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CIVIL AND HIGHWAY TECHNOLOGY, SUGGESTED TECHNIQUES FOR DETERMINING COURSES OF STUDY IN VOCATIONAL-TECHNICAL EDUCATION PROGRAMS.

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THE PURPOSE OF THIS REPORT IS TO EXPLAIN HOW BASIC OCCUPATIONAL INFORMATION FROM A JOB ANALYSIS IS USED TO SHOW THE RELATIONSHIPS AMONG JOBS AND TO ESTABLISH COURSES OF STUDY FOR OCCUPATIONAL EDUCATION. IT WAS DEVELOPED UNDER TITLE VIII OF THE NATIONAL DEFENSE EDUCATION ACT OF 1958. TOPICS COVERED ARE THE FIELD OF WORK, JOB RELATIONSHIPS, JOB DESCRIPTIONS, TRAINING REQUIREMENTS, AND DEVELOPING THE CURRICULUM. THE FOCUS IS ON AN ANALYSIS OF OCCUPATIONS IN TECHNICAL FIELDS FROM WHICH A CURRICULUM CAN BE DEVELOPED. THIS DOCUMENT IS AVAILABLE AS GPO NUMBER FS 5.280--80018 FOR 25 CENTS FROM SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402. (EM)

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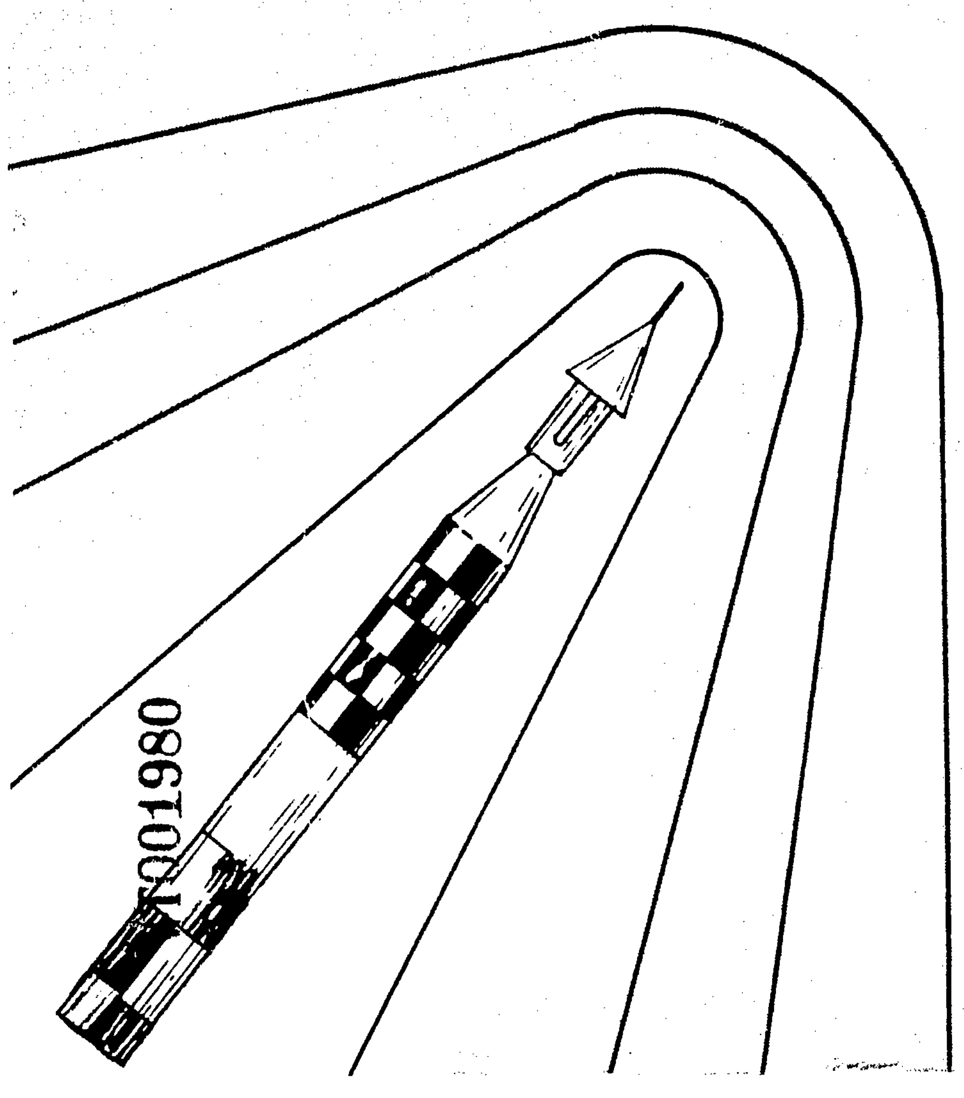
Civil and Highway Technology



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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Division of Vocational and Technical Education, Technical Education Branch

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FOREWORD

This publication on civil and highway technology is the fifth in a series designed to provide information to help the States organize and operate programs under Title VIII of the National Defense Education Act of 1958, Public Law 85–864. The other publications in this series are: Mechanical Drafting and Design Technology (OE–80000), Electrical and Electronic Technologies (OE–80004), Mechanical Technology—Design and Production (OE–80014), and Chemical and Metallurgical Technologies (OE–80016).

These State-organized programs, in keeping with the provisions of Title VIII of the National Defense Education Act of 1958, offer instruction leading to employment in occupations requiring scientific or technical knowledge in fields of work essential to the national defense. The programs are open to anyone qualified to benefit from such training. As used in this publication, the terms "technician" and "technical worker" refer to respective scopes of training and work capabilities rather than to employment classifications.

Each publication in this series indicates how job analysis and job relationship techniques can be used to facilitate the planning of training programs. Each publication contains the following information and suggestions:

1. General information about a technology or broad field or work
2. A procedure for determining the relationship among jobs in order to develop homogeneous groups or clusters of occupations for which training may be given
3. A method for determining the courses of study required to prepare students for a cluster or group of closely related occupations or for a specific occupation within a group.

The occupations discussed in this document are typical of those found in this field of work, but are not meant to be all-inclusive. They represent typical areas of activity in which technically competent workers are engaged, and should not be considered in all cases as entry jobs. Students who have received instruction in an organized training program for a specific technology are provided with the technical knowledge and skills of this field of work, but they usually serve a period of internship in order to learn how to apply their knowledge to technical problems likely to be encountered in the specific job to which they are assigned.

This manuscript was prepared by Clarence E. Peterson, occupational analyst, Technical Education Branch, Division of Vocational Education. He was assisted by other staff members of the branch.

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Vocational and Technical Education.

CONTENTS

INTRODUCTION

The purpose of this publication is to explain how basic occupational information resulting from job analysis is used to determine relationships among jobs in civil and highway technology, and the technical knowledge required for successful job performance; and how such information is then used to establish the courses of study required to prepare students for a cluster of closely related jobs or for a specific job within a cluster.

Accurate information about jobs is fundamental to the planning of any occupational training program. The nature of the job information required varies according to the program contemplated. Regardless of its ultimate use, however, the data must be up to date, accurate, and presented in usable form.

The process of obtaining and reporting pertinent information concerning the nature of a specific job is called "job analysis," the technique used in determining the actions, skills, knowledge, abilities, and responsibilities required of a worker for successful performance of his job, and in identifying the tasks or elements which differentiate the job under study from all others.

Basically, there are three parts to the analysis of any job: (1) the job must be completely and accurately identified; (2) the duties and actions required of the worker to perform the job must be complete and accurate; and (3) the knowledge and skills required for each element or task within the job must be specified.

"Job analysis" as used here is not intended to establish a means for determining absolute or relative wage rates, nor is it to be used as a means of establishing seniority groupings or units for purposes of collective bargaining.

After the needs for technical manpower have been determined, it will be necessary, in most cases, to analyze the various jobs for which training is contemplated. There are several methods for making a job analysis. Some methods that are widely used are those described in the Training and Reference Manual for Job Analysis prepared by the U.S. Department of Labor. A recent publication prepared by the Department of the Navy—Handbook for Naval Occupational Analysis—also contains helpful techniques for analyzing jobs. (See Bibliography.)

This report does not describe the methods and techniques of job analysis but assumes that this function will be performed by personnel experienced in the field. It is recognized that the States may not have experienced personnel on their staffs who can devote sufficient time to make the necessary job analyses, but the information needed may be available from other sources. In some cases, industry or labor has job analysts who can provide detailed information about the significant factors of each job or who can make the necessary analyses. Also, the State Employment Security Agency may have such information in its files or may assign an occupational analyst to work with educators in gathering these data.

Because of the specialized nature of technical jobs, it is essential that data be as detailed and complete as possible, this is especially true of educational and training requirements. For example: (a) *Basic knowledge of physics with emphasis on mechanics, heat, sound, light, statics, and dynamics* is more specific and meaningful than *basic knowledge of physics; and* (b) *must have a working knowledge of algebra, trigonometry, analytical geometry, and vector analysis* is more meaningful than *uses mathematics in solving engineering problems.*

Most of the information about technical occupations must be obtained through interviews with the worker and his supervisor, with little opportunity for observing the job. Some of these jobs are in areas which are classified for security reasons, or the end product being worked on may be classified. In such cases, it may be necessary to conduct the interview with the worker in a nonclassified area under whatever security regulations may be in effect in the establishment where the study is being made.

A successful training program requires detailed information concerning the nature, duties, responsibilities, significant job elements, educational requirements, and related factors of each occupation for which training is contemplated. The content of the training curriculum and the selection of trainees depend on a thorough analysis of each job.

CHAPTER I

THE FIELD OF WORK

Civil and highway technicians perform many of the planning and design tasks necessary in the construction of highways, railroads, bridges, hangars, missile sites, airfields, viaducts, dams, factories, and other structures necessary for national defense. In the planning stages of construction they may be engaged in estimating costs, purchasing materials, preparing specifications, computing fills and cuts and storm drainage requirements, surveying, drafting, or designing. Once the actual construction work has begun, many of them perform supervisory functions. Some may be responsible for seeing that construction activities are performed in proper sequence, and for inspecting the work as it progresses for conformance with blueprints and specifications.

Although civil and highway technicians are trained to perform many different tasks, they generally specialize in certain activities. For example, those working primarily as surveyors, use the transit, the level, and other surveying instruments to determine the locations and measurements of land areas and buildings for construction and other purposes. Recent developments in the science of photogrammetry have led increasingly to use of aerial photography to solve location problems and determine the amount of fill and excavation required for a project. Electronic computers are used to analyze the data. Some technicians are being trained in photogrammetry and in the use of the electronic computers to aid in the planning stages of construction projects. Electronic computers save a vast amount of time in the design of highway facilities, as do map plotting devices such as the stereoplanigraph, which converts aerial photographs into maps.

As assistants to construction engineers, technical workers help make estimates of the costs, materials, and time necessary in the construction or repair of structures. They usually supervise the clearing of rights-of-way and the preparation of roads for surfacing. Many civil and highway technicians become specialists in some field of drafting, such as drawing plans for large buildings or preparing maps of cities and other areas.

Today civil and highway technicians may be called on to assist the engineer in preparing plans for expressways or freeways carrying large volumes of traffic through, around, or between cities. They may assist in designing the accompanying complicated traffic interchanges and traffic distribution centers or may be involved in making studies of traffic conditions to determine the location and type of roads and intersections needed.

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Technical specialists are employed in every branch of highway engineering. They do drafting, survey work, operate electronic devices and computers, inspect materials and construction, do testing work, serve as assistants to engineers, collect factual data, and perform other specialized duties in the field of civil and highway technology.

Although there are no statistics available as to the number of civil and highway technicians needed throughout the country, all indications are that the demand for them is good and is increasing. According to the latest figures (November 1961) in the Index of Professional Job Openings from State Agencies issued by the Bureau of Employment Security, U.S. Department of Labor, 11 percent of engineering vacancies are in civil engineering, 12 percent in aeronautical, 24 percent in mechanical, and 38 percent in electrical and electronic engineering. In a recent study sponsored by a joint committee of the American Association of State Highway Officials, and the Highway Division, American Society of Civil Engineers, the ratio of technicians to engineers in the highway field (1½ to 1) is higher than in other engineering fields and is expected to rise rapidly within a few years, increasing to 3 to 4 for each engineer employed.

According to a report issued by the National Science Foundation in 1961, there were about 41,000 scientists and engineers employed by the State governmental agencies in 1959. This represented between 3 and 4 percent of the country's total scientific and engineering manpower sources. Ninety percent of the engineers (26,092) were civil engineers. The number of State-employed technicians exceeded the number of scientists and engineers by a ratio of 115 technicians to 100 scientists and engineers. This contrasts with that in private industry where a ratio of only 72 technicians to 100 scientists and engineers existed in 1959.

CHAPTER II

JOB RELATIONSHIPS

Before technical curriculums can be established, the individual occupations for which training is needed should be identified. The next step is to analyze each of the jobs and prepare brief job descriptions covering the typical work activities, functions, and performance requirements for each occupation.

The occupations should then be arranged in homogeneous groups or clusters, and the kind and amount of basic and applied science, mathematics, and technical know-how required to prepare workers to perform the duties of each job should be specified. Training curriculums which grow out of such analyses and groupings are commonly called "cluster-based" curriculums.

The procedure used in determining the similarities in jobs and the common knowledge and abilities involved is called the job relationship technique. The criteria used by industry for establishing job relationships vary. However, all or most of the following factors are used in establishing the homogeneous groups or job clusters referred to in this bulletin:

1. Similarity of work performed
2. Abilities and knowledge required of the worker for successful job performance
3. Personal characteristics required by the job, such as high degree of accuracy, above-average mental application, creative ability, and use of independent judgment
4. Tools, machines, instruments, or other equipment used on the job; also the reading and interpreting of blueprints, or the use of special measuring devices
5. Basic material worked on or with; occupations may involve working with more than one material or with the same material in different forms.

In a cluster of related jobs, most of these factors should be present and, through not exactly matched, should be analagous. For example, in developing the relationships of jobs found in the broad field of drafting and design, it is readily apparent, when using the criteria shown above, that the electrical draftsman and the mechanical draftsman have one factor in common—that of drawing. Their abilities other than manipulative skills and the knowledge required for successful job performance are dissimilar, however. The mechanical draftsman prepares drawings for mechanical devices. He knows how to calculate engineering details such as strength-weight ratios, tolerances, and elements of practical machine design. He is familiar with the working properties of metals, metal alloys, and other materials, as well as with machine shop operations and practices. The electrical draftsman, on the other

hand, prepares plans and wiring diagrams. His knowledge encompasses electricity and magnetism, circuitry, and other factors related to electrical engineering. It is evident, therefore, that these two jobs are not closely related and do not belong in the same cluster or major grouping. The same conclusion might be drawn regarding construction and architectural drafting.

The Job Factor Comparison Chart on page 10 suggests a procedure for establishing clusters of related jobs by comparing the characteristics or factors of a number of occupations. It should be clearly understood that no attempt is made to place a relative value on any of the factors. Furthermore, a relatively higher number of factors does not necessarily imply greater skill.

A preliminary analysis was made of a number of jobs which seemed to belong in the field of work under study. The characteristics or significant factors of the jobs under consideration were identified and only those having similar characteristics were used. Of these, 11 jobs were selected for comparison purposes in order to determine their interrelationships. It is recognized that other jobs might have been included in this list, those selected merely illustrating how the technique may be used.

The Job Factor Comparison Chart provides a graphic illustration of the relationship among these various jobs. A close look at the chart reveals that at least one-half of the factors 1 through 12 are present in all of the jobs except A and H. Usually if less than half of the factors are found to exist in a particular job, the relationship would not be close enough to warrant its inclusion in the cluster or major grouping. Jobs A and H, which are one-task jobs, were used as extreme examples to illustrate the lack of relationship which precludes them from this family of jobs.

CHAPTER III

JOB DESCRIPTIONS

The job descriptions included in this section are given as examples of the kinds of occupations found in the field of work described in this publication. They are developed from data in the Dictionary of Occupational Titles, Vocational-Technical Training for Industrial Occupations (Bulletin No. 228), Highway Research Board bulletins, and similar publications.

Since these job descriptions are based on source data assembled from studies made in various parts of the country, they must be considered as composites and may not coincide with a specific position in a specific organization.

It should be clearly understood that these job descriptions are given as examples of closely related jobs for which vocational training is indicated; they cannot be considered as standards for setting hours and wages, for settling jurisdictional matters, or for use in formal job evaluation systems.

The following job descriptions, which describe the principal duties of each job, should be useful in identifying technical jobs in the civil and highway technology. Also, they may be used for comparison purposes when making analyses of related jobs. In many cases, jobs studied may reveal only minor differences from those shown in one of these job descriptions. In such an event, only the differences in job content and the performance requirements need be considered. Care should be exercised so that courses of study resulting from the job analyses will not be limited by accommodation to local conditions. Actually, instruction for a technology should be broad enough to fit the training needs on a national basis as well as the needs of industry at the local level.

CHAINMAN, SURVEYING

Measures distances as directed by the surveyor, using steel tape, cloth tape, or surveyor's chain. Marks measuring points with keel (marking chalk), scratches, tacks, or stakes. Performs other duties relating to surveying work as directed by the surveyor. Chainmen work in pairs, the head chainman holding the advanced end of tape and establishing the most advanced measuring point, the rear chainman holding the rear end of tape at last-established measuring point.

CONSTRUCTION ENGINEERING AIDE

Designs and drafts charts, graphs, and tabulations to indicate construction progress, production, and costs. Tabulates and recapitulates material derived from charts; maintains and keeps up-to-date, detailed records of trades and labor personnel

JOB FACTOR COMPARISON CHART

Significant characteristics	Chainman, surveyor A	Construction engineering aide B	D
1. Has knowledge of and facility with plane and solid geometry and trigonometry.			
2. Makes simple measurements, using tape, chain, level, or rod.			
3. Reads and interprets construction blueprints and drawings.			
4. Interprets topographic maps for computation purposes.			
5. Computes labor, material, and other construction costs.			
6. Estimates materials, equipment, and incidentals needed for a construction project.			
7. Prepares sketches, drawings, and specifications needed for construction purposes.			
8. Has knowledge of surveying methods and practices and facility with instruments used to determine exact location and measurement of points, elevations, lines, areas, and contours.			
9. Makes maps using data from aerial photographs or from field surveys.			
10. Assists civil engineer or architect in designing parts of highways, bridges, buildings, or other structures.			
11. Indicates production progress and costs through charts, drafts, and tabulations.			
12. Computes excavation and embankment quantities by planimetering cut and fill-in area, and establishes superelevations and widening limits on curves and spirals.			

CIVIL AND HIGHWAY TECHNOLOGY

Chainman, surveyor	Construction engineering aide	Draftsman, architectural	Estimator	Highway engineering aide	Instrument man	Multiplex-projection topographer	Rodman	Surveyor	Surveyman
A	B	C	D	E	F	G	H	I	J

for administrative use; acts in a liaison capacity between time office, cost engineering office, and construction office. Examines drawings and bills of material; prepares requests for the purchase of certain materials.

Must have a working knowledge of basic geometry and trigonometry; methods of computing volume quantities; blueprints; the organization structure of the project; the construction schedule; schedule of trades and labor classification and rates of pay; drafting techniques; standards, and conventionalized representations; symbols and nomenclature of engineering office or construction project. Must have sufficient tact, ingenuity, and persuasiveness to get important work done by others without having direct supervisory authority; must be able to use basic drafting tools, calculating machines, slide rule, and blueprint machine.

DRAFTSMAN, ARCHITECTURAL

Develops preliminary sketches; prepares clear, complete, and accurate working plans and detailed drawings; makes necessary changes in drawings; makes tracing on tracing paper or cloth; sometimes writes specifications and meets clients for discussion of plans.

Must be able to use drawing instruments; must be thoroughly familiar with building materials and their uses in construction; must know standard building practices; should be familiar with principles of heating, plumbing, and electrical construction; must understand specifications; must be able to use advanced algebra and trigonometry; must have ability in freehand and prespective drawings; must be able to visualize completed project; should be familiar with elementary architectural design.

ESTIMATOR

Takes off quantities from blueprints. Computes labor, material, and equipment installation costs; prepares estimates; sometimes does cost accounting or makes drawings or sketches.

Must have thorough knowledge of building materials, their sizes, units, and uses; must have understanding of various construction practices; must be acquainted with carpentry, masonry, plumbing, and other skilled trades; must be thoroughly versed in interpreting construction blueprints; must be a careful worker with figures and be familiar with geometry and trigonometry; should have some knowledge of sketching and drafting; may need to know cost accounting.

HIGHWAY ENGINEERING AIDE

Prepares hard-copy or rough-draft drawings; checks and reduces transit notes (station and angle traverses); checks and reduces complete alignment notes including curve data; computes coordinates and bearings of center lines that are tied into permanent controlled movements, and plots alignment notes on hard copy drawings; establishes superelevations and widening limits on curves and spirals from tables

and formulas; computes excavation and embankment quantities by planimetering cut and fill-in areas; determines the extent of drainage areas from topographic maps.

Must be familiar with field surveying methods; must understand surveying procedures, highway engineering standards and conventions, methods of estimating quantity computations including the more difficult earthwork computations, elementary engineering mathematics, and plane and solid geometric principles; must be able to interpret field notes of surveying parties and to use drafting instruments, lettering pens and guides, scales, drafting machines, planimeter, calculating machine, and the slide rule.

INSTRUMENT MAN

Sets up and operates an alidade, engineer's level, transit, and other surveying instruments to establish angles and elevations, or to secure data pertaining to angles and elevations for construction, mapmaking, mining, or other purposes. Keeps notes, sketches, and records of work performed and data secured. Is frequently the surveyor and has full supervision over other members of the surveying party, and is responsible for the quality of the work done. May perform duties of Chairman, Surveying.

MULTIPLEX-PROJECTION TOPOGRAPHER

Makes topographical maps from aerial photographs using a machine that produces simultaneous projections of two photographs, taken from different positions, in a manner that permits stereoscopic viewing for analysis of contours; sets up projection machine and makes adjustments so that image from one photograph is projected upon a screen in one color, and image from the other is superimposed on the first image, in a complementary color. Views screen through colored lenses arranged so that each lens permits view of image only in opposing color, enabling operator to see three-dimensional image. Determines contour interval and vertical scale of image, using mathematical tables. Traces contours and topographical details to produce map, controlling pencil point stereoscopically. May use aerial photographs to form a mosaic pattern, the data from which are used to determine one primary and one secondary route as well as the amount of fill or earth movement required for each route.

RODMAN

Holds level rod or stadia rod at points designated by Instrument Man or Surveyor for purpose of establishing or obtaining the elevation or angle of those points. Reads rod and calls out readings to Surveyor. Marks points with elevation or an identifying mark. Locates points of established elevations with reference to other points by making measurements between the points. Performs other duties relating to surveying work as directed by Surveyor.

SURVEYMAN

Sets up transit or level, makes necessary sightings and observations, reads horizontal and vertical vernier scales, needle bearings, etc., occasionally makes solar

or stellar observations for the determination of azimuth; tests and adjusts instruments, and operates a transit on preliminary survey; gives lines and grades for construction work such as running out the center lines, computing curve and spiral data, referencing in-points, staking out structures and rights-of-way, and measuring angles; records field notes and locates contours; may instruct rodmen, chainmen, and others as to the sequence and specific nature of their tasks; may indicate work operations to surveymen of lower grade especially when the Instrument Man is in charge of the party.

Is required to use instruments to the full extent to which the particular branch of engineering involved requires, and to make all necessary computations; must be able to walk considerable distances over rugged and difficult terrain, and carry surveying instruments; should be able to deal with others fairly and tactfully, as he is frequently required to contact property owners, tenants, and contractors to obtain permission to enter private property for survey purposes, confer with adjoining landowners to identify or locate dividing lines and corners, and explain and interpret construction stakes and markers to either the contracting agency's or contractor's construction foremen.

SURVEYOR

Supervises, directs, and is responsible for the accuracy of the work of an engineering survey party engaged in determining the location and measurements of points, elevations, lines, areas, and contours on the earth's surface for purposes of securing data for construction, mapmaking, land valuation, mining, or other purposes. Calculates information needed to conduct survey from notes, maps, deeds, or other records. Keeps accurate notes, records, and sketches of work performed or data secured. Verifies by calculations the accuracy of survey data secured. Adjusts surveying instruments to keep them accurate, or oversees the adjustments.

Surveyor, Highway

Establishes lines, points, and grades for highway construction work, and computes cuts and fills and storm drainage requirements.

Surveyor, Land

Makes surveys to establish boundary lines of townships, lots, and other areas of land, using notes, maps, title deeds, and other records to conduct the survey and check its accuracy.

Surveyor, Pipe Line

Directs a party engaged in surveying right-of-way for construction of pipe lines. Directs grading of lines to obtain maximum gravity flow where needed. Establishes property lines, sets grades for buildings and tanks, and stakes out earthwork for tank levees and drainage projects.

Surveyor, Topographical

Surveys the topography of a certain area or region, locating contours of the earth, roads, farms, rivers, and lakes for purpose of recording and mapping the area.

CHAPTER IV

TRAINING REQUIREMENTS

If the purpose of a technical training program is to prepare workers for a single occupation, the content for such a program is derived from the analysis of that specific job. However, inasmuch as most training programs for a specific technology are designed to prepare workers for a cluster of occupations, the content should be derived from analyses of all the jobs in the cluster. In the latter case, it is necessary to assemble the occupational data gathered during the job analysis study; compare the elements or characteristics of the various jobs; determine the elements that are common to the several jobs in a group; ascertain the skills and knowledges required for their performance; and develop a reasonably complete list of the skills and knowledges needed for all the jobs in the cluster. From this list, the specific courses of study which make up the curriculum are developed.

It should be recognized that instruction for a specific occupation within a given cluster may require greater depth and emphasis on certain aspects of the training than that required for a cluster-based curriculum. Such highly specialized training may be given through extension courses after the individual has entered employment and has gained some experience and understanding in his field of work. Methods and procedures for determining requirements for effective extension training programs are described in Determining Requirements for Development of Technical Abilities Through Extension Training (OE–80010).

The job descriptions contained in the preceding chapter, augmented by the information gathered through individual job analyses made by State or local personnel, should provide much of the data needed to determine training requirements. A job description should be in two parts. The first part should describe the work performed, i.e., what the worker does and why he does it. The second part should describe the skills, knowledge, and abilities required of the worker in performing the job.

The Training Requirements Analysis Form on page 22 illustrates a method for recording the technical knowledge and ability required for each of the clusters of related jobs. The subheading on the form "Civil and Highway Technology" is the field of work for which training is required.

The first column lists the subject matter areas discovered through job analysis as being basic in a training program to the occupations noted. Other subject matter areas might have to be added as the requirements of these occupations vary from plant to plant, among industries, and in different parts of the country. The determination of the subject matter required for successful performance in the various

occupations of a cluster of related jobs depends on the adequacy of the source data obtained through job analysis and the ability of the person preparing the form to interpret these data.

If the job descriptions resulting from the job analyses indicate that a knowledge or skill in a certain area is essential, the letter "E" is entered. If it is not absolutely essential but advisable for a worker to receive instruction in a specific area, the letter "A" is entered.

The nature of the work and the industry in which a job under study is found usually suggests to an experienced analyst other subjects which might be helpful to a worker in a particular field of work. In some cases, it may be found that industry supplies training in these areas, and in other instances the limited demand for such skills in the employment market or lack of facilities in the school makes it inadvisable for the school to set up special courses.

The completed chart serves the following purposes:

1. Indicates the technical knowledge and abilities needed by workers to perform the duties of various occupations found in a given field of work
2. Identifies the subject matter areas that are common to the several jobs in a cluster of related jobs within each technology
3. Provides, in convenient form, a list of the subject matter areas and specific courses of study that should be considered when building the training curriculum.

TRAINING REQUIREMENTS ANALYSIS FORM

SUBJECT MATTER AREAS REQUIRED (Instruction to be included in the application of science and mathematics to the technology)	CIVIL AND HIGHWAY TECHNOLOGY Symbols: A—Advisable E—Essential							
	Construction engineering aide	Draftsman, architectural	Estimator	Highway engineering aide	Instrument man	Multiplex-projection 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

CHAPTER V

DEVELOPING THE CURRICULUM

When the field of work for which training is to be provided has been defined, the individual occupations in the cluster of jobs analyzed, and the training requirements identified, the curriculum and individual courses of study required to prepare students to perform the various job duties may be prepared.

A curriculum may be defined as a systematic group of courses of study designed to prepare persons for a cluster of jobs or for a specific occupation in a given field of work. It is an organized body of content for the training program—all that the school offers for reaching the desired educational goals.

Curriculums can be developed in several ways. The simplest method is to use the curriculum of another institution without modification. The hazard of such an approach lies in the possibility that the curriculum may not be a good one or, even if satisfactory for the original institution, may not fit into the conditions of the setting where it is to be used. For example, entrance requirements for institutions vary from State to State and from one institution to another.

A second method is to study a number of curriculums and develop a composite curriculum embodying the best points of all of them. The difficulty sometimes encountered with this method is that the resulting program may not constitute a complete integrated curriculum.

Probably the most effective method is to use the approach outlined in this pamphlet which depends on up-to-date analyses of the occupations with which the program is concerned and the development of a curriculum based on these analyses. As a check against this method, it is usually helpful to study other curriculums for structure and content.

In undertaking the construction of a curriculum based on job analyses, the first task is to prepare a composite list of all of the knowledges and skills needed for effective performance in the occupations making up the cluster. In the preceding chapter, the technique for developing a list of subject matter areas has been described (Training Requirements Analysis Form). The job descriptions in chapter III cover typical occupations found in civil and highway technology and are not meant to be all-inclusive. Therefore, the two fields should be explored further to ascertain what other jobs should be included in the clusters. All of the jobs should then be analyzed and the findings checked against the present lists to determine whether additional subject matter areas are necessary. Thus, a reasonably complete list of items for the proposed curriculums is assured.

A curriculum would not usually include all of the items which appear on a Training Requirements Analysis Form. Students may be expected to have attained certain knowledges and skills previously. If the curriculum is on the post high school level, admission requirements may specify high school graduation; completion of certain subjects undertaken while a student was in high school; or attainment of satisfactory scores on achievement or aptitude tests. In some cases, the list might include certain items which might be learned after the student is employed.

On the other hand, the curriculum designer might find it necessary to include some items which did not appear on the list found in a Training Requirements Analysis Form. For example, job analysis might have led to the conclusion that proficiency in mathematics was not required in the training program because the duties of the job did not include mathematical calculations. Such a conclusion would have overlooked the need for mathematics as a learning and communication tool, adversely influencing curriculum and course design.

In theory, one might take the content revealed by the occupational analyses, organize the content into courses, select the methods to be used for instruction, list the equipment needed, plan the space required, set up standards for student admission and for the instructional staff, and determine the length of the program, without regard to details of the setting in which the program is to operate. But, it does not work out that way. There are many factors which must be taken into account. For example, the program may be one of several given by a large institution which imposes conditions on admissions, length of school year and school day, budget, and space, which in turn would affect curriculum planning. Therefore, the curriculum builder may have to compromise in order to adapt the desired elements of the curriculum to what is available. In any case, the curriculum should be broad enough to provide adequate preparation for successful performance of entry occupations identified as belonging to a specific technology.

After the subject matter areas have been selected for inclusion in the curriculum, they are divided into groups which become courses. Next, the courses are arranged in a pattern which recognizes psychological sequence, time allocation, and relative importance of each course. Modifications are then made to adjust all of these considerations so that the final curriculum is a well-balanced and integrated program.

This chapter reviews the general problem of curriculum designing rather briefly, assuming that the reader is familiar with pedagogical practice and with curriculum building in other areas of education. Certain points should be made, however, about curriculum development as it relates to technical training specifically.

In technical training of the level required for the fields of work described in this publication, the curriculum content should meet the following conditions:

1. The range of course content for preparation for the jobs in the cluster should be reasonable for the time allotted to the training program.
2. The technical content should lend itself to organized instruction.

3. A substantial part of the curriculum should be such that it can be mastered by a reasonably high proportion of students having the necessary educational background to benefit from the technical training provided.
4. The psychological order of learning should be followed to provide spiral teaching of the subject matter.
5. The curriculum content should include technology of the occupational field, sound training in science and mathematics including *applied* science and *applied* mathematics (applied to the field of work for which training is provided), other applied content such as technical report writing, highway design, or other areas which are essential to satisfactory job performance, and general subjects such as communications and social sciences.
6. Mathematics and the physical sciences are key disciplines in all technical study. Therefore, the various areas of mathematics or science should be integrated so that the application of mathematical or scientific principles supplement and support the specific course work in these areas. A high degree of coordination is required involving the teaching of mathematics or science by application in technical courses, concurrent with the more formal instruction in the mathematics or science classes.
7. The relative emphasis to be placed on each subject and the time that should be allotted to each subject should be carefully analyzed so that the courses of instruction are properly integrated and the total curriculum is in balance.

The subject matter areas in the list of civil and highway occupations shown on the Training Requirements Analysis Form are not arranged as they will appear in the curriculum, but they indicate the areas of knowledge which should be covered. Analysis of these items is an important step in developing a course of study. From this list the curriculum builder selects by careful analysis those subjects essential to the cluster of occupations and practical to include.

A second step is to group the selected items to provide an orderly, logical arrangement of the subjects, and then to determine if all of the items can be covered adequately within the time limits specified for the training program.

Another step in curriculum construction is to develop instructional units which will convey the necessary instruction and provide the trainee with the desired learnings. The instructional unit may take the form of a typical task to be performed, the principles to be mastered, a laboratory experiment to be carried out, a problem to be solved, a case to be discussed, a drawing to be made, or a malfunction to be analyzed. The type of instructional unit depends upon the educational objectives, the school facilities, and many of the other factors discussed heretofore.

The techniques in this publication, together with the charts and forms, provide basic information regarding techniques that can be used in organizing curriculums which will meet specific technical training needs in the civil and highway technology.

BIBLIOGRAPHY

U.S. Department of Labor, Bureau of Employment Security. *Dictionary of Occupational Titles,* Volume I, Definition of Titles. Washington: Superintendent of Documents, Government Printing Office, March 1949, 1518 p. $5.25.

Contains definitions of the various jobs found in the American economy arranged alphabetically according to job titles. There are 22,028 definitions which are known by 40,023 titles.

U.S. Department of Labor, Bureau of Employment Security. *Dictionary of Occupational Titles,* Second Edition, Supplement 1. Washington: Superintendent of Documents, Government Printing Office, March 1955. 341 p. $1.

Contains 2260 new and revised definitions and 1322 code numbers arranged alphabetically according to job titles, and supersedes all releases to the *Dictionary* issued since the second edition was published in March 1949.

U.S. Department of Labor, Bureau of Employment Security. *Reference Manual for In-Plant Manpower Planning.* Washington: Superintendent of Documents, Government Printing Office, April 1951. 53 p. 45 cents.

Provides employers with practical methods for use in manpower planning. Includes instructions and suggestions for: (1) preparing a job inventory, (2) converting plant titles to a standard classification system, (3) inventorying work-force skills, (4) filling vacancies by transfer of workers, and (5) determining relationships between jobs.

National Science Foundation. *Employment of Scientific and Technical Personnel in State Government Agencies—Report on a 1959 Survey.* Washington: Superintendent of Documents, Government Printing Office, 1961. 67 p. 45 cents.

Summarizes the findings of a survey sponsored by the Foundation to provide information on the employment, occupations, and activities of scientific and technical personnel in the various agencies of the State governments in January 1959.

U.S. Department of Health, Education, and Welfare, Office of Education. *Determining Requirements for Development of Technical Abilities Through Extension Courses.* Washington: Superintendent of Documents, Government Printing Office, 1961. 14 p. 15 cents.

Provides suggestions and information to help educational institutions, industrial organizations, and others concerned with the development of extension or supplementary training courses to improve and increase the capabilities of workers.

Federal Security Agency, U.S. Office of Education. *Vocational-Technical Training for Industrial Occupations*, Washington: Government Printing Office, 1944, 307 p. (Out of print.)

Sets forth findings of a consulting committee appointed by the U.S. Commissioner of Education concerning the need for vocational-technical training, typical jobs for which training is essential, job descriptions exemplifying various occupational fields, and other information pertaining to the nature of the need for vocational-technical training, including subject-matter requirements.

Department of the Navy, Bureau of Naval Personnel, *Handbook for Naval Occupational Analysis*, Washington: The Department. (A limited number of copies have been made available to the Division of Vocational Education. Single copies may be obtained by writing to the Technical Education Branch, U.S. Office of Education, Washington 25, D.C.)

Provides a guide for making occupational analyses in naval installations which is readily adaptable to civilian occupations. Provides methods for planning a study, collecting the information, and preparing job descriptions. Includes a questionnaire form together with functional verbs for use in preparing the occupational analysis schedules.

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