates of the same year the average starting salary was $570. These figures compare to reported monthly starting salaries for Industrial Technology graduates for the same year of $649. These data suggest the relative position of industry's evaluation of graduates, based on salaries paid, between Industrial Technology graduates, engineering graduates, and non-technical graduates at a particular point in time. The indication is that industry considers the Industrial Technology graduate to be of considerably greater value than the non-technical four-year graduate, but places somewhat more value on the engineering graduate.

While the above information is of some value in interpreting industry's evaluation of Industrial Technology graduates, it is obvious that a more extensive study is required in order to produce the meaningful information necessary for comparing the value of Industrial Technology with highly related programs such as engineering technicians, specific areas of engineering, business administration, and possibly industrial education.

How Graduates Obtain Placement

The past experience of Stout State University as primarily a teacher's college had considerable influence on how the Industrial Technology graduates were placed. Table V illustrates an increase of approximately 140 percent in the number of industries actively coming to Stout seeking Industrial Technology graduates. It seems safe to assume that this increase would be considerably greater if such information had been available for the year of the first graduating class, 1959.

Tables VI and VII reflect a similar change in industry's acceptance of Industrial Technology graduates. In the earlier

Table V

Number of Industrial Firms Placing Vacancy Notices for Stout Graduates

Year	Number of Firms
1962	51
1963	50
1964	42
1965	74
1966	118
1967	120

Table VI

Methods of Placement for Initial Positions of Industrial Technology Graduates of 1966 & 1967

Method	Percent
Personal Contact	48
Stout Placement Office	38
Employment Agencies	7
Other Methods	7

Table VII

Methods of Placement for Present Positions of Industrial Technology Graduates 1959 - 1962

Method	Percent
Personal Contact	51
Employment Agencies	22
Newspaper Ads	14
Stout Placement Office	10
Other Methods	3

years of the program, 39 percent of the graduates obtained jobs through methods other than personal contact or Stout placement office. In 1966-1967 this proportion dropped to 14 percent while the placement office as a method of procuring employment increased from 10 to 38 percent. The implication is that industry has become increasingly aggressive in their recruitment of Industrial Technology graduates. A secondary implication is that the placement office has become more effective in serving the needs of Industrial Technology graduates.

As an indication that quantitative data do not give the complete picture, the consistent 50 percent figure for students obtaining employment through personal contact can be misleading. The fact that 50 percent of the graduates still secure employment through personal contacts might indicate that a large percentage of graduates still have to go out and knock on doors to secure employment. Yet, a more intimate understanding of what is actually happening reveals that a large share of graduates now in this category actually made their personal contacts through their experiences related to the recent Field Experience program (summer work experience for credit for the cooperative program), or through contacts resulting from student-faculty relationships.

A NATIONAL STUDY

Industrial Technology may very well have entered a crisis period: a time when it can either establish itself as a vital contributor to the nation's professional/technical manpower needs, or be submerged by competing educational programs. The key to achieving success is in the development of programs that uniquely contribute to meeting the future manpower needs of our industrial society.

Three focii were identified for this chapter: (1) types of job placement data needed for projecting employment opportunities for Industrial Technology graduates; (2) the presentation and discussion of these data; and (3) the need for obtaining projected employment opportunity data in order to establish Industrial Technology as a valid professional field. The major portion of the chapter was developed to the first two focii. The remainder is concerned with action to fulfill the need of the third focus.

The two theses presented earlier in the chapter force consideration of a thorough national study of future employment opportunities in order to achieve the success alternative of the crisis situation. The major recommendation of this chapter is that a national study of employment opportunities for Industrial graduates be made as soon as it is feasible.

The major objective of such a study would be to provide a valid projection of "employment opportunities" for graduates of future Industrial Technology programs. The data resulting from this study should provide guides for developing: an operational definition of Industrial Technology; accreditation standards; and curriculums and courses for future programs.

In order to achieve the purposes suggested above, such a study must be comprehensively conceived and rigorously implemented. It necessitates a multi-faceted approach including several concurrent and interrelated sub-studies, including studies of: job-placement of Industrial Technology graduates; job-placement of graduates of related programs (i.e., Engineering, Engineering Technology, two-year technician programs, business administration, and industrial education): curriculum trends in Industrial Technology and related professional areas; trends in those manpower needs related to future programs; certification and accreditation movements; and the future philosophy and objectives of Industrial Technology.

Most of the existing studies related to Industrial Technology have been undertaken as theses for the doctorate. Some of these studies have made distinct and positive contributions to Industrial Technology. However, it should be obvious that the magnitude and sophistication of the required study is such that no single doctoral candidate, or even several candidates in a coordinated effort, can accomplish it. Nor can a mature scholar make such a study in his spare time. What is required is a large scale study, adequately funded, involving the full-time efforts of several competent researchers.

Some suggested steps in developing the type of study recommended include:

1. The leadership of the National Association of Industrial Technology agree that an intensive study be made, and establish objectives and general procedures.

2. A specific group be identified to coordinate the total planning and implementation of the study.

3. A specific group be assigned responsibility for the initial design of the study.

4. Another specific group be assigned responsibility for providing adequate project funding.

5. A project director be provided with adequate funding to develop a comprehensive study design which covers several pro-

gressive phases and thrusts; and prepares funding proposals for the various phases.

6. With the appropriate agencies — government, foundations, or companies — providing sufficient funding, the project director organizes a team to conduct the study.

7. The study is conducted and reports made. Plans for continuing study and evaluation are made and implemented.

The above steps are only meant to emphasize the necessary scope and involvement inherent in producing the required comprehensive study. It is a conclusion of this chapter that without the rigorous analysis of the relationship of Industrial Technology to the future professional/technical personnel needs of industry there may be no future for Industrial Technology. It is hoped that the National Association of Industrial Technology will accept this responsibility and take appropriate action.

APPENDIX: DESCRIPTIONS OF MAJOR JOB CATEGORIES AND SPECIFIC JOB TITLES[1]

Industrial Trainee

Description. A position in industry consisting of a general training program. This classification includes those graduates who join companies with no specific work area in mind. After completion of the training program, a work area is selected.

Related Job Titles. Industrial Trainee, Trainee, Management Trainee, General Trainee.

Product Development

Description. This classification refers to jobs which are product oriented. The sub-classifications are defined as Product Design, a job directly related to the development of product, and Test Engineering, a job related to development of functional models and analysis of these models.

Related Job Titles — Product Design. Project Design Engineer, Draftsman, Project Engineer, Design Engineer, Senior Draftsman.

Related Job Titles — Test Engineer. Experimental Engineer, Test Engineer, Electronics Technician, Supervisor Test Lab.

[1]The job titles listed are actual titles reported by Industrial Technology graduates.

Manufacturing

Description. This classification refers to jobs which are process oriented. Five sub-classifications further divide this general category: (1) Material and Production Control, defined as related to inventory control, transportation, scheduling, routing, etc., (2) Methods and Work Standards, defined as related to work simplification and work measurement, (3) Production Supervision, defined as a line position of authority, (4) Quality Control, defined as a position related to process observation and analysis and product quality control, (5) Plant Engineering, defined as related to physical facilities planning and maintenance.

Related Job Titles — Material and Production Control. Production Planner, Buyer, Purchasing Agent, Expediter, Manufacturing Specialist.

Related Job Titles — Methods and Work Standards. Associate Industrial Engineer, Industrial Engineer, Process Engineer, Process and Industrial Engineer, Industrial Engineering Assistant.

Related Job Titles — Production Supervision. Assistant Manager, Division Manager, Plant Manager, Production Foreman, Assistant Department Head.

Related Job Titles — Quality Control. Quality Engineer, Analyst, Quality Control Analyst, Quality Control Engineer, Process Engineer.

Related Job Titles — Plant Engineering. Plant Engineer, Facilities Planner, Facility Layout Technician, Process Engineer, Industrial Engineer.

Marketing

Description. This classification refers to positions involving finished product and the distribution and maintenance of such. The sub-classifications are Sales, defined as distribution of product, Service Engineering, defined as related to installation and maintenance of product, and Technical Writing, defined as development of manuals, instructions, and other written material accompanying the product.

Related Job Titles — Sales. Sales Engineer, Marketing Representative, Sales Representative, Salesman, Sales Application Engineer.

Related Job Titles — Service Engineering. Field Engineer, Customer Service Engineer, Field Service Engineer, Service Instructor, Customer Relations Specialist.

Related Job Titles — Technical Writing. Technical Writer, Associate Engineer Writer, Technical Illustrator, Supervisor Technical Literature, Analyst.

Industrial Relations

Description. This classification related to personnel, employee relations, labor relations, etc.

Related Job Titles. Representative, Training Coordinator, Analyst, Personnel Manager, Safety Engineer.

Data Processing

Description. This classification refers to positions involving data processing equipment such as the computer and reporting of various types of information.

Related Job Titles. Programmer, Production Accountant, Cost Accountant, Data Development Engineer, Data Analyst.

CHAPTER NINE

Evaluation Guidelines for Industrial Technology

JAMES N. HARRIS

One of the fastest growing areas of technical education is that of four-year technology programs. The increasing complexities of our industrial enterprise have created new needs and requirements for technical personnel with a broad-range of abilities who can shift with technological change and assume new responsibilities. The need for technically competent personnel requires expanded educational services. As these educational services develop, there will be an increasing need for improved standards.

The increasing demands for persons who can fill newly created industrial positions continue as a major impetus in the emergence of four-year technology programs in many of our educational institutions. Although industrial technology programs have been in existence since 1923 (12: 1), they have only recently become a significant factor in the preparation of a "new breed" of qualified graduates for high-level industrial employment. One major concern that accompanies this dramatic growth of industrial technology curricula is the noticeable absence of organized guidelines or evaluative criteria for measuring the quality of these programs. Hopefully, the writer's research now in progress in this area will be helpful in alleviating this situation.

STATUS OF INDUSTRIAL TECHNOLOGY PROGRAMS

Industrial Technology curricula that lead to the baccalaureate degree are now enjoying unprecedented growth and development. Recent studies have identified more than eighty colleges and universities with four-year technology programs. Most of these programs have appeared since World War II, and many of these were developed after 1960. (7, 12) George McNelly of Purdue University claims that the bulk of the four-year technology programs in the nation have grown from the industrial education institution. (16: 3)

A description of four-year technology programs that may be helpful at this point is provided by the Engineers' Council for Professional Development (ECPD). These programs are described by ECPD as: (1) those which evolved from the two-year and three-year engineering technology program, and (2) those which evolved as industrial options (non-teaching) from the traditional industrial arts and industrial education curricula. (10: 16) Recent reports indicate that four-year technology education is continuing to make giant strides forward. (7, 13)

ROLE OF MISSISSIPPI VALLEY CONFERENCE

One of the first organizations to investigate the status, purpose, and administrative organization of four-year technology programs was the Mississippi Valley Industrial Arts Conference. Their meeting in 1963 focused on curriculum patterns of four-year industrial technology programs, and in 1965 the conference emphasized accreditation procedures and the administrative structure of industrial technology programs. A conclusion drawn in the 1965 report of the group's investigative activities was that, while several professional organizations and the federal government were promoting an increase in the number and quality of technical education programs, "there has yet to emerge a single group organized for the specific purpose of setting standards and accrediting technology programs on a wide scale." (20: 1) This observation, unfortunately, is still applicable to industrial technology curricula.

ECPD ACTIVITY AS RELATED TO FOUR-YEAR TECHNOLOGY CURRICULA

The most recent period of expansion (1965-1967) in the number of four-year technology programs also produced some rather interesting developments. The Engineers' Council for Professional Development (ECPD), which has long been active in the field of evaluation and accreditation of technical institute-type engineering technology programs, expressed concern about the widespread appearance of "degree (baccalaureate) programs in industrial technology." They also expressed "some fear" that the attractiveness of a baccalaureate program would take potential students away from ECPD-accredited associate degree programs. (15: 2)

ECPD, at one time, actually ruled as unacceptable to the organization for accreditation purposes any technology program with a "vocational heritage." (10: 16) To deal with the "special problems" posed by the appearance of increased numbers of four-year industrial technology programs, the Engineering Technology Sub-Committee of ECPD has encouraged the development and expansion of four-year engineering technology programs. (12: 2)

Although ECPD has now been granted authority to evaluate and accredit engineering technology programs of any length, there was some delay in receiving this authority until certain questions posed by the American Association of Junior Colleges (AAJC), the American Vocational Association (AVA), and the U. S. Office of Education could be settled. (11: 12)

AVA COMMITTEES

Because of the growing concern over quality education and the rapidly expanding number of four-year technology programs in colleges and universities across the country, increased attention has been devoted by at least two American Vocational Association (AVA committees to problems related to guidelines for evaluation and to the establishment of a professional group to coordinate these activities. (6: 4) This report is limited to a discussion of the activities of the Industrial Arts Division subcommittee on four-year technology programs. The matter of evaluation and accreditation of the broad spectrum of programs under vocational education, excluding four-year technology programs, has been left to still another AVA committee headed by Dr. Joseph T. Nerden. (19: 18)

The Industrial Arts Division subcommittee, under the leadership of Dr. C. Thomas Dean, has considered questions related to status, future development, and standards which might be used in the evaluation procedures for curricula in industrial technology. Unable thus far to resolve some of the larger issues related to developing evaluative guidelines, the subcommittee recommended in its 1967 report that the primary work for developing professional standards be left to the newly organized National Association for Industrial Technology (NAIT) of which Dr. Charles Keith serves as president. It was also the consensus of this AVA subcommittee that some group which was unhampered by any allegiance to other professional areas could best study the entire question of evaluation standards.

THE NCA POINT OF VIEW

One of the concerns expressed recently by Dr. Frank Dickey, Executive Director of the National Commission on Accrediting, was the number of instances in which colleges and universities were "blithely" adding courses of study they considered themselves capable of offering. A number of questions are being raised about this practice. Many professional groups are becoming increasingly disturbed at seeing so many colleges and universities adding or expanding educational programs of study with little or no concern as to how adequately prepared they are to provide quality education even in the fields they have already undertaken. Dr. Dickey declares the time has arrived when post-secondary education must take a stand for integrity and that the following questions must be answered: (8: 287-8)

> Are all of the programs of study, professional or otherwise, in each of our colleges and universities soundly conceived and conducted?
>
> Are the immense sums of money entrusted to our institutions being prudently spent?
>
> Are the endowment funds of our independent institutions being invested without moral compromise?
>
> Are the policies of each of our institutions with regard to faculty tenure and academic freedom irreproachable?
>
> Are our student admission and housing policies morally correct?
>
> Is higher education doing all that must be done to eradicate the dishonest and fraudulent diploma mills that thrive in our midst under the guise of education?

Because there are no organized guidelines or criteria for establishing and/or evaluating four-year industrial technology programs, we are left, therefore, with as many different approaches to industrial technology education as there are colleges and universities with such programs that meet certain minimum standards of quality. Such information is needed not only to assist in furnishing answers to questions raised by Dr. Dickey but also to protect the society as a whole.

EVALUATION GUIDELINES AND STANDARDS

A major purpose of developing evaluation standards for industrial technology curricula is to establish bases with which persons responsible for carrying out evaluation procedures may be assisted in making objective judgments of the curriculum being examined. Such standards would also provide guidelines for establishing new programs, facilitate student transfers from one institution to another, and provide better qualified graduates for prospective employers.

Evaluation guidelines that have been established for engineering technology curricula are not entirely suitable for industrial technology programs because of the heavy engineering orientation. While there are some similarities between the two, there are at the same time differences in objectives and curricula content which in general distinguish industrial technology programs from those in engineering technology.

The following guidelines listed under seven headings are representative of those now being researched and developed in terms of appropriateness for evaluating industrial technology programs in higher education. Several years of study have already been devoted to this research project which is expected to be completed at Wayne State University during the Spring of 1969. These do not suggest a plan as such for programs in industrial technology but do provide a frame of reference for drawing conclusions concerning program administration and development.

Program Objectives

Program objectives for industrial technology should be agreed upon, geared to the preparation of students for industrial and/or technical positions, periodically reviewed by the faculty, and used as a basis for conducting and/or modifying the educational program as well as evaluating educational results.

1. Program objectives should be developed and clearly stated in writing by the faculty.

2. The objectives should be consistent with the purposes of the institution and reflect a broad concept of:
    a. The present and emerging roles of industrial technology in the industrial enterprise.
    b. The need of students to develop as knowledgeable individuals and as contributing members of society.
3. The objectives should be stated in terms consistent with changes expected to occur in technology and in students.

Organization and Administration

The organization and administration of industrial technology should be in accordance with the organizational and administrative policies that govern comparable departments with technical program interests in the institution.

1. The industrial technology department should be established in accordance with the administrative structure of the institution with respect to:
    a. Relationships with the central administration.
    b. Interrelationships with other departments and educational units of the institution.
    c. Representation on central and other important committees in the institution.
    d. Relationships with business and industry.
2. The administrative policies in effect for industrial technology faculty should be the same as those in effect for faculty throughout the institution.
    a. Faculty members should be appointed to academic ranks that are appropriate to their respective qualifications and functions, and the advancement and tenure policies should be consistent with those of other units in the institution.
    b. The functions and the responsibilities of each faculty member should be defined in writing.
    c. The faculty personnel policies should be in accord with those of other units in the institution.
3. The department should have administrative authority and responsibility consistent with general policies of the institution with respect to:
    a. Selection and recommendation of qualified candidates for faculty appointment and advancement.

b. Internal organization of faculty.
c. Development and conduct of the educational program.

The Faculty

The faculty for industrial technology should be adequate in size, and in qualifications for effective performance of its functions.

1. The primary functions of the faculty should be consistent with those for faculty of any educational department in the institution.
2. All faculty members should be academically, professionally, and technically qualified in that they:
   a. Meet the institution's requirements for faculty appointment.
   b. Hold a master's degree as minimal preparation.
   c. Maintain expertise in their technical and/or professional areas of specialization.
3. Faculty members should be sufficient in number to:
   a. Carry out the industrial technology program.
   b. Permit continuity and coordination in the industrial technology curriculum offerings.
   c. Provide individual academic guidance and counseling.
   d. Permit time for research, writing, continued development as a teacher-scholar, and participation in other activities that advance technical education.

The Students

The policies in effect for industrial technology students should be consistent with those in effect throughout the institution for students at the same academic level and with similar interests.

1. The general policies of the institution should be applied with respect to:
   a. Publicity and recruitment.
   b. Counseling and health services.
   c. Food and housing facilities and services.
   d. Tuition and maintenance charges.
   e. Opportunities for financial aid and voluntary employment.

f. Membership in student organizations.

g. Opportunities for recreational, social, cultural, and religious activities.

2. The academic policies should be consistent with those for institutions of higher education and reflect the requirements of both the institution as a whole and the industrial technology department with respect to:
   a. Selection and admission of students.
   b. Requirements for graduation.
   c. Counseling with regard to job placement.

The Curriculum

The curriculum and instruction in the industrial technology program should be such that they prepare graduates for high-level competence in management-oriented positions in industry.

1. The curriculum should maintain an approximate balance between:
   a. General education requirements.
   b. Social science and the humanities.
   c. Professional industrial technology courses.
   d. Courses in a technical specialty (where required).
2. The curriculum should be organized and conducted so that:
   a. Basic and contributory science and technical courses are prerequisite to or concurrent with advanced learning.
   b. The level of instruction in successive years is appropriate to students' stage of advancement.
   c. Learning experiences throughout the curriculum require advanced problem-solving ability and independent study.
3. The curriculum should include selected learning experiences to develop in students:
   a. Competencies essential for skillful performance of technical and managerial functions in the industrial enterprise.
   b. Understandings, skills, and attitudes necesary for effective cooperation with other personnel.
   c. Increasing competence and responsibility in technical and administrative performance.

Resources and Facilities

Resources, facilities, and services needed for effective development and conduct of the program in industrial technology should be adequately provided by the institution with the appropriate advice and/or assistance of industry.

1. Courses in subjects other than industrial technology should be available and appropriate for the required instruction including:
   a. Mathematics through beginning calculus.
   b. Courses in the physical sciences and chemistry.
   c. Opportunities to increase communication skills.
2. There should be adequate facilities for effective instruction in all courses.
3. Library facilities, resources, and services should be provided by the department through the general library services.
4. Computer services should be available for student use.
5. Audio-visual facilities and services should be available for student use.

Evaluation of the Curriculum

Periodic self-evaluation of the curriculum with faculty, student, and industry participation should be planned as an on-going part of curriculum development.

1. The extent to which educational objectives have been achieved in the curriculum should be continuously assessed, and the information obtained should be used for further development and improvement of content and methods.
2. Measurable educational outcomes should be continuously assessed in terms of technological change.
3. Students should be encouraged to participate in evaluation of their own progress in relation to program objectives and industry requirements.
4. Evaluation procedures should include follow-up information regarding graduates' opinions and achievements.

IMPLEMENTATION OF GUIDELINES

A number of factors influence the effectiveness of industrial technology programs. The preceding guidelines could be helpful in increasing this effectiveness if they are properly implemented. Perhaps some insight into two important areas pertaining to these guidelines will serve to illustrate how they can be implemented. These areas are (1) the relation of curriculum content to objectives, and (2) the selection and development of faculty.

In assessing the relative merits of any technical program, the amount of success obtained in implementing the stated objectives is of utmost importance. Professor Robert L. Brackenburg of the University of Southern California says that "objectives are to the educational enterprise what destinations are to a ship — both teaching and seamanship require direction if they are to have meaning and significance." (3: 89) Industrial educators have long recognized the need for objectives in planning and evaluating an educational program. In fact, almost any course of study or college catalog contains a list of objectives. Most of these statements, however, are often "lost" as teachers continue their undisturbed routines to the conclusion of their courses. Why has the implementation of the objectives failed in these instances? Professor Brackenburg offers a clue when he contends that "Educators have frequently failed to recognize that there are various levels of objectives and that objectives at each level differ from those of another in specificity and origin. These three levels of objectives are societal, institutional, and instructional." (3: 89) Unfortunately, industrial educators frequently formulate objectives without making clear the level to which they are referring (societal, institutional, and instructional) or, without recognizing that objectives at one level cannot effectively serve at another level until they have been reformulated. (3: 90) Thus, to be effectively implemented, objectives must first be reformulated in order to be useful for the level at which they must serve. Successful instruction and learning in industrial technology, therefore, is highly dependent upon closely related and thoughtfully formulated objectives.

This is not to suggest, however, that industrial technology programs should be evaluated only in terms of the objectives stated by their developers. They must also be evaluated in terms of the outcomes. Jerome Moss thinks that "the profession should suggest outcomes expected at both the most general, philosophical level, and at the level of measurable indices." (18: 7)

A second and most important area related to the implementation of the preceding guidelines is that of recruiting, selecting, and developing a competent faculty. Most industrial technologists agree that the quality of faculty is, perhaps, the single most important controlling factor in the implementation of guidelines or evaluative criteria into any technical education program. Of paramount importance to the success of the industrial technology program is the personnel that is responsible for its operation. To develop and improve curriculum content, to acquire resources and build up facilities, and to retain respect and stature in the academic community requires a faculty of highly competent teachers and scholars. A competent staff for industrial technology instruction can be acquired and maintained only if the college or university administration gives singular attention to the important problems of recruitment, selection, working environment, and faculty growth as these relate to departments of industrial technology.

Finally, most of the important criteria for the evaluation of industrial technology programs may be synthesized in the six major assumptions underlying program evaluation that were set forth by Ralph W. Taylor more than twenty-five years ago (1942). These may be thought of as some of the essentials to be considered in the evaluative process and they have been reformulated as follows:

> (1) education is a process in which change of behavior patterns is an essential characteristic; (2) the kinds of changes and patterns of human behavior that the college (or school) seeks to effect represent its educational objectives; (3) the appraisal of educational programs is realized by ascertaining to what extent the objectives of the programs are being attained; (4) the manner in which a student organizes his patterns of behavior is an essential feature to be determined; (5) methods of evaluation embrace [not only assessment of educational results, but also any other] devices that furnish valid evidence concerning the degree to which students have attained educational objectives; and (6) maximum values are to be gained in the evaluation process when teachers, students, and parents all participate. (17: 374-5)

SUMMARY

Suggestions involving basic steps in the evaluation process of programs have been presented. In the evaluation of industrial technology programs at the college and university level, emphasis has been placed upon the development and use of operationally-formulated objectives which can be translated into effective learning experiences. Behavioral changes occurring in connection with formal and informal educational experiences in turn can be assessed through self-evaluative measures and procedures that also have been based on the same objectives.

Industrial technology programs should be evaluated not only in terms of the stated objectives, but also in terms of the measurable outcomes. Careful analysis of available procedures, may permit one to draw relevant inferences and conclusions regarding establishing a meaningful dialogue for developing appropriate industrial technology program guidelines for the years ahead.

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CHAPTER TEN

Implications for Future Planning

C. THOMAS DEAN

Satisfying the demands for change has become a dominant factor for educational administrators and business and industry personnel. Always a viable process, education today is confronted with desirable innovations of new magnitude, and with progress that constantly accelerates and proliferates. Techniques to effect change for maximum benefits are as numerous as the advancements they are designed to implement.

James B. Reston, executive editor and columnist of the New York Times, in his Roy A. Roberts lecture at Rockhurst College summed up the problem with the following, "We are all in a race with the pace of history, and the pace is very swift indeed. It is almost beyond the mind and institutions of man, for we are changing the world faster than we can change ourselves."

The industrial technology curriculum has been an outgrowth of this demand for change and the need for developing a stable link in our changing technological society. As the engineering curriculum became more research oriented, the need for personnel who could apply the principles of science and technology became greater. A technological gap existed which had to be filled in order to eliminate a void in today's industrial complex. This resulted in the rapid growth of the four-year technology programs. Most of the new programs have been formulated in the industrial arts teacher education departments and in most cases have been continued as a segment of that curriculum. The two areas, industrial arts teacher education and industrial technology, should when possible be separate entities with each having its own budget, faculty, courses and facilities. The two academic areas have some similarities but are so distinctly different in objectives and student personnel that it mandates their separation. If this is not done one curriculum will dominate the other and eventually one of the two areas will cease to exist or will be so weak that it will be ineffective.

The four-year technology programs should correlate closely with the two-year technical programs located in the community colleges. An articulated transfer program should be developed so that the junior colleges can develop an open-ended transfer program. This will not only add status to the two-year technical curriculum but will also provide students for the upper division who have in-depth technical training. This will also eliminate the necessity for having many technical laboratories in the upper division program. It is even feasible to think about the industrial technology curriculum as being primarily an upper division offering based upon a well articulated junior college transfer program. This has been developed at California State College at Long Beach and has been most effective. However, this can only be done in those areas where strong junior college technical programs exist.

Industrial technology will only achieve academic respect and professional status if it is based on a rational set of objectives that are unique when compared to other professional areas. Such objectives must be founded on educational needs that have been clearly identified through carefully structured investigations.

In order to have a valid professional education field called industrial technology there must exist a clear statement of educational objectives based on a thorough study of the present needs of industry. When such a set of valid objectives exists, it will be possible to have the maximum flexibility in curriculum development that is necessary to avoid "locking-in" obsolete curricula.

There is a major need for a national study of industry's needs that can and should be met by the industrial technology programs. Such a study can only be made through the combined efforts of those concerned with industrial technology.

There is a distinct and urgent need for a strong national industrial technology coordinating organization that owes no allegiance to any other professional area. Such a coordinating organization must be representative of the majority of programs that now exist. Hopefully, it could secure supporting funds from the group whose programs it seeks to serve — industry.

A national study with the major purpose being the clear identification of objectives does not have to be conducted as one project with a huge budget. Although in this day of large research grants it is common to think in terms of foundation- or federally-supported programs, it is entirely possible to conduct a national study by having many groups accept the responsibility for certain parts of the study. In either case, it is necessary to have one representative group design the total study, supervise its implementation, and present the results.

Since large scale studies take time to design, implement, and conclude (i.e. — the American Society for Engineering Education's recent study took three years after being designed), industrial technology educators should establish tentative sets of objectives based on the best available information concerning industry's needs related to the potential of present programs. Here again is the need for an active coordinating and planning organization. This organization should strive immediately for a full-time staff.

Although a thorough national study of industry's needs must be accomplished, curriculum innovation and experimentation should begin immediately based on a valid set of tentative objectives. The important thing to recognize is that tentative objectives cannot in the long run substitute for those based on a thorough study of the field.

In order to have well defined programs several items need to be implemented as early as possible:

1. The newly formed National Association of Industrial Technology should become very active and provide the leadership so essential for guiding the development of industrial technology on the national level.
2. The National Association should endeavor to procure a national grant to study the status and position of the four-year technology curriculum throughout the country.
3. A set of guidelines should be developed that would include tentative objectives, procedures for developing and implementing four-year technology programs, articulation with the two-year colleges, faculty recruitment and selection, program evaluation and accreditation, a recommended core curriculum, and any other segment that appears valid for inclusion in the guidelines. This should be constantly updated as data become available.
4. The National Association should consider affiliating with other professional organizations so that it will have greater support and a more solid foundation on which to expand.

5. Evaluation and accreditation procedures should be developed as soon as possible. The National Association should work closely with the National Accreditation Association to implement the procedures needed to obtain recognition as an accrediting body.

At the present level of economic activity, almost any educational program that produces "men to fill the needs of industry" will be successful. In the future it is very possible that those programs that are not actually doing an effective job of education related to industry's needs will fail to survive. Based on this assumption the industrial technology curricula must be founded on valid objectives if they are to survive and increase in professional stature.

The industrial technology program should be a separate entity but should also be interdisciplinary in nature. It should take advantage of the engineering programs, the offerings in science, mathematics, business administration, industrial education and the liberal arts. If this is done the end-product will certainly meet the needs of industry. An interdisciplinary steering committee consisting of representatives from the above areas could do much to strengthen the technology curriculum. It will also do much towards providing additional status to the program. This group should be used to supplement an active advisory committee consisting of lay personnel from business and industry.

A work study program should be considered for implementation in the curriculum to provide on-the-job experience for the student. Graduates who have had an opportunity to perform on the job within their major area of concentration will find more opportunities for employment with a higher starting salary. Every industrial technology graduate should have some work experience in his area of training. Here again it is wise to use the advisory committee to assist in developing job opportunities for the trainees.

The future for the four-year industrial technology program is unlimited. The only restrictions will be those placed upon it by the people administering the curriculum. If it is given proper support and if adequate standards are maintained by the institutions offering the program, there will be no limit to how far the curriculum could progress in the area of higher education.

Index