A COMPILATION AND STUDY OF CIVIL ENGINEERING TECHNOLOGY CURRICULA IN THE UNITED STATES WITH ANALYSIS OF THE FORCES BEARING ON THE CURRICULA

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ABSTRACT

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by Richard L. Rinehart

This is an attempt to compile a definition of the civil engineering technician in terms of curriculum. The possible fields of study were identified and the institutions offering such programs in the United States were contacted. The total study was limited to those programs wherein the graduate would be assumed to work under the direct or general supervision of the civil engineer, thus eliminating electrical and other related programs. Those institutions offering such programs reported on the required and optional fields of study and on the number of classroom hours devoted to the fields of study. Approximately one hundred separate study areas were used. Additional surveys were made of the faculty backgrounds and student characteristics.

A second major part of the study was the determination of the relative forces affecting the curricula, such as government, professional societies, employers, school organization and students. The directions of these forces on the curricula were identified and some measure of the comparative strengths or influences of the forces was made. Employers and graduate technicians on the job in Michigan were interviewed and a few other knowledgeable persons in nearby states were contacted.

It was concluded that only a few basic fields of study are uniformly required in significant amounts in all programs. These are basic mechanics, English, mathematics and elementary drawing and surveying tech-

niques. Other fields of study are required in varying degrees, but a wide dispersion of effort was recorded on the various subjects. It was apparent that very little basic research has been done on a national basis in the field of civil engineering technology curricula; the individual programs in existence have generally been planned to meet local needs. The civil engineering technician is different from other engineering technicians, in that no single specialized study has been uniformly required in depth.

There is lack of accepted leadership necessary for such programs and some degree of over-generalization in federal government publications.

The American Society for Engineering Education and the Engineers' Council for Professional Development seem to have exerted the greatest amount of influence on the curriculum, while employers and students have had the least recorded effect. The work experience of some faculty members has shown a high correlation with courses taught in the field of surveying and construction, but not in highway work.

The general conclusion was made that civil engineering technology is not presently established as an identifiable curriculum in the United States, together with the observation that strong leadership from the civil engineering profession is lacking. If such leadership is not provided, there is danger that the field of civil engineering technology could disintegrate.

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A Dissertation

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Doctor of Education

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Richard Lawrence Rinehart

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This research was undertaken while the writer was teaching and supervising in a civil engineering technician program and has continued because of the interest in the field and concern over the future of civil engineering technology as a discipline. The completion of this research was possible only through the long and continued guidance supplied by Dr. Max S. Smith, as chairman of the doctoral committee. In addition, extremely valuable advice on educational research by Dr. John X. Jamrich and authoritative information as well as counsel regarding the field of civil engineering from Dr. Charles E. Cutts were received. In addition to the assistance rendered by the members of the doctoral committee, the writer is deeply indebted to Mr. John Overhouse, of The Michigan State Highway Department, and other officials of that organization for continuing assistance, particularly in regard to interviews of the technicians and supervisors in the Department. Mr. Philip Gannon, of Lansing Community College, has also assisted. Many friends in the field of engineering have contributed moral support as well as specific assistance upon occasion.

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CHAPTER I

INTRODUCTION TO STUDY AND NATURE OF THE PROBLEM

Several trends and phenomena in technical education exert an influence on the education of engineering technicians. The movement of engineering curricula from practice toward theory; from the application of science to more understanding of science principles is a well established trend. This factor, together with social mobility and other aspects of the culture of the United States, has resulted in considerable overlap and confusion between the roles and functions of the scientist, the engineer, the technician, and other technologists. There is little agreement on the extent of general education that colleges should be responsible for in technical curricula. The sources of support for technical education are several: government, students, industry, the professions, and each has its own goals.

The general problem might be stated as the determination of the curricular definition of the civil engineering technician, in relation to the engineer, the scientist, the skilled craftsman, and other technologists. Equally important is the analysis of the curriculum force. The understanding of the force directing curriculum or determining the material to be learned must be understood in order for the employer to predict the abilities of the civil engineering technician. This knowledge of what determines actual curriculum would also be important to the student and to all other agencies involved in this program, such as the administration of the college planning to offer Civil Engineering Technology.

A. Statement of the Problem

This is to be a definitive work on the Civil Engineering Technician, leading to a detailed description of the educational program. The necessary abilities, competencies, and expectations of the student going into the curriculum, the depth and breadth of the studies, and the possible and potential job descriptions of the graduate will be identified. An equally important part of the study will be the determination, relative importance within a given program, or in the overall configuration of civil engineering technician programs, of the curricular definition, the leadership of learned and professional societies, the influence of government and other financing sources, the faculty orientations and abilities, and of the student's own expectations and abilities.

What is a civil engineering technician? Related to this, what is a highway technician or a surveying technician or other technicians related to the civil engineering field? The study is concerned with the future of this person on the job, as well as his entry skills and ability.

An answer to these kinds of questions will help define the technician in the family of occupations related to civil engineering. This information is to be determined in as much detail as possible. Major areas of study will be analyzed, but more importantly, specific skills and abilities within major course areas will be tabulated. For example, it will be important to know what proportion of civil engineering students study the subject of structural drafting and, in addition, what extent of ability in reinforcing steel or structural steel detailing is understood by the majority of the students.

Any other identifiable characteristics or attitudes that are measurable as being distinctive within this group will be tabulated, such as the ability to solve problems in comparison with the ability of the same skill of the engineer, the skilled craftsman, and the average person having two years of college education. It is possible that there will not be an identifiable, distinctive characteristic in the group. It is also possible that only negative conclusions may be drawn concerning what is expected. For example, it may be that no degree of uniformity is observable in the extent of taking calculus or the extent of teaching technical report writing to the technician. It is also possible that there will be no significant difference in attitudes between the civil engineering technician and the journeyman carpenter in many fields. Negative conclusions stating that there is no such distinctive characteristic will be important, but will be further analyzed to attempt to determine what forces do determine the extent of these non-uniformities. If the analysis of curricula indicates a wide variation in the understanding of geology or soils, then it will be concerned with what affects this variation. Is it the background of the faculty, variation in the instructor's own experiences that causes this variation, or is some other factor causing it?

B. <u>The Importance of the Problem</u>

An answer to these kinds of questions will help define the technician in the family of occupations related to civil engineering. This definitive information is needed for counseling prospective students and to encourage more students to enter this type of curriculum.

Planning and legislation are sometimes hampered by the need for more specific information about these programs and, above all, the civil engineer could make more use of technicians if he knew what he could expect of the graduate.

The field of civil technology is possibly broader than that of the much older technologies: electronic and mechanical. This may be one reason that it has not become as popular. There are several hundred colleges and technical institutes offering some form of electrical and industrial type curricula, but there are only thirty technician schools offering something related to civil engineering. The Department of Health, Education and Welfare, Office of Education, has been studying the older curricula in detail and has published sample programs, suggested outlines, and conference reports on curricula for them. They are in the planning stages for doing similar work on metallurgical and a few other curricula for technicians, but they have only one brief publication for the field of civil engineering technology.[1] It is probable that they have not done more in civil technology because of the small size of the enrollment compared to the older technologies. This smallness makes it possible for this dissertation to study the existing situation, using a complete sample, and the information will be of value to the colleges beginning such programs in the next ten years or so. Lansing Community College has received requests for guidance and information on curricula from ten other colleges around the country who plan to initiate similar programs. In addition, four State Departments of Instruction have requested information on curricu-

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[1]Civil and Highway Technology, U. S. Department of Health, Education and Welfare, O E 80018 (Washington: Government Printing Office, 1962).

lum to help the development of civil engineering technology in their states. It seems that there is a growing need for this curricular information.

Another important need is the low enrollment in technician programs as well as in engineering. The need for more technicians and better engineers hardly needs documentation today. It is a standard topic of discussion. The lack of sufficient students in this area is due at least in part to misunderstandings of the roles or definitions of the engineer and the engineering technician. This study should help to provide definition and improve counseling of potential students. It is hoped, in addition, that the results of the study might point out some areas where the apparent goals of the curricula are perceived as being undesirable by the students or employers who could use additional technicians. It is certainly not intended to set up curricula simply to please students, but if the study can highlight apparent discrepancies in desires, then the image controlled by public relations may be improved.

A related problem and need for the study is the existence of dropouts in the student body. It would seem that if the curriculum is more clearly defined, then better guidance should reduce the number of dropouts. Again, it is possible that some dropouts occur where the curriculum is not nearly enough appropriate to the perceptions of people in related jobs.

Another importance for the study stems from the misunderstandings in federal agencies on the definition of the technician. Federal aid to technical education is not always being used for the "high level technician" because of the lack of good definition and the efforts of other pressure groups.

C. Definition of Terms and Limitations of the Study

The study examines curricula for civil engineering technicians. This includes all and any programs of approximately two academic years equivalent length beyond high school. It is assumed that the student has graduated from a typical secondary school. The study includes Highway, Structural, Surveying and other technologies wherein the graduate technician will probably work under the general supervision of a civil engineer, but does not include architectural or building programs where the technician would probably not be working with engineers.

All colleges or institutes offering such programs in the United States are asked to reply to the curriculum analysis. Some are proprietary institutions, some are extensions of universities, some are public technical institutes, some are community colleges; both accredited and nonaccredited schools will be contacted. Schools which do not schedule regular classes, such as correspondence and on-the-job training programs are not included. The academic part of co-op programs is included, and it is assumed that most of the programs lead to an Associate Degree in the field, but this is not required.

Since the research deals with subject matter, there may be some confusion or difference in course titles. The course titles used in the survey form are, therefore, provided with a short description and typical titles are used where possible. Only technicians in Michigan are interviewed.

D. Assumptions and Theoretical Development

It is a basic social fact that the institutions of society compete with each other for support in personnel and financial support. These resources are always in short support in comparison with the ultimate aims of the institutions, so critical decisions must continually be made as to the best allocation of these for the maximum good to society. The topic of distribution of wealth is certainly considered to be in the field of economics, but the actual process is controlled by the personalities and values of the persons involved and by the social forces to a large extent.[2] Many people who have been trained in economics have doubted that man operates like a machine, always seeking to maximize gains and minimize costs, and men are necessarily involved in the critical decisions of allocation. There have been trenchant attacks on the psychological assumptions of economics; Veblen took a great delight in pulling the rug out from under the learned by forcing them to recognize that many elaborate economic systems were built on psychological quicksand.[3] Many changes in the role of work are observable now from the perspective of the "Theory of the Leisure Class." Work is respectable; to have a job is increasingly viewed as a positive value, and leisure is now within the reach of all. It is apparent that the concepts of role theory, group theory, and motivation must be included in a study of the allocation of resources to institutions. These will now be demonstrated in respect to educational institutions and

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[2] Orville G. Brim, Jr., Sociology and the Field of Education, (Russell Sage Foundation, 1958), p. 24.

[3] Eli Ginzberg, Human Resources, (Simon and Schuster, 1958), General statement paraphrased.

later on the paper will apply the developed theory to a specific type of education.

Support to education is made for many reasons and most of the reasons can be identified with a reasonable degree of clarity. The support comes from the student, the federal, state and local governments, private philanthropy, industry, and other occasional sources, such as churches. The education is aimed at some or all of the following goal areas: training of manual and mental skills, teaching an understanding of scientific and social theories, development of habits and personality. The typical objectives of education are: procurement of employment, development of judgment, critical thinking, general education, entertainment, and now and then to satisfy a sense of curiosity. Students perceive education as a means of getting a good job. Local government views education as a means of gaining political support through satisfying the demands of the voters. Federal government uses education as a means of international competition as well as other reasons. Industry expects education to improve their profit situation through efficiency and research. Scholars in general hold that education exists to search for knowledge or truth. All of these perceived needs are, or can be stated, in terms of minimum requirements plus desirable additions in extent. Education must compete for the support of the various groups against other institutions of our society; and there is competition within education for resources.

The question of efficiency or the effectiveness of the multiple support of education will be considered. The concepts defined by Chester Barnard can be used throughout this paper in this sense: "What we mean by effectiveness of cooperation is the accomplishment of the recognized objectives of cooperative action. The degree of accomplishment indicates the degree of effectiveness...Although effectiveness of cooperative action or effort relates to the accomplishment of an objective of the system and is determined with a view to the system's requirements, efficiency relates to the satisfaction of individual motives."[4] The theory to be developed by this paper will be a means of measuring the effectiveness and efficiency of the allocation of resources in educational cooperation.

This theory, relating the resources supporting education and the various objectives of the education in terms facilitating a measure of effectiveness and efficiency, must deal with several intervening variables. The perceptions of the role of the student, the institution, and the graduate must be considered instead of objective or impersonal statements of purposes. The personality, abilities, and motivations of the student affect any outcome of an educational program. Another variable to be considered is the existence of group pressures, social forces, and the clash of interest groups. The frame of reference of the people involved in the process of education and the reference groups of these concerned affect the process also. It is hoped that this theory will stem from generalizations possible from examination of the system of the above variables. The system will be empirical, but possibly some degree of logical verification may be made. The behavior of the persons making critical decisions is the handle to be used in making data measurements.

As a construct for handling relationships in the variables, a force system acting to move a mass from one locus to another can be used. The forces are the sources of support allocated to education, their direc-

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[4]Chester I. Barnard, The Functions of the Executive, (Cambridge, Massachusetts: Harvard University Press, 1960), p. 55.

tion being perceived objectives, and their magnitude being the amount of effort made. The mass is, of course, the number of students, and the loci represent relative degrees of attainment of goals. A few physical concepts used with such force systems will be needed including: Work - the force times the actual net distance moved; Energy - force times distance potential; Components - the relative force or displacement in a given direction of a general direction force. Efficiency will be the ratio of the total work accomplished to the energy used; effectiveness will be the degree of attainment of a goal. This is a dynamic system in which forces and goals will be changing with respect to time. Since multiple goals are involved for each force, the centroid of the configuration will be used to direct the forces.

Each source of support for education is a force directing a student toward a perceived set of goals that will maximize the attainment of objectives desired by the source of support. In more general terms, the allocation of support for an institution of society is made in such a way as to achieve a maximum of goals determined by the forces of society, recognizing that complete accomplishment or satisfaction is rarely attained, due to the limits of society and resources. The various forces or drives each have their own particular set of goals, and they expect a reasonable degree of attainment of the goals. The goals are changing and are subjective for the force. This statement of theory leads to some hypotheses:

1. Efficiency of allocation of resources increases as the congruency of goals among forces increases.
2. Effectiveness of support is the degree of mee-ing success on goals; if satisfactory effectiveness is not attained, the force will probably be withdrawn or reduced.

Other hypotheses may be drawn from the model, or theory, by reference to the axioms of dynamics and mechanics of force systems. Impulse is defined as the product of a force and the time of application of the force. This concept has similar implications for social forces. Momentum is defined as the product of a force and the velocity of the action resulting from the force. Momentum, in its physical sense, shows a remarkable similarity to the ideas of political or social momentum. The popular word "power" is found in mechanics also, with a quantifiable specific definition: the rate of doing work. (Remember that work is actual accomplishment, not the expenditure of energy). This suggests that this model could be used to quantify power in political theory.

The model of a socio-politico-economic-behavioristic force system and the theory borrowed from mechanics and dynmaics will now be applied to a situation with which the author is familiar, technical education. The Lansing Community College has a curriculum in "Civil Technology." This program was begun at the request of the Michigan State Highway Department to train technicians who could relieve engineers in the Highway Department of routine tasks in technical areas. The program thus got impetus from that department. This was an initial force, gradually replaced by the support of providing jobs for the students on a cooperative schedule. Financial support is received from the student in fees, from the State of Michigan in general college student reimbursement from taxes, from the Federal Government through National Defense Education Funds, from other Federal sources for specific items, such as equipment, from the City of Lansing School District as a part of school taxes going to the Community College, and from a few gifts of individuals. Other support comes from the faculty teaching the technicians, since the teaching required knowledge

and experience that command a higher salary in the engineering field. The individuals in each case had motives for contributing or exerting pressure toward accomplishment of their own set of goals.

As constructed, this theory will use the assumption of rationality of the individual with behavior being a measure of the motivation. The psychoanalytic concepts must be considered as hypothetical constructs, not as intervening variables. It will be necessary to do more than listen to the statements of the persons to adequately determine their objectives and motives for the operation in question. The motives must be inferred from the behavior of the person. However, underlying unconscious motivations within him will not be evaluated; one can only recognize that such factors exist.

The person who was assigned the responsibility for this program development in the Highway Department had an academic background and was necessarily close to the students applying for the training. His goals reflect the goals of the student and a concern for the future education of the student beyond the student. The person in the Community College who was given the responsibility for the program with his own individual goal for the program also demonstrated the goals through his behavior. The student goals can be measured by their decisions and stated objectives. The State of Michigan stated goals for education in colleges and the Federal Government has prepared statements of the goals for education in terms of generalities. These are included as an appendix to this report.

Directions for the forces can be derived from a study of these goal orientations. The magnitudes are not all in the same units, but it is appropriate to convert them to a common unity for comparison. This paper will use the dollar as the common unit; this usually makes an appeal-

ing and understandable scale. The total amount of money spent to educate a class by each group must be calculated. The time spent by the student is to be added to his tuition, and the interest and intelligence could be used also, if desired. The amount of money and time spent by the Highway Department will constitute the magnitude of its force. The time spent by agencies of the engineering profession and the forces of society should be included. The status and expectations thrust upon education by society can be evaluated in terms of goals or directions and the size of the force can be determined by comparison with the expectations of the student or other groups and their financial contributions. It should be repeated that these directions or goals are functions of time and any changes should be measured. It is readily observed that students' goals change as they approach transition points in the education program.

In order to handle the concepts of the force system it is necessary to use several other concepts and constructs from theory in existence. Role theory and the expectations of the parts of the system are needed to determine the directions of some of the forces. The role of the student or the job that he sees for himself is the suggested way to identify the goals he has set. For example, a student failing out of engineering might transfer to a technician program to identify himself with success in a related field. This orientation would be different from that of the student who enrolls in a technical program because it leads to a job in a shorter time than other fields might.

The magnitudes of some of the forces is often dependent on more than just the size of the dollar investment. It varies with the personality of the person involved and so the concepts of drive, tension, the psychic mobility of the persons, and frustration can be used to better evaluate the forces. Some of the handy psychological concepts, such as intelligence or I.Q., are of dubious value, but a behavioral approach might be useful.

CHAPTER II

REVIEW OF PERTINENT LITERATURE AND UNPUBLISHED STATEMENTS

Chapter II is a review of the general literature, together with reports from meetings and studies dealing with civil engineering technicians. Due to the interrelationships between the many aspects of the problem, this is not organized by the specific topic or sub-study area. The topics are organized rather by the source. The groups of people making statements provide the best means of organizing this section of the paper. Within each section the topics will be arranged chronologically. The groups who have something to say about civil engineering technology are many and varied, but they will be broken down into the following categories:

1) Government organizations (federal, state and other organizations)
2) Consultants and experts in the field for being leaders in the development of civil engineering technician programs
3) Learned societies (statements made from a society standpoint as position statements)
4) Accreditation groups, particularly the Engineers' Council for Professional Development
5) Faculty (statements made by teachers and department heads in civil engineering technician programs)
6) Employers of civil engineering technicians
7) Students and graduates of the programs

It will be helpful to see the differences in viewpoints in these various groups; it will also be helpful to ascertain any change or trend of thinking within a group from the early publications to the more recent. The following statements are selected from a larger number as being most representative.

Many publications and most authors seem to prefer to generalize to all of engineering technologies. As was observed in the introduction, such generalization is not necessarily valid, since the general work and orientation in the field of civil engineering is different from that in other fields of engineering. The civil engineering fields deal with some topics that do not lend themselves to the refined scientific knowledge found in other fields. For example, soils and public welfare are of immediate concern to people in the field of civil engineering. In working on such projects, the technician must deal with research and procedures developed from the social sciences in addition to those of the physical sciences. In addition to this, problems involving political value and judgments of unknown quantities, such as future loadings on bridges, call for a different type of decision making than do the design procedures for comparatively short lived electronics apparatus.

A. Government Sources

Government units seem to have taken little or no notice of civil engineering technology until 1962. This apparent void is noticeable in several governmental publications prior to that time. Highway departments and some other state agencies of government were interested in programs prior to that time, but no recommendations for programs were observed in federal government publications. In a 1957 article discussing the develop-

ment of two year colleges, Martorana observed that nineteen statewide studies of higher education between 1950 and 1957 included recommendation for organized occupational curricula in two year colleges.[1] A publication of the Office of Education in 1958 recommending particular programs omitted any mention of the civil engineering technology field. Under the general heading of engineering technicians and technical occupations, it did list building construction foremen as the nearest thing to the civil engineering field.[2]

In 1959, Kenneth Brunner, of the Office of Education, presented a historical review of the Federal Government's interest in technical institute education, which again made no mention of programs in the civil engineering field.[3] The report covered government activities dating from a 1946 commission reporting to President Truman through World War II and 1959. During this time the Office of Education was counting the number of civil engineering technician programs without definition in their annual reports on education. Mr. Brunner listed such things as the Engineering Science and Management War Training Program for World War II, the National Defense Education Act work by the Department of State, the Department of Labor, without mention or examples from the field of civil engineering.

In the debate on the National Defense Education Act, the Congressional Committee Proceedings include the controversy on the level of tech-

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[1]S. V. Martorana, "Two Year Colleges," American Education, August, 1957, p. 57.

[2]Lynn Emerson, Vocational-Technical Education for American Industry, U. S. Department of Health, Education and Welfare, Circular 530 (Washington: Government Printing Office, 1958).

[3]Kenneth A. Brunner, "The Federal Government and Technical Institute Education," Technical Education News, Special Issue, 1959, pp. 1 - 3.

nician programs. The first Act in 1958 provided for assistance to engineering technician programs under Title VIII, but did not include technical institutes. The revision to this act in 1962 continued the debate and finally reworded the limitations to include technicians "or skilled workers requiring scientific or technical knowledge." This, in effect, moves in the other direction to include some skilled labor and was initiated on the recommendations of representatives of organized labor. Summaries of arguments at that time for this change were that it extended the usefulness of the act, and those against were that it departed from the stated purposes of the act. In 1962, a publication of the United States Office of Health, Education and Welfare, Office of Education, to help implement the National Defense Education Act, listed some of the fields of study and the requirements within these fields.[4] Again, no civil engineering fields were mentioned, although some of the advice could be applied to civil engineering technician programs.

A trend toward lower level programs was still noticeable in this publication, although it is recommended that most programs would be post-high school; however, they included a sample mechanical technology program for high school. This indicated that the Office of Education believed that the technician program could be offered either in high school or post-high school institutions. A subsequent series of publications of the Office of Education[5] involving education for a changing field of work

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[4]Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs, U. S. Department of Health, Education and Welfare, OE - 80015 (Washington: Government Printing Office, 1962).

[5]Lynn A. Emerson, Education for a Changing World of Work, U. S. Department of Health, Education and Welfare, OE - 80021 (Washington: Government Printing Office, 1963). Also Technical Training in the United States, OE - 80023.

again made the recommendation that technician programs be offered in the high schools, as well as in special vocational schools for non-high school youth and engineering colleges, in addition to technical institutes and community and junior colleges. There seemed to be the belief that these programs could be instituted at any level.

In 1962 the Office of Education did publish the suggested curriculum development plan for civil and highway technology.[6] This is the only significant publication of the Office of Education dealing with civil technology. In this publication they listed job descriptions of chainman, construction engineering aide, surveyor, as well as other fields, as occupations for which the training has prepared students. Of these listed occupations, those of chainman, architectural draftsman, instrument man and rodman are generally filled by persons with no technical training. High school graduates or other students pick up the knowledge on the job to become chainmen and rodmen. Instrument men could conceivably be supplied through a short course, but in actual practice, most people come into this position without any technical training. The architectural draftsman is another field completely outside of civil engineering.

B. Experts and Consultants in the Field

Again, there have been many statements published by a group of experts in the general field of technician programs and engineering technician programs particularly. However, civil engineering technology does not seem to have attracted the interest of this group of experts as much as

[6]Civil and Highway Technology, U. S. Department of Health, Education and Welfare, OE 80018 (Washington: Government Printing Office, 1962).

mechanical and electronics technology. Moreover, most of the statements on technology in general reflect this concern for the mechanical and electronics programs, in that they imply a relationship with industry found in those areas and not found in the area of civil engineering technology. Some of the statements that have been noted reflect the interest of the private technical institute in the time prior to 1957 and the Sputnik.

Russell Beatty, President of Wentworth Technical Institute, reported in 1957 and 1958 on the technician programs.[7] He listed the civil and highway engineering technician program at Wentworth and its problems and advantages. This report to the Board of Trustees is interesting, because it reflects the general point of view of the Engineering Council for Professional Development. These programs require an extensive investment in equipment and assume that the program will serve an area at least as large as a state, or a population of 500,000 people for the minimum programs and 2,000,000 for programs such as civil engineering technology. J. Ross Henninger, in a series of reports between 1957 and the present time on technical institutes and engineering technicians, listed civil engineering technician programs.[8] He seemed to feel that they were similar to other engineering technician programs, except that they are smaller in numbers. Research and publications by Dr. George Brandon, of Michigan State University, in 1959 and 1960 focused attention on curricula for technician programs.[9] A close study of the research seems to indicate that his concern was for the industrial technicians,

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[7]Russell Beatty, Report of the President to the Board of Directors, 1957-58, (Wentworth Institute, 1958).

[8]G. Ross Henninger, The Technical Institute in America, (McGraw Hill Book Company, 1959).

[9]George L. Brandon, Explorations in Research Design: Curricula for Technicians, College of Education E R - I, (Michigan State University, November, 1960).

since he is more concerned with skills and manual abilities rather than with scientific understandings. In fact, his main statement, that a matrix for the curriculum could be developed itemizing the specific skills, is less applicable in an engineering technician program, where the abstract and more complex ideas are considered to be the more important thing. These things do not readily lend themselves to a matrix of specific skills as the one he developed.

The Technical Engineering News, published by McGraw Hill Book Company, provides many articles on civil engineering technician programs and their editorials deal with the need for concern with these programs and support from the legislatures and Congress. Congressman Brademas was quoted extensively, because he was the chairman of the committee dealing with the revision of Title VIII of the NDEA. Other experts have developed core or common curricular foundations for engineering technician programs. One was reported in the Technical Engineering News in 1961,[10] others included proposals by Norman Harris, of the University of Michigan.[11] Core required courses would be necessary for civil engineering technician programs, as well as other engineering technologies. There is not a significant difference between these core programs. The significant difference seems to be in the extent of transferable courses within the core that might be included in an engineering program. Dr. Karl Werwath, President of the Milwaukee School of Engineering, and Ken Holderman, of Penn State University, were leading

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[10]H. B. Desnoyers, "The Common Technical Curriculum," (Editorial), Technical Education News, January, 1961, p. 1. Also "Gaston Technical Institute" December, 1964, pp. 11 - 15.

[11]Norman Harris and William Yencso, Technical Education in Michigan Community Colleges, School of Education ORA 06321, (University of Michigan, March, 1965).

authorities during the period of rapid growth following 1957 and they have been proponents of the idea that transferability of the courses is inappropriate.

C. Professional Societies

The Michigan State Board for Vocational Education sponsored a survey and study by Dr. Harris and Dr. Yencso, of the University of Michigan, dealing with the technical terminal curricula in junior colleges.[12] They reported on the frequency of various kinds of programs. The civil engineering technologies were of very low frequency. They were listed once compared with ten programs for electrical technology, twelve times for drafting technology and twenty-two times for general engineering technician programs.

In 1959 the American Society of Civil Engineers held a general meeting of major importance on civil engineering instruction at the University of Michigan.[13] This brought out several recommendations, the most significant for this paper being that recognition of the civil engineering technician should be reflected in the undergraduate curricula. Recommendations, if adopted, would reduce the specialization of courses in civil engineering, which was one of the major goals of the conference.

The Professional Engineers Conference Board for Industry reported in 1962 on plans for surveying the need for technician programs in the field

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[12]Norman Harris and William Yencso, Technical Education in Michigan Community Colleges, (Ann Arbor: University of Michigan Office of Research Administration, 1965), p. 60.

[13]Civil Engineering, (American Society of Civil Engineers, 1962)

of civil engineering and concluded that there was a probable need for more civil engineering technician programs. The professional engineers of the Province of Ontario have licensed engineering technicians since 1961 and their examinations in civil technology have a bearing on the curriculum in the engineering technology.[14] The National Association of Manufacturers and the Technical Institute Division of the American Society for Engineering Education have published brochures describing the general work of the civil engineering technician to encourage enrollment in these programs.[15] The American Concrete Institute and other specialized organizations in the civil engineering field have published in their journals descriptions of courses for technicians.

The American Society for Engineering Education is the most widely recognized organized organization in the field of engineering technicians and their journal has reported several times on civil engineering technician programs. The American Society of Civil Engineers has done less on civil engineering technicians, in spite of the fact that this is the founder society in the field of civil engineering. They have studied the education of the civil engineer in great depth and in doing this, have made some references for civil engineering technicians, but they have not performed a study of civil engineering technicians as such. The National Society of Professional Engineers has instituted a program to certify engineering technicians, including civil engineering technicians and the requirements of this certification again have a bearing on the curriculum.

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[14] Syllabus of Examinations for Engineering Technology, (Toronto, Ontario: The Association of Professional Engineers of the Province of Ontario, 1961), Section D, Civil Technology.

[15] Your Opportunities as a Technician, (National Association of Manufacturers, 1957) and The Engineering Technician, (American Society for Engineering Education, 1960).

D. Accreditation

The Characteristics of Excellence in Engineering Technician Education[16] is a publication that spells out requirements for accreditation of civil engineering technician programs. This was published in 1962 by the American Society for Engineering Education in cooperation with the Engineers' Council for Professional Development. The annual reports of the Council indicate that few civil engineering technician programs have been accredited.[17] Ten such programs were reported in 1960 and in 1964 this had only grown to twelve such programs.

E. Employers in Founding Societies

The Consulting Engineers Council and the American Association of State Highway Officials, as well as individual highway department heads, have offered some comments on civil engineering technician programs, while some companies, such as General Electric, in the National Association of Manufacturers, have reported on engineering technician needs in general. The Highway Department reports are usually self-centered. For example, in 1962 Connecticut boasted of a unique training program,[18] apparently feeling that they were the only one having such a program, when as a matter of fact, fifteen such programs were in operation at that time. The Minnesota Highway

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[16]American Society for Engineering Education, Characteristics of Excellence in Engineering Technician Education, (Urbana, Illinois: American Society for Engineering Education, 1962).

[17]Annual Report, (New York: Engineers' Council for Professional Development, 1964).

[18]Howard S. Ives, "Connecticut Boasts of a Unique Training Program," American Highways, 41: 4, October, 1962, pp. 11 - 15.

Department also published a similar article in Better Roads Magazine.[19]

The general point of view of consulting engineers was somewhat different as reported by Crawford,[20] in that the consulting engineer wanted a civil engineer who was closer to the engineer in curriculum than the requirement of the Highway Department. Probably the civil engineering technician in the consulting engineer's office would work for and with the civil engineer. He would take over as much as possible. Since the highway departments have a thousand or more engineers and technicians, the relationship would be more that of the mechanical engineering technician in industry, where the technician does not work as directly for the engineer. A study of the Michigan State Highway Department and the employer's needs will be reported in detail in Chapter IV and Chapter VII.

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[19]"Technician Training Program, Better Roads, May, 1962, p. 24.

[20]L. K. Crawford, "Education and Practice Viewed by Consulting Engineers Council," (Chicago: Presented at the World Congress on Engineering Education, June, 1965), p. 3.

CHAPTER III

CURRICULA COMPILATION AND ANALYSIS

This section of the paper shows the breakdown of curricula, makes comparisons with different types of institutions, and provides some analysis of the factors affecting the curricula. Individual study areas are analyzed and tabulated, together with comparisons of related courses. This is to be followed by an analysis of the major aspects of the curricula, such as the extent of general education. The relative emphasis upon skills, sciences, technical and general education courses will be compared.

Throughout this chapter there will be two general purposes. The first is the determination of what is actually being taught and the extent of teaching. The second purpose is the analysis of why there are differences between institutions in the various areas and a prognosis of the reasons for the differences.

A. Methodology

The preliminary analysis of selected catalogs and curriculum plans was made by the writer. In addition to this, several interviews were held to ascertain a general picture and the various options that are offered. With this information and the author's own experience, a tabulation of all possible areas of study was made.

An attempt was made at this time to identify the institutions offering civil engineering technology as herein defined. The definition used

includes the criteria that the graduates of such a program would generally be working for the civil engineer or engineering organization. This would be either an indirect or direct relationship; however, it excludes those programs wherein the graduate would not have any relationship to the civil engineer. Therefore, programs in building construction, which are more closely related to the skilled trades, and programs directly aimed at work for an architect only were excluded. The list of selected institutions was derived from various sources, including government reports of engineering technician programs and state highway departments. Additional programs were discovered through an analysis of membership in the American Society for Engineering Education. Those members who had an interest in civil engineering and also in technical institute work were contacted for information relating to programs.

The first questionnaire (Appendix A) was then sent to the thirty identified programs in the United States. The questionnaire asked some preliminary questions concerning prerequisites for students entering the program, the length of the program, and the description of the faculty. The bulk of the questionnaire then asked for information about the curriculum. The unit of measurement selected for this questionnaire was the classroom hour, either in a lecture or laboratory situation. Also a sufficient breakdown of study areas was made because of the differences between institutions in course organization. It was discovered that a simple listing of courses as included in a catalog would be quite misleading, since there is no clear-cut pattern whatsoever of course content. Especially in the technical areas it was apparent that considerable variation existed. For example, a study of concrete might be included in any one of six different course titles and conversely, several institutions having the

same course title, such as "Survey I," had a complete divergence of topics included under such a title. The unit of classroom hour made it difficult for respondents to fill out the questionnaire; however, a sufficient number of responses were received. This unit indicated the extent of teaching, rather than just the fact that such a subject was taught. This information is quite important. Two institutions might easily require a knowledge of the properties of asphalt. If one institution spends twenty hours on this and the other spends only two, it is quite apparent that the depth of understanding is quite different. Since the results of this paper should be of value to the employer, it is important that he know the extent of the graduate's knowledge to be expected in each field. The results of this tabulation show the range of instruction and a statement on the probability of an individual institution's offering. Replies were received from twenty-six of the thirty questionnaires.

A second questionnaire was sent out two years later to twenty-two of the same institutions. This second questionnaire was also sent to thirteen institutions apparently adding the program in this period of time, a total of thirty-five institutions. The questionnaire this time used the same study areas, but asked for a sample check on whether the areas were required or optional. The tabulation of this instrument helped to verify responses from the first instrument and it also provided some further knowledge. An additional questionnaire (Appendix B) was sent out asking for information about the background of education and experience of the faculty. In addition to these principal surveys, some individual samples and interviews were conducted on specific questions as they arose. Twenty-seven usable responses and three additional replies were received from the thirty-five institutions. The three non-usable replies generally indicated that

such a program was not really under way yet or was restricted to part time evening students.

B. Specific Study Area Analyses

The following pages show the results of surveys in each course area and show relationships between related courses. The results are calculated from the twenty-seven usable replies from ten community colleges, eleven technical institutes, and six university related programs.

The statistics to be used in this section are the classroom hour distribution of the total population and the percentage of required and optional courses. The distribution of required classroom hours for all responding schools is made first. For a given area the seventeenth percentile of hours, the fiftieth percentile (median) and the eighty-third percentile were calculated. These are percentiles of the total distribution of all reports of classroom hours by all responding institutions. For example, from Table I, it is seen that eighty-three percent of all programs require less than fifty-one class hours in trigonometry. This description gives a truer indication of probabilities than would a statement of the mean number of hours, since these are not normal distributions. Following this, the percentage of schools requiring this course and the percentage listing the course as optional are shown in each chart. Then a breakdown of institutions by their organizational structure is made. This is done to indicate differences due to the institutional organization. Quite often statements regarding the propensity of technical institutes to omit general education and for community colleges to over-emphasize general subjects are made.

Tables I through XX are based on the twenty-seven replies. The

numbers are omitted from the charts for clarity and ease of comparisons.

TABLE I

THEORETICAL MATHEMATICS

This table shows the extent of emphasis placed on the traditional academic mathematics fields.

TRIGONOMETRY

Trigonometry is required by one hundred percent of the institutions and the distribution of hours shows a high degree of concurrence. Quite obviously the graduate will have a good understanding of trigonometric calculation, regardless of the institution. It was noted that some of the schools list trigonometry as a prerequisite before entering the program and the report on hours for these institutions was adjusted to show the prerequisite hours. Analysis of catalog statements and personal interviews with faculty indicate that these trigonometry courses are generally taught by the mathematics faculty of the institution. In all cases, some degree of skill in application was stressed. Naturally, this would vary from instructor to instructor, even within an institution. However, it can be safely assumed that the ability to transform equations, to solve formulas for unknowns, and to work out somewhat complicated formulas such as are used in celestial observations, is achieved. In all cases, a knowledge of logarithms is required; however, not all institutions develop practice to the same degree of precision. Five place precision is uniformly required by all tested courses; however, only a few give practice in seven or eight place precision. This information was obtained from interviews of selected representative programs.

TABLE I

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Trigonometry	Analytic Geometry	Calculus	Differential Equations
17th percentile (number of hours)	33	0	0	0
50th percentile (number of hours)	47	9	13	0
83rd percentile (number of hours)	51	35	58	0
Median no. of laboratory (hours)				
Percent of schools requiring (%)	100	82	52	19
Percent of schools, optional (%)	0	18	37	33

COMMUNITY, JUNIOR COLLEGES

Percent of schools requiring (%)	100	60	10	20
Percent of schools, optional (%)	0	40	70	50

TECHNICAL INSTITUTES

Percent of schools requiring (%)	100	91	64	9
Percent of schools, optional (%)	0	9	27	36

UNIVERSITIES

Percent of schools requiring (%)	100	100	100	33
Percent of schools, optional (%)	0	0	0	0

ANALYTIC GEOMETRY

It is quite probable that the student will have studied analytic geometry, since seventy-nine percent of the institutions require such knowledge. However, the extent of classroom hours is small for many institutions and this is apparently a topic within a more general mathematics course, such as Technical Mathematics, for many institutions. The median number of nine classroom hours would teach enough analytic geometry so that the technician can calculate intersections and rates. The most typical problem for civil engineering technicians involving analytic geometry is the determination of the intersection station and the angle of intersection for highways. There is a seventy-five percent probability that the technician will be able to solve different types of problems. However, it is likely that he would need extra experience on the job to do such calculation with sufficient precision and accuracy to be of value in actual practice. It is noted that one hundred percent of the university related institutions and ninety percent of the technical institutes require this course, but that only fifty percent of the community colleges require analytic geometry. This is a significant difference between institutions and will be commented on at the conclusion of analysis of this table.

CALCULUS

Differential and integral calculus receive more attention in classroom hours than does analytic geometry; however, it is required by a smaller percentage of institutions. This would indicate that the institutions requiring calculus require a larger amount of time to be spent on it than they do in near related subjects. Since most institutions now combine analytic geometry and differential equations with calculus in integrated courses for engineering students, it is apparent that the technicians are not taking the same courses. Otherwise the percentage of institutions requiring these three courses should be approximately the same instead of the noticeable difference.

DIFFERENTIAL EQUATIONS

Very few institutions require this and the distribution shows that apparently only the top seventeen percent of the distribution have any time in class on differential equations.

An examination of Table I makes it quite clear that the universities and technical institutes conducting such programs make a much heavier demand in mathematics than do the community colleges.

The preliminary analysis of catalogs made it apparent that this study could omit the subject "algebra." There are two reasons for this omission: first, the fact that almost all programs expect high school algebra as a prerequisite and, second, that there is considerable confusion between different institutions on the identification of algebras. The topics that may be considered to be college algebra in one institution are referred to as intermediate algebra in others and sometimes are included in non-credit algebra. Therefore, it was felt that the statistics on the subject would be of little value unless the specific topics within algebra were studied.

TABLE II

APPLIED MATHEMATICS

The subjects of statistics, computer programming, slide rule usage and desk calculator proficiency are included here as applied mathematics. This definition would be in conflict with the more commonly accepted idea that applied mathematics would be "technical mathematics" or an equivalent title. Resolution of this conflict of definitions is not important for the purposes of this paper, since we are concerned with the specific topics and understandings rather than course titles and, therefore, this breakdown is used. Usage of titles such as technical mathematics would be of little value in this study, since it does not explain the particular skills or understandings involved. It is recognized that many applications will be taught under the headings in the previous section.

STATISTICS

Only one institution surveyed requires a course in statistics or probability. It is optional at a small percentage of the institutions. Therefore, the employer could not expect an understanding in this field. Some specific topics under this heading are probably taught in the geodetic surveying of courses and have a median of fourteen class hours. A knowledge of probable error and the handling of measurement statistics must be taught in such courses. Although the survey does not have this information, it is felt that many of the faculty would teach a few hours on the subject of least squares and related factors in the balancing of survey networks. There was no apparent difference in institutions in the emphasis on statistics.

TABLE 11

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Statistics	Computers	Sliderule	Calculators
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	0	0	5	0
83rd percentile (number of hours)	5	2	20	5
Median no. of laboratory (hours)				
Percent of schools requiring (%)	4	33	89	52
Percent of schools, optional (%)	26	15	4	7
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	0	60	100	60
Percent of schools, optional (%)	50	10	0	10
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	0	18	91	55
Percent of schools, optional (%)		18	0	9
UNIVERSITIES				
Percent of schools requiring (%)	17	17	67	33
Percent of schools, optional (%)		17	17	0

COMPUTER PROGRAMMING AND APPRECIATION

An apparent contradiction in statistics is evident in the table. Very few class hours are scheduled by any institution, with only two class hours at the eighty-third percentile and zero for most institutions, while one third of the institutions indicate that they require study in this area. Apparently the subject of computers is at least mentioned, possibly in an orientation course, with a brief description of its possible applications. However, the technician graduate certainly cannot be depended upon to have any developed knowledge in working with computers. With the advent of computers in many activities, such as highway design and structural analysis, some of the graduate technicians will be faced with learning on the job. Due to this low frequency, it is quite probable that civil engineering technicians will not generally find themselves working with computers, but rather that specialized computer technicians will do all of the direct work with data processing.

SLIDE RULE USAGE

Quite obviously, the graduate will definitely know how to use the slide rule. An extremely high percentage of schools require this. Although the classroom hours are rather low, not many hours are required in class to teach the usage of the slide rule. The median of five classroom hours should certainly be sufficient to instruct in the use of the eight or ten principle scales of the slide rule. With this understanding most students would be able to adapt to specialized scales and circular rules.

DESK CALCULATORS AND RELATED MACHINES

Approximately half of all institutions require some knowledge of desk calculators. The number of classroom hours here is zero at the median; therefore, it is probable that the graduate will not have any skill in desk calculator usage. This would seem to be a serious deficiency, since most of the jobs for graduates would involve some usage of calculators. An attempt was made to draw a correlation in this topic with other characteristics, but none was apparent with faculty description, school organization, accreditation of size.

TABLE III

COMMUNICATION AND SOCIAL SCIENCES

The subjects in Table III are English, speech, political science, and history or humanities. These could be referred to as the general education component; however, many definitions of general education do not include English and technical report writing and would include economics, psychology and the behavioral sciences. Since it is more appropriate to define general education on the basis of the goals of the course, a separate tabulation of total effort in general education is made later in this chapter. This tabulation will include ethics and philosophy, but will not include English and speech, since these usually have an applied orientation when taught for civil engineering technicians.

ENGLISH AND TECHNICAL REPORT WRITING

It was necessary to combine the two general headings, because there is a considerable overlap between technical report writing and English composition. The statement of the American Society for Engineering Education on this topic recommends a minimum of six credit hours in written and oral communication. This recommendation and that of other experts point out the need for such courses for success on the job. This is not the same reason and goal as that of the general educationist. The American Society for Engineering Education statement further recommends that proper writing and speaking be taught in every class in the program.

The statistics show that this subject has the highest degree of constancy of all subject areas studied. One hundred percent of the institutions require it and the classroom hour distribution for the middle two-

TABLE III

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	English	Speech	Political Science, Gov't.	History, Humanities
17th percentile (number of hours)	32	0	0	0
50th percentile (number of hours)	90	4	14	0
83rd percentile (number of hours)	108	33	50	11
Median no. of laboratory (hours)				
Percent of schools requiring (%)	100	59	41	45
Percent of schools, optional (%)	0	26	22	33
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	100	60	40	50
Percent of schools, optional (%)	0	30	40	50
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	100	64	36	36
Percent of schools, optional (%)	0	36	0	18
UNIVERSITIES				
Percent of schools requiring (%)	100	50	50	50
Percent of schools, optional (%)	0	0	33	40

thirds of the institutions ranges from thirty to one hundred eight classroom hours. A preliminary survey of employers conducted to initiate this paper showed that English was the most important topic in their recommendations. A serious deficiency in the use of English was observed by almost all employers of engineers and technicians.

PUBLIC SPEAKING AND SPEECH IMPROVEMENT

This subject is not considered to be as important as written work apparently. Two-thirds of the institutions require a study of this subject either in an English class or in a speaking class. There is not a significant difference between institutional organization and the emphasis upon speech and also the distribution of classroom hours indicates that one-half of the institutions would have four classroom hours total or fewer on the subject. Since the study of employers indicated the need for improvement in spoken as well as written English, it would seem that the employers have relatively little influence on this part of the curriculum. This is also apparent when a detailed analysis is made of the specific topic taught. The employers indicate a severe problem in spelling, grammar and precision in the use of written and spoken English. The actual teaching is much more concerned with academic styles and techniques and literature. The writer's personal experience in discussing this has shown that English is generally taught by members of the English department and that these faculty members generally do not consider it proper to include grammar and spelling in their courses. In this situation, it seems that the faculty members in the discipline have much more influence on the curriculum than anyone else.

POLITICAL SCIENCE AND HUMANITIES

The two categories of government (political science) and history or geography (humanities) will be considered together. The survey shows that more classroom hours are spent on political science than on history; however, that a slightly larger number of schools require history than political science. Tabulation of schools requiring one or the other shows that fifty-eight percent of the institutions have such a requirement and that the median of seventy-three classroom hours are spent in the combination of such subjects. There could be some specific topics particularly available for the civil engineering technician, such as the knowledge of local and state government organization, to understand the relationships between county road commissions and state highway departments or the ramifications of federal and state monies on design practices. These specific topics are not likely to occur in an ordinary political science or government class. If they are to be taught at all, they would be more likely found in a class taught by the technical faculty.

An examination of the areas of English, speech, political science and history shows that a higher percentage of community colleges require these courses than technical institutes or universities. The difference is not extremely large, but it is consistent. Seventy-five percent of the community colleges compared with fifty-five percent of the technical institutes and forty percent of the universities require either social science or humanities. The same relationship is apparent in speech. The tabulation of faculty descriptions shows that the faculty is generally the same in the three institutions, the only difference being that the

TABLE IIIa

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Political Science or Humanities			
17th percentile (number of hours)	0			
50th percentile (number of hours)	73			
83rd percentile (number of hours)	135			
Median no. of laboratory (hours)				
Percent of schools requiring (%)	58			
Percent of schools, optional (%)				
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	75			
Percent of schools, optional (%)				
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	55			
Percent of schools, optional (%)				
UNIVERSITIES				
Percent of schools requiring (%)	40			
Percent of schools, optional (%)				

community colleges and universities have a greater probability of having people with a Master's Degree in civil engineering, whereas the technical institutes have people with Bachelor's Degrees in civil engineering. Therefore, it may be concluded that the organizational structure of the institution does affect the extent of general education. The community college, having transfer programs on the same campus, requires more general education because of this. The universities would also have baccalaureate programs; however, the technician program is generally run in isolation from the rest of the university.

TABLE IV

PURE SCIENCES

These areas of study are differentiated from engineering sciences as well as from social sciences and behavioral sciences. These courses are concerned with understandings in applications.

INORGANIC AND ORGANIC GENERAL CHEMISTRY

Only one-third of the institutions require general chemistry courses, although another one-quarter list them as optional. Almost all of the optional courses are in community colleges and more of the required courses are in technical institutes. The number of classroom hours spent in a typical program is rather small. A further breakdown of laboratory hours indicates that the institutions requiring chemistry are offering typical laboratory sessions. It is apparent that the graduate cannot be expected to have had a course in chemistry at the college level. It is much more likely that he would have had courses in materials, as we shall see later.

MOLECULAR STRUCTURE AND FORCES

A very small percentage of students will have been exposed to this theoretical understanding of why certain materials have the properties they have. Again we shall see later that they may have studied metals and concretes enough to know what the properties are, although they will not have the current understandings of the inter-atomic forces that result in these properties.

TABLE IV

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Chemistry	Atom. Theory	Physics Topics	Biology
17th percentile (number of hours)	0	0	12	0
50th percentile (number of hours)	0	0	36	0
83rd percentile (number of hours)	22	3	66	0
Median no. of laboratory (hours)			15	
Percent of schools requiring (%)	30	19	74	4
Percent of schools, optional (%)	26	19	15	19
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	20	20	70	0
Percent of schools, optional (%)	50	40	30	40
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	36	18	73	9
Percent of schools, optional (%)	18	9	9	9
UNIVERSITIES				
Percent of schools requiring (%)	33	17	83	0
Percent of schools, optional (%)	0	0	0	0

PHYSICS

An effort was made in the questionnaire to distinguish between topics of pure physics, such as light and sound, and topics that would be applied to civil engineering technology, such as force systems. Seventy-five percent of all institutions require a course in physics and the total number of classroom hours show a significant concentration of either one or two semesters in length. A comparison of the mathematics requirements proves that these physics courses required are not based upon calculus and, therefore, are not the typical engineering courses. A median of fifteen laboratory hours and twenty-one lecture hours is authorized. Quite apparently, physics is relevant to the civil engineering technician, but chemistry is not in actual curricula.

BIOLOGY

The statistics show that this is almost completely neglected in the education of the technician. Other surveys referred to later in the study will show that employers have not recommended this and that no group has felt it to be sufficiently important to include.

TABLES V AND VI

MATERIALS AND PROPERTIES

These two tables are combined to indicate the relative importance of various types of materials. The study of portland cement and asphalt cement are put together on Table VI because of the close relationships between them and their resulting concretes.

GEOLOGY, SOILS AND AGGREGATES

A significant number of institutions and a relatively large number of classroom hours indicate that the technician will have studied these topics. Examination of catalogs and interviews indicate that the student will be concerned with the classification of various soils and rock. The student should be conversant with the terminology and a general understanding of these materials. These topics could have been separated; however, many courses developed for the technician include knowledge of all three topics. The particular classification systems of soils depends somewhat on the system in use by the local state highway department, although the empirical systems, such as the A.A.S.H.O., probably receive more emphasis than do the pedalogical systems. The extent of geology would probably be limited to the applications in construction rather than the historical and theoretical aspects. It is also more likely that only surface soil properties would receive sufficient attention for use. Foundation engineering would be described but left to the engineers.

METALS

Only a small number of hours are spent on metallurgy. This is a clear distinction from the mechanical technician programs. The civil

TABLE V

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Geology	Metals	Timber	Ceramics
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	47	0	2	0
83rd percentile (number of hours)	87	9	9	3
Median no. of laboratory (hours)	23			
Percent of schools requiring (%)	70	33	56	22
Percent of schools, optional (%)	19	19	7	7
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	60	50	80	30
Percent of schools, optional (%)	30	30	10	20
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	73	27	45	18
Percent of schools, optional (%)	18	18	9	0
UNIVERSITIES				
Percent of schools requiring (%)	83	17	33	17
Percent of schools, optional (%)		0	0	0

TABLE VI

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Portland Cement	Asphalt Cement		Spec'ns. Codes
17th percentile (number of hours)	0	0		0
50th percentile (number of hours)	5	1		5
83rd percentile (number of hours)	30	40		30
Median no. of laboratory (hours)				
Percent of schools requiring (%)	82	67		74
Percent of schools, optional (%)	0	11		7
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	80	60		60
Percent of schools, optional (%)	0	20		20
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	82	73		91
Percent of schools, optional (%)	0	9		0
UNIVERSITIES				
Percent of schools requiring (%)	83	67		67
Percent of schools, optional (%)	0	0		0

engineering technician would not have an understanding of heat treat and other specialized topics. It is quite likely that his knowledge would be restricted to the properties of ferrous materials.

TIMBER

Somewhat greater emphasis is put upon timber than upon metals; however, it is still not enough to depend upon. A higher percentage of the community colleges than of technical institutes study this and it is quite probable that it will never be a course by itself. Later on we will see that a few more hours might be spent on timber design, but this topic is generally omitted in favor of the study of concretes and their design.

CERAMICS, PLASTICS, GLASS

A neglible amount of time is spent on these topics, even though portland cement concrete is a ceramic material.

CEMENTS, PORTLAND AND ASPHALT

The statistics show that there is approximately the same effort put on the two materials and both are significant. Portland cement is required in more institutions and not optional in any; asphalt is required in fewer institutions, but is optional in three. The distribution of classroom hours is approximately the same.

These topics are very important in the eyes of the employers and it is somewhat surprising that approximately one quarter of the institutions do not offer courses in these fields. It seems apparent that the technician will know something of the properties of these materials, but probably will not have skills in the testing and sampling of these materials. Apparently the technician will rely more upon specifications and codes than upon a rational understanding of the design of concrete materials.

SPECIFICATIONS AND CODES

It is quite likely that the technician will have studied some of the common sets of specifications and should be able to develop a proficiency in the application of specific codes encountered on the job. It is apparent that more technical institutes emphasize this subject than do other types of institutions. The graduate technician would probably have about a seventy-five percent probability of being able to do construction inspection, based upon specifications and codes, upon graduation.

TABLE VII

ENGINEERING MECHANICS

The four categories of statics, dynamics, thermodynamics and strength of materials would be a part of the engineering sciences. These four are shown together because of their close relationship. A sequence of statics to dynamics, to strength of materials has been traditional in engineering curricula, although this is rapidly being replaced by slightly different emphases in vector mechanics. In technician programs the statics is often included as a first part of a course in strength of materials, giving only sufficient coverage for typical applications of elementary structures. Thermodynamics could be considered separately, but it is included here for illustration and comparison.

STATICS AND GRAPHICS

All of the institutions except one require study in force systems and the number of classroom hours, ranging from twenty-two to seventy-five, show that fairly thorough coverage is given. It may be concluded that the technician will be able to determine forces, components, and resolutions in simple structures. In addition, he will understand the distribution of forces on surfaces. Therefore, he will be able to analyze elements of structures in a design office and should be able to understand construction forces.

DYNAMICS

Only a small proportion of institutions require a knowledge of moving particles or machines. Technical institutes are more likely to

TABLE VII

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Statics	Dynamics	Thermo-dynamics	Strength of Materials
17th percentile (number of hours)	22	0	0	40
50th percentile (number of hours)	44	10	0	54
83rd percentile (number of hours)	75	31	16	87
Median no. of laboratory (hours)	10	3		21
Percent of schools requiring (%)	96	30	7	93
Percent of schools, optional (%)	4	15	26	0
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	90	30	0	90
Percent of schools, optional (%)	10	30	50	0
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	100	36	18	100
Percent of schools, optional (%)	0	9	18	0
UNIVERSITIES				
Percent of schools requiring (%)	100	17	0	83
Percent of schools, optional (%)	0	0	0	0

teach this, but even here fewer than half of the institutions do. Because of the fact that only twenty-five percent of the institutions require this and a few more list it as optional, it is surprising that a median of ten classroom hours are reported. Apparently a few lectures are given on the subject in some other course. It cannot be expected, however, that the technician will be able to analyze systems in motion.

STRENGTH OF MATERIALS

Like statics, stress analysis is often required. The median of fifty-four classroom hours would indicate that a fairly thorough knowledge of simple stress analysis is taught. The laboratory-lecture breakdown shows that a median of twenty-one laboratory hours are required. This is probably involved with tensile compression and flexural testing. It is also likely that some combined stresses may be studied in the laboratory. The technician, therefore, should be able to deal with various design systems including ultimate strength and elastic theory. Because of the mathematics limitations, these courses are probably taught on a non-calculus level; however, many instructors may very well have time to show the theory limits. The technician might be expected to realize the complexity of actual stress concentrations and distribution. He, therefore, should be quite qualified to do simple design and routine analysis. Such work could be done manually; it is not likely that the technician could directly use computers for this work.

THERMODYNAMICS

It is extremely unlikely that the civil engineering technician will have a knowledge of heat flow and transfer. This should not hinder his work on structures, although it would indicate that his knowledge of insulation in buildings and heat-air conditioning systems would be very limited.

TABLE VIII

ADDITIONAL ENGINEERING SCIENCES

Electricity, hydraulics, hydrology and meteorology are additional areas of engineering sciences. These engineering sciences are distringuished in many definitions from the pure sciences upon which they are based, and the technical specialties which would be based upon them.

ELECTRICITY AND ELECTRONICS

There is a fifty percent probability that the technician will have an understanding of either electricity or electronics. An analysis of the course descriptions indicates that when taught, the topic of AC and DC circuits and motor generator systems would be included. It is not likely that knowledge of electron properties, vacuum tubes or semiconductors would be involved. The number of classroom hours would indicate that only rarely would any depth be taught. Therefore, no knowledge in this field should be assumed by an employer of the technician.

HYDRAULICS AND FLUID MECHANICS

This subject is very similar to electricity in its coverage and there is little probability that the technician would have an understanding of closed or open circuit calculations. It is interesting to note the tendency for technical institutes to apparently favor hydraulics and for university related programs to favor electricity, while community colleges show a consistently low interest. The differences in these subjects will be further analyzed later on with comparisons of the type of faculty work experience.

TABLE VIII

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Electricity	Hydraulics	Hydrology	Meteor-ology
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	1	11	0	0
83rd percentile (number of hours)	40	48	20	0
Median no. of laboratory (hours)				
Percent of schools requiring (%)	44	44	22	4
Percent of schools, optional (%)	19	19	15	19
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	40	40	30	0
Percent of schools, optional (%)	40	20	20	40
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	36	64	18	9
Percent of schools, optional (%)	9	18	18	9
UNIVERSITIES				
Percent of schools requiring (%)	67	17	17	0
Percent of schools, optional (%)	0	17	0	0

HYDROLOGY AND METEOROLOGY

A very small probability of these topics being taught is apparent. Somewhat greater emphasis upon hydrology indicates that this is probably related to the drainage design which fifty percent of the institutions require. The subjects were included in the study because of their occasional use in sanitary engineering projects and in construction operations. It is disappointing that the graduate will not have a better knowledge of run off calculations, because of its many applications, especially in highway drainage. The knowledge of weather forecasting is apparently not important.

TABLE IX

STRUCTURAL DESIGN

These courses involve the application of engineering sciences to design problems and an effort was made in the selection of courses to determine the extent of design complexity to be expected of the technician. The general literature has never been very clear on the subject of design. Many employers of technicians seem to say that design is an engineering function and that only routine calculations could be provided by the technician for the designer. Others have indicated that the technician can actually do some types of design. The topic is further complicated by the extent of computer use in design. Another aspect to be considered is the extent of creativity in design. Should the technician be concerned with handbook design only and selection from catalogs, or should he be taught some basic principles of creative design?

STRUCTURAL STEEL

Since more than three-quarters of all types of institutions require a course in structural steel design, with an average of twenty-three classroom hours, it can be assumed that the graduate would at least be able to select proper sizes and shapes of rolled steel and standard connections. The technician would probably be familiar with the handbooks of shapes. It is most likely that he will be able to compute stresses based on the elastic theory. Flexure tension and compression, shear and routine stresses in normal shapes would be included. The small percentage of schools not offering structural steel design concentrate more on surveying and are in reality surveying technology programs. Related to this in Table XV, the same number of

TABLE IX

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Structural Steel Design	Reinforced Concrete Design	Timber Design	Indeterminant Analysis
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	23	25	0	0
83rd percentile (number of hours)	66	65	18	1
Median no. of laboratory (hours)	4	4		
Percent of schools requiring (%)	78	63	48	22
Percent of schools, optional (%)	7	11	15	19
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	70	60	60	10
Percent of schools, optional (%)	20	20	30	30
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	91	82	55	45
Percent of schools, optional (%)	0	9	9	18
UNIVERSITIES				
Percent of schools requiring (%)	67	33	17	0
Percent of schools, optional (%)	0	0	0	0

institutions require additional hours in structural steel drawing. Therefore, the employer can expect that the graduate can be productive in structural steel detailing and design of the individual elements.

REINFORCED CONCRETE DESIGN

Two-thirds of the institutions, a smaller proportion than in steel, require work in reinforced concrete design. The number of classroom hours is approximately the same as for structural steel; however, it is not nearly so clear whether the technician would actually understand the design problems. Since it is not a matter of selecting shapes and sizes from a catalog and since reinforced concrete is necessarily rigid and indeterminate, it is likely that only a smaller range of elements can be covered. An examination of catalogs indicates that simple beams are the only element covered in the majority of the courses. The technician employer will probably find that only a general understanding can be expected. This should be sufficient for catching errors in bar placement on inspection and for drawing work in this field.

TIMBER DESIGN

Fifty percent of the institutions require a course in this field. This and the distribution of classroom hours indicate a fifty percent probability that the technician will be able to design timber structures. These statistics and the relatively small emphasis on timber as a material, as indicated in Table V, show that no real mill design can be expected.

INDETERMINANT ANALYSIS

The small numbers involved here clearly delineate the extent of technician design ability. Continuous, rigid and other structures of any consequence should not be entrusted to the civil engineering technician for design. All significant structures involve some degree of rigidity and cannot properly be analyzed by the design principles the technician has learned. Of course, all welded and reinforced concrete connections are indeterminant. Technicians can certainly learn on the job some factors to make them of more value in design; however, their background would still restrict the extent of their ability in structural design.

TABLE X

SPECIFIC DESIGN COURSES

These courses could either build upon the structural design study as integrated courses, or it is possible that these could be completely separate from the preceding study areas.

ARCHITECTURAL DESIGN

It is apparent that the civil engineering technicians, as defined in this paper, are not taught problems in architectural building design. The other programs excluded from this survey, such as building and construction technologies, probably would go into this in more detail. The survey instrument pointed out that design, not architectural drawing, was being measured. Architectural drawing included in Table XV involves somewhat more emphasis; however, even there only a small number of institutions include this in the curriculum. The curriculum analysis would indicate that current programs do not turn up graduates who can be of use both in structural engineering organizations and in architectural organizations.

BRIDGE DESIGN

Obviously, the design of a bridge must be the responsibility of an engineer. However, this course was designed to measure the extent of the technician's knowledge in this field. Even though many of these technicians will work for bridge divisions of highway departments, it is not likely that they will have studied bridges to a significant extent. It had been theorized that they might at least be taught the geometric design of the relative merits of various bridge styles. This is apparently not true. With their knowledge of structural steel and reinforced concrete design, they will be able

TABLE X

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Architectural Design	Bridge Design	Highway Design	Individual Project
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	0	0	13	0
83rd percentile (number of hours)	11	10	78	0
Median no. of laboratory (hours)				
Percent of schools requiring (%)	26	37	70	11
Percent of schools, optional (%)	11	19	7	30
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	20	50	80	10
Percent of schools, optional (%)	20	20	10	50
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	27	36	82	9
Percent of schools, optional (%)	9	27	9	27
UNIVERSITIES				
Percent of schools requiring (%)	33	17	33	17
Percent of schools, optional (%)	0	0	0	0

to learn on the job that they would not be productive upon employment.

HIGHWAY AND GEOMETRIC DESIGN

Seventy percent of the programs require courses, and the distribution of classroom hours indicates that civil engineering technicians will have some knowledge of highway design. This is probably limited to a brief comparison of various paving materials, pavement thickness selection from empirical formulas, and use of standard codes for dimensions. It is not likely that they will have studied traffic engineering and other specialties, but they probably could adapt themselves to work in most divisions and most aspects of highway work. Many of the programs involve a co-op program with highway departments; it can certainly be expected that these students will know the relationships of highway planning, programming, route selection design, construction maintenance and scheduling. With this background they probably could also be of value in financing estimates and detailed design.

INDIVIDUAL PROJECTS

Although the A.S.E.E. recommendations strongly favor such an activity to integrate the knowledge learned in the various courses, very few institutions have such an activity. In view of the surprisingly low frequency of this requirement, an attempt was made to verify this fact. Apparently some institutions have a degree of cases or project work; it is aimed at a specific topic so that more new information can be taught instead of integrating the other courses. The principal conclusion that may be drawn from this is that the graduate technician will require a brief period of time to adjust to the actual job situation.

TABLE XI

SANITARY ENGINEERING DESIGN

These courses may not be strictly in the field of sanitary engineering, but they are combined here because of their mutual dependence upon public health principles and hydraulics. We have already seen that approximately half of the programs involve a study of hydraulics, and so this cannot be depended upon. The combination of these fields is an indication of the flexibility of the technician. Several experts recommend that civil engineering technology is too broad for a single curriculum and that options in sanitary, as well as highway and construction should be planned for second year specialization.

DRAINAGE DESIGN, SEWERS AND CULVERTS

There is a fifty-fifty chance of the technician having studied in these fields. There is no distinction between institutional organization on this subject and we will later see the relationship between the faculty work experience and the tendency for this to be included. The unusual distribution of classroom hours would indicate that schools either offer no classroom hours at all, or a full course of twenty-five hours or so. Therefore, the employer must look at the individual curriculum to find out whether the graduate can be used to plan drainage structures. Culvert and storm sewer selection can only be handled on a rational basis after a full course is taught.

WATER SUPPLY, SEWAGE, TREATMENT AND COLLECTION

The statistics show that the technician will probably not have studied in this area. It is surprising that almost as many schools list

TABLE XI

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Drainage Design	Water Supply	Sewage Treatment	Public Health
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	1	0	0	0
83rd percentile (number of hours)	25	0	11	1
Median no. of laboratory (hours)				
Percent of schools requiring (%)	52	26	19	4
Percent of schools, optional (%)	11	22	22	22
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	60	30	20	10
Percent of schools, optional (%)	10	30	30	40
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	55	18	9	0
Percent of schools, optional (%)	18	27	27	18
UNIVERSITIES				
Percent of schools requiring (%)	33	33	33	0
Percent of schools, optional (%)	0	0	0	0

these subjects as optional as require them. Apparently the institutions having such courses arrange for options within the civil engineering technician program. A graduate, therefore, would have to be recognized as having had this option for the employer to expect any proficiency. There is no significant difference between the emphasis on the two major headings here.

PUBLIC HEALTH

Since it had been suggested that civil engineering technicians could be useful as sanitarians, this item was included. It can positively be stated that the general civil engineering technician is not qualified in this field without further training.

TABLE XII

CONSTRUCTION METHODS

The following subject areas would develop sufficient understanding in the various specialties to allow a graduate to work for contractors or to do inspection if taught. The limited definition of this paper excluded programs aimed specifically at this field and so the general question to be answered here concerns the ability of the technician, with a general background to be of value in construction. By consensus in the industry, heavy construction involves earth moving, highways and engineering structures, such as dams. This is differentiated from light construction involving buildings. Contracting organizations typically are smaller and are concerned with immediate problems. They are not able to offer on-the-job training and require experience or immediate usefulness of their employees. The Associated General Contractors have been reluctant to even involve much in the way of apprentice programs and have made several public statements concerning the need for education of technicians in construction. A recent example is that of Mr. James Chase, Executive Secretary of the Michigan A.G.C., speaking on ipril 1, 1966 in East Lansing. He said that there was a vacuum in the construction industry. He also said that there are few skilled personnel being turned out by the universities for construction and consequently "tradesmen must make too many decisions on construction." There is an apparent opportunity here for technicians who would know enough about construction to provide the link between design and actual construction. One factor restricting the amount of construction is the shortage of this type of person. This person would understand computers as used in construction and the problems of design and would also know enough of construction practices and methods for translation.

TABLE XII

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Heavy Construction	Light Construction	Residential Construc.	Conservation Organiza.
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	2	0	0	0
83rd percentile (number of hours)	36	38	0	22
Median no. of laboratory (hours)				
Percent of schools requiring (%)	44	33	22	48
Percent of schools, optional (%)	11	11	11	11

COMMUNITY, JUNIOR COLLEGES

Percent of schools requiring (%)	40	30	20	40
Percent of schools, optional (%)	20	30	30	30

TECHNICAL INSTITUTES

Percent of schools requiring (%)	55	36	18	55
Percent of schools, optional (%)	9	0	0	0

UNIVERSITIES

Percent of schools requiring (%)	33	33	33	50
Percent of schools, optional (%)	0	0	0	0

HEAVY CONSTRUCTION

About one half of the institutions require a course in heavy construction; however, the number of classroom hours indicates that only a few hours would be involved for most schools. Apparently there are some general lectures on equipment and definitions. It must be concluded that the general civil engineering technician cannot be expected to be of value in heavy construction. Those programs under the heading of civil engineering technology that have some instruction in this area apparently are planned for specific use, such as highways.

LIGHT CONSTRUCTION

An even smaller emphasis is placed upon architectural construction. Strictly residential construction is practically ignored. The civil engineering technician is not being trained for these fields. This industry either must get people from construction technology programs (whose graduates would not be trained to be of value to the civil engineer), or additional courses would have to be taken upon the conclusion of a two year civil engineering technology program.

CONSTRUCTION ORGANIZATION AND PLANNING

There is a fifty percent probability that the technician would have learned something of the methods by which construction is planned. Large contracting organizations and related organizations have developed considerable science of organizing and planning in their work. Apparently it is much more expected of the employer than of the technician.

TABLE XIII

ECONOMICS ANALYSIS AND FINANCIAL ACCOUNTING

These study areas of economics analysis, planning, cost estimating and accounting are combined because of their relationship. Under some definitions these could be construed as general education for the technical person; however, they have definite job applicability and, therefore, are separated. In the education of the engineer, as well as the technician, a conflict of opinion exists in this area. Some experts recommend their inclusion in a curriculum so that the technician will see the physical aspects of his work, while others recommend concentration in the technical specialty and object to the dilution of effort by the inclusion of subjects. It will be of interest to see what pattern the curricula actually take.

ECONOMIC ANALYSIS AND PLANNING

Very little effort is included in the curricula in either of these areas. Only university programs seem to have a real interest in this area. Therefore, the technician cannot be expected to understand the business or financial aspects of his work.

COST ESTIMATING AND ACCOUNTING

It is surprising that only half of the institutions offer courses in cost estimating, since it is often suggested that the graduate technician could be useful in this field. The lack of courses is particularly noticeable among the community colleges. Accounting and business courses in general are only listed in university related programs. Apparently the employer of a technician will have to make most cost estimates himself. The consult-

TABLE XIII

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Economic Analysis	Planning	Cost Estimates	Accounting, Business Management
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	0	0	0	0
83rd percentile (number of hours)	0	0	51	0
Median no. of laboratory (hours)				
Percent of schools requiring (%)	33	7	48	19
Percent of schools, optional (%)	26	22	11	26
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	20	0	30	0
Percent of schools, optional (%)	40	40	20	50
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	36	0	55	18
Percent of schools, optional (%)	18	18	0	9
UNIVERSITIES				
Percent of schools requiring (%)	50	33	67	50
Percent of schools, optional (%)	17	0	17	17

ing engineer is certainly required to provide estimated costs, as well as control, on the projects for his clients. The government organizations employing technicians are also required to provide such information. It is recognized that judgment must be used in cost estimating; however, the preliminary and basic data, such as material take-offs, could be done by a technician, if he has had such a course. Responses to the survey, however, show that he probably has not had much instruction in this field.

TABLES XIV, XV AND XVI

DRAFTING AREAS

The next three tables represent a detailed analysis of the content in drawing courses. This is to be distinguished from design courses, in that the skill of drawing together with knowledge concerning proper graphic presentation is being studied, not the principles underlying the design itself. This organization was felt necessary to arrive at a better understanding of the technician's actual functions and capabilities.

MECHANICAL DRAWING AND LETTERING

All technicians have taken courses in principles of drawing, with a median of forty-eight classroom hours, of which forty-five would be laboratory hours, being recorded. This shows that a rather high degree of general drawing skills can be expected. Various projections and views, as well as graphic terminology, will certainly be taught. The extent of time spent on lettering would depend upon the individual instructor; however, the principles of dimensioning and layout can also be expected.

DESCRIPTIVE GEOMETRY

Although more than half of the institutions require such study, the distribution of classroom hours is low and indicates that a truly complete course in descriptive geometry cannot be expected of the graduate. The distribution of hours also indicates that a small proportion of schools do teach a large number of hours. Therefore, the top seventeen percent of the institutions, having sixty or more classroom hours, have the equivalent of a regular engineering level course.

TABLE XIV

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Mechanical Drawing	Descriptive Geometry	Sketching & Perspectives	Inking
17th percentile (number of hours)	15	0	0	0
50th percentile (number of hours)	48	0	4	6
83rd percentile (number of hours)	100	60	17	16
Median no. of laboratory (hours)	45		4	
Percent of schools requiring (%)	96	59	63	48
Percent of schools, optional (%)	4	15	4	15
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	100	80	70	80
Percent of schools, optional (%)	0	10	10	10
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	91	55	55	45
Percent of schools, optional (%)	9	18	0	18
UNIVERSITIES				
Percent of schools requiring (%)	100	33	67	0
Percent of schools, optional (%)	0	17	0	17

TABLE XV

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Scribing	Structural Steel Drawing	Rein-forced Concrete Drawing	Archi-tectural Drawing
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	0	36	10	0
83rd percentile (number of hours)	1	110	56	88
Median no. of laboratory (hours)		33	10	
Percent of schools requiring (%)	7	78	59	37
Percent of schools, optional (%)	26	4	15	11
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	10	90	60	40
Percent of schools, optional (%)	50	10	20	30
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	0	82	73	45
Percent of schools, optional (%)	18	0	18	0
UNIVERSITIES				
Percent of schools requiring (%)	17	50	33	17
Percent of schools, optional (%)	0	0	0	0

TABLE XVI

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Cartography	Plats	Highway Drawings	Charts, Drawings
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	0	0	12	0
83rd percentile (number of hours)	17	10	34	6
Median no. of laboratory (hours)			10	
Percent of schools requiring (%)	52	63	63	22
Percent of schools, optional (%)	15	0	0	15
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	70	90	70	30
Percent of schools, optional (%)	20	0	0	20
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	36	55	82	18
Percent of schools, optional (%)	18	0	0	18
UNIVERSITIES				
Percent of schools requiring (%)	50	33	17	17
Percent of schools, optional (%)	0	0	0	0

SKETCHING AND PERSPECTIVES

There is a reasonable probability that the technician can do sketching; however, even the top seventeen percent of the institutions do not require more than seventeen classroom hours on this topic. This is the reverse of the situation for descriptive geometry. A comparison of these first three fields would indicate that the civil engineering technician graduate will be able to provide informative drawings formally or informally. However, he should not be expected to be able to solve problems graphically without further on-the-job training.

INKING AND SCRIBING

The low percentage of institutions requiring these courses and the small amount of classroom time expected shows that the technician will probably have some difficulty if he is expected to prepare permanent drawings. The civil engineering field is somewhat different from other technologies in its requirements, since many applications would require a form of permanent record. Utility drawings, property drawings and locations of underground utilities must be treated in such a way that they can be referred to seventy-five or one hundred years later. It is, therefore, somewhat unfortunate that more time is not placed in this. It is possible that microfilms and other special processes will solve the problem in some occupations; however, smaller organizations still depend upon drawings themselves. It seems that the drawing courses for civil engineering technicians are generally taught by persons more familiar with mechanical and industrial drawing. In these industries there is very little need for permanent drawings and inking is regarded as an anachronism.

STRUCTURAL STEEL AND REINFORCED CONCRETE DRAWINGS

Both of these skills can be expected of the technician to some extent. The techniques of structural steel conventions and symbols are more heavily emphasized than would be the bar schedules and conventions of reinforced concrete. It is to be observed that the programs affiliated with universities have a much smaller emphasis on these particular areas. This may reflect the fact that engineering faculty members have little concern with subjects of steel detailing practice.

ARCHITECTURAL DRAWING

As previously observed, under the heading of architectural design, most institutions ignore this subject; however, those that do teach it offer a considerable number of hours. There is no degree of knowledge that can be expected of all technicians.

CARTOGRAPHY

Map making is required in fifty percent of the institutions, with a smaller number of classroom hours involved. It is possible that this subject is even taught within a surveying course as often as it is taught in a drafting course. Topographic drawing is related to cartography; however, it is very definitely taught within the surveying courses, since it is impossible to do topographic surveying without a knowledge of the drawings that result from the survey.

PLATS

It is quite likely that the technician will have been taught something about land plats and the drawings necessary for the approval of subdivision layout. There is not enough classroom time necessary to teach the principles that lie behind the drawing, but these would be taught in related courses. The technician should be able to adapt to the specific legal requirements of plats within a given state.

HIGHWAY DRAWINGS

There is a two-thirds probability that the technician will be able to prepare highway plan and profile drawings. It is possible that he will know something of mass diagrams and other specific types of highway drawings. It is to be observed that the university related programs neglect this, as they do structural drawings.

CHARTS AND DIAGRAMS

This topic was included in the survey to determine the likelihood of the technician's having skills to present graphic information. Display graphs, statistical charts and scheduling devices are not taught and, therefore, the employer would have to provide on-the-job training if the technician is to be able to make proper charts.

TABLES XVII, XVIII AND XIX

SURVEYING

Surveying is another area of study wherein the detailed breakdown must be made. There is as much difference between second order and third order surveying as there is between eighth grade arithmetic and differential equations. Surveying technology programs were included in this survey if it seemed that the graduate would be working on engineering projects for engineers. Those programs that are for land surveyors did not chart the definition of this study and were excluded. There have been recommendations for additional programs specifically for surveying and it will be of value to determine the relative merit of general and specific programs.

PLANE SURVEYING

Measurement based upon assumptions of a plane surface is the elementary course. One hundred percent of the institutions require such study. A very large amount of time is spent on this subject. Of the median eighty-three classroom hours, twenty-nine are lecture and the other fifty-four are laboratory or practice hours. This would guarantee that the technician will know how to use the equipment for measuring distances, angles and elevations, using conventional equipment. Third order precision can be expected and some degree of skill and efficiency can be expected of the graduate. With this amount of instruction the graduate can perform as an instrument man on conventional work and could become a party chief with a small amount of on-the job training. He will be able to use vernier instruments and should be adaptable to different models.

TABLE XVII

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Plane Surveying	Instrument Adjustment	Geodetic Surveying	Optical Micrometer Use
17th percentile (number of hours)	45	0	0	0
50th percentile (number of hours)	83	10	14	0
83rd percentile (number of hours)	133	20	30	17
Median no. of laboratory (hours)	54	6	10	
Percent of schools requiring (%)	100	85	37	37
Percent of schools, optional (%)	0	0	7	11
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	100	100	50	50
Percent of schools, optional (%)	0	0	10	20
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	100	73	27	36
Percent of schools, optional (%)	0	0	9	9
UNIVERSITIES				
Percent of schools requiring (%)	100	83	33	17
Percent of schools, optional (%)	0	0	0	0

TABLE XVIII

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Route Surveying	Topo-graphic Surveying	Cadas-tral Surveying	Surveying Law
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	49	8	3	4
83rd percentile (number of hours)	110	48	47	20
Median no. of laboratory (hours)	30	5		
Percent of schools requiring (%)	93	81	63	41
Percent of schools, optional (%)	4	7	19	15

COMMUNITY, JUNIOR COLLEGES

Percent of schools requiring (%)	90	90	50	20
Percent of schools, optional (%)	0	10	40	40

TECHNICAL INSTITUTES

Percent of schools requiring (%)	91	82	73	64
Percent of schools, optional (%)	9	9	9	

UNIVERSITIES

Percent of schools requiring (%)	100	67	67	33
Percent of schools, optional (%)	0	0	0	0

TABLE XIX

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Photo-grammetry	Celestial Observa-tions	Stadia	Construction Surveying
17th percentile (number of hours)	0	0	0	0
50th percentile (number of hours)	8	9	7	8
83rd percentile (number of hours)	46	21	17	30
Median no. of laboratory (hours)	5	7	4	4
Percent of schools requiring (%)	41	41	81	
Percent of schools, optional (%)	22	11	0	
COMMUNITY, JUNIOR COLLEGES				
Percent of schools requiring (%)	40	60	90	
Percent of schools, optional (%)	40	20	0	
TECHNICAL INSTITUTES				
Percent of schools requiring (%)	36	36	91	
Percent of schools, optional (%)	18	9	0	
UNIVERSITIES				
Percent of schools requiring (%)	50	17	50	
Percent of schools, optional (%)	0	0	0	

INSTRUMENT ADJUSTMENT AND REPAIR

Most of the institutions teach the adjustment of transits and levels. The median of ten classroom hours, six of them in practice, should be sufficient to make routine adjustments. It should also be sufficient for the technician to learn the first lesson: that thorough checking must be done before attempting adjustment.

GEODETIC SURVEYING

First and second order work are apparently not as often taught. Just over a third of the programs require this. The distribution of classroom hours shows, however, that half of the schools involve fourteen or more hours. Therefore, it can be concluded that the technician will not be proficient in geodetic work upon graduation. A much larger amount of time would be needed to develop the detailed techniques and calculation procedures.

OPTICAL MICROMETER USE

Fewer than half of the programs indicate work on optical micrometer instruments. They will, therefore, have to learn this on the job. A similarity of curriculum is observed with the subject of geodetic surveying and this is to be expected, because such programs involve theodolites. Most theodolites in current use involve optical micrometers. It would seem that, for engineering surveys, such instruments would often be required and it may be that their omission is due to the reluctance of institutions to invest in this type of expensive equipment. A peculiarity of surveying instruments is the retention of value over a long periof of time and the increasing tendency to avoid replacement.

ROUTE SURVEYING

This is a normal second course offering following plane surveying. It is required by almost all institutions. There is a reasonable distribution of classroom hours and it can be concluded that the graduate can perform in this field. Thirty of the median total of forty-nine classroom hours are spent in the field. An examination of course descriptions indicates that the following topics are definitely included: curves, horizontal and vertical, earthwork, slope staking and on miscellaneous highway surveys. Other specialized topics could not be depended upon as much.

TOPOGRAPHIC AND HYDROGRAPHIC SURVEYING

Three quarters of the institutions require study in this specialty. A distribution of classroom hours is irrigular and there is a considerable range of classroom hours. Hydrographic surveying was included in this category because of its close relationship; however, it is expected that such activity is a minor part of the study.

CADASTRAL AND PROPERTY SURVEYS

Two thirds of the institutions teach this. It is noticeable that almost all of the technical institutes and universities require it, while only half of the community colleges do. Of the two-thirds of the programs required, most will include land description systems, such as the public land system. Small property surveys would not call for any special techniques over and above plane surveying; however, an appreciation of the peculiar problems and appropriate precision is important.

SURVEYING LAW

This topic could be considered to be duplicating the preceding headings. The difference is that the question here asked for requirements in law related to property rights. The study of law necessary for licensing and practice as a land surveyor is not covered well in civil engineering technician programs. It is not likely that he would know the relative strengths of conflicting property descriptions. It is quite clear that a civil engineering technician could perform field work for a land surveyor, but could not act as a party chief or assume responsibility for the resulting information in general. On the other hand, the civil engineering technician does have a knowledge of roads and other general topics. Therefore, a civil engineering technician could be of value to the land surveyor, but would need additional work experience to properly conduct such surveys. The programs designed particularly for surveying technicians can develop people who would be able to do land surveys, but it is likely that they would be of limited value in subdivision planning and particular problems involving a knowledge of applice engineering.

PHOTOGRAMMETRY

It is not likely that the technician will have enough knowledge of photogrammetry to be of value immediately upon graduation. There is a fifty percent probability that he will know enough about the topic to learn on the job.

CELESTIAL OBSERVATIONS

There is only a fifty percent probability that the student would have studied this field and so he may not be able to determine bearings and other factors from solar or stellar observations.

STADIA

Most of the programs involve some knowledge of stadia and, therefore, there is a reasonable expectation of proficiency here. Although this technique is quite old, it is an indication of the type of surveying that the civil engineering technician could do. Even with the indicated coverage of stadia principles, he should be able to adapt to geodetic methods for using stadia. The type of stadia used in plane table work, precise leveling, and subtense bar usage can be handled by the technician, but probably not by the land surveyor.

The study of plane tables and alidades is somewhat related here. A preliminary examination of catalogs and experience indicated that very little plane table study was done and that even if it were taught, very few employers would be interested in its use in this country.

CONSTRUCTION SURVEYING

The number of classroom hours was recorded; however, the second questionnaire did not include this study area. This was eliminated because of confusion between it and general surveying. The particular techniques for construction surveying depend to a large extent on the individual surveyor and, with the exception of batter boards, it is not a significantly different or identifiable field of study. It is more concerned with manual techniques, such as driving stakes and unusual markings, than with practices that are commonly accepted in the industry. A more identifiable area of study might have been the surveying related to major equipment installation and industrial layout. The use of particular instruments, such as collimators and wires and working with millwrights could be taught, together with the surveying done in the air frame manufacture. The preliminary analysis of catalogs indicates a negligible interest in these topics.

TABLE XX

MISCELLANEOUS

The last three study areas are included here because they have not seemed to fit into the other categories.

WELDING PRINCIPLES AND PRACTICE

There is little probability of the technician's having any exposure to welding, outside of that which might be taught in the structural steel design. This field was included because of the interest in using the civil engineering technician for inspection of major construction. It must be concluded that under the present curricula, the technician should not be expected to inspect this aspect of construction. There is little likelihood that welding inspection can be effective when the inspector is unfamiliar with the process. In addition to this, there is a normal apprehension of the process on the part of the neophyte. It would be very helpful if the technician could at least have the opportunity to do a small amount of welding so that such apprehension could be overcome.

ENGINEERING LAW

There is a high probability that the graduate of a technical institute program will have studied this area. There is a very low probability for graduates of other programs. When taught, this would include contracts and agency principles as well as particular documents. Since the technical institutes are teaching most of the courses here, it is probable that the applications will be stressed much more than the underlying bases of common law equity and the judicial process.

TABLE XX

CLASSROOM EFFORT ON SPECIFIC COURSES
BY TYPE OF INSTITUTION

ALL RESPONDING SCHOOLS	Welding	Law	Ethics	
17th percentile (number of hours)	0	0	0	
50th percentile (number of hours)	0	4	0	
83rd percentile (number of hours)	1	31	10	
Median no. of laboratory (hours)				
Percent of schools requiring (%)	15	56	26	
Percent of schools, optional (%)	30	11	11	

COMMUNITY, JUNIOR COLLEGES

Percent of schools requiring (%)	20	30	20	
Percent of schools, optional (%)	60	30	30	

TECHNICAL INSTITUTES

Percent of schools requiring (%)	9	91	36	
Percent of schools, optional (%)	18	0	0	

UNIVERSITIES

Percent of schools requiring (%)	17	33	17	
Percent of schools, optional (%)	0	0	0	

ETHICS

Although the preliminary investigation showed that this was not likely to be taught, it was included because of a general concern in technical fields. Much of the criticism of engineering and technician education by the employers and professional societies has been directed toward the problems of professional practice. It is apparent that the technician will have had little exposure to the concepts of ethics. Whether this should be included is a matter of values and, therefore, no recommendation can be made.

C. Major Study Area Analyses

In this section of the report comparisons of the energy expended upon major categories will be analyzed. The headings of general education, manual skills, sciences and technical subjects will be used. As another dimension, comparisons will be drawn between the total number of classroom hours as one unit and percentage of the total curriculum as another unit. Although all of the programs are approximately two years in length, the total number of classroom hours vary considerably from one institution to another and, therefore, six hundred class hours might be forty percent of the total program for one institution and fifty percent for another institution. The total number of class hours, as shown in Table XXI, ranges from 1,220 for an institution at the seventeenth percentile to 2,000 for other institutions.

Another basis for comparison here will be on institutional size. Programs involving more than two faculty members and more than fifty students will be distinguished from the smaller institutions. All of the data appears in Table XXI.

DEFINITION OF MATERIALS USED

SCIENCE AND MATHEMATICS

These are the theoretical courses in basic disciplines, including chemistry, physics, biology and all mathematics courses, except the use of desk calculators.

COMMUNICATIONS

English and speech are the only topics included here.

TABLE XXI

DISTRIBUTION OF HOURS IN CLASS, AND OF PERCENTAGES OF TOTAL HOURS, FOR MAJOR CATEGORIES

Distribution Percentiles:	All Programs			Large Programs		
Classroom Hours:	P_{17}	P_{50}	P_{83}	P_{17}	P_{50}	P_{83}
Science, Mathematics	137	248	410	115	215	278
Communications, General Educ.	143	207	264	144	198	263
Engineering Sciences	101	219	375	180	253	391
Technical Specialties	596	780	1216	609	880	1359
Manual Skills	18	53	116	18	64	122
Total Hours by Institution	1220	1658	1914	1425	1706	2299
Percentages of Hours:						
Science, Mathematics	10.3	15.2	22.8	10.0	16.1	22.5
Communications, General Educ.	8.8	11.5	20.0	8.3	9.8	20.0
Engineering Sciences	7.6	14.0	22.1	9.4	14.8	21.7
Technical Specialties	38.1	50.7	64.1	39.1	51.4	61.7
Manual Skills	0.9	3.6	7.7	0.9	3.4	7.2

GENERAL EDUCATION

This is the total of study areas designed to improve civic knowledge, cultural appreciation, behavioral sciences, and the humanities. It includes the communication courses, social sciences, such as political science, humanities, such as history, management and economics courses. All courses in these fields are included regardless of their titles, because the actual teaching of the class determines the extent of direct application. Therefore, courses in technical report writing, psychology of human relations, and economic analysis are included. This definition of general education would not agree with that used for baccalaureate programs; however, it is necessary here because this is the definition used in technical institute evaluation. In reality, some general education is invariably taught in technical courses. The concepts of critical thinking and communications are usually accepted as general education and these are taught in many design courses. In addition to this, a knowledge and appreciation of astronomy is required in an advanced surveying course and a knowledge of governmental relationships is necessary in a highway design course, since the design is based on these relationships.

ENGINEERING SCIENCES

This includes geology, soils, metallurgy, properties of materials, statics, dynamics, thermodynamics, electronics, strength of materials, hydraulics, hydrology and meteorology.

TECHNICAL SPECIALTIES

This is the summation of studies in various direct applications.

It excludes manual skills, such as drafting and welding. It includes a wide variety of courses in construction, structural design, drafting applications, surveying, sanitary and highway design.

SKILLS

This includes those studies designed to improve manual skills and it includes lettering and basic drawing techniques, the use of desk calculators, welding and occasional other applications.

PROCEDURES

The total number of classroom hours in a given category was calculated for each institution. A distribution of these totals was then analyzed and the seventeenth, fiftieth and eighty-third percentiles of each distribution were recorded. The percentages were handled in the same way.

Large schools were selected on the following criteria. The number of students in the two year programs must be equal to or greater than fifty, as recorded in government surveys, and the number of full time faculty members, as recorded on the survey instruments, must be two or more who devote full time to teaching in the program. None of the small institutions are accredited by the Engineering Council for Professional Development. Some tabulations of technician data distinguish on the basis of this accreditation. It is felt here that some large and successful programs have not sought this E.C.P.D. accreditation and it would be misleading to include them with the small programs.

RESULTS

Science and mathematics range from ten to twenty-three percent of the effort for the center two-thirds of all responding institutions. It is apparent that there is no significant difference between the large and small institutions on this distribution. There is somewhat more noticeable difference when the number of classroom hours is the unit of measurement. The larger institutions consistently require fewer hours than the total of all institutions (including large and small). The total of all general education ranges from eight to twenty percent and one hundred forty-three to two hundred sixty-four classroom hours. A striking similarity is noticed when the larger institutions are analyzed by themselves. It is also noticeable that this is not a normal distribution, as was the case for science and mathematics, wherein the median is approximately the average of the seventeenth and eighty-third percentiles. In this case it is apparent that almost all institutions are within a small range, while the top figures increase considerably.

Engineering science courses range from 7.6% to 22.1% of the total effort, a normal distribution. Here the larger institutions are consistently higher in their classroom hours. Apparently the large institutions tend more to the engineering sciences and away from general education to this extent.

In technical specialties a consistency is again recorded. These courses constitute the bulk of the curriculum and effort for all institutions. For this reason a breakdown within the technical specialties will be analyzed later.

Manual skills obviously call for a small effort in the education of civil engineering technicians. This is not affected by the size of the institution and the average of 3.6% of fifty-three classroom hours is very small. It is quite apparent that the civil engineering technician program is completely distinguished from the industrial technician and skilled trades education. There is no doubt that some confusion exists; however, these figures make it clear that the technician is much more closely related to the engineer than to the skilled craftsman. A construction foreman and a highly experienced survey man cannot be construed to be a technician and neither can the technician be expected to be proficient in these skills.

The total number of classroom hours has a large range. For a collection of two year programs, it is surprising that this discrepancy in classroom hours is so great for all sizes of institutions. Of course, a student can learn outside the classroom to a certain extent; however, much more can certainly be expected of those graduates having a larger number of classroom hours.

GENERAL DIRECTIONS OF CURRICULUM RECOMMENDATIONS

Table XXII is a tabulation of recommendations on civil engineering technician curricula as interpreted and translated from specific statements. Four sources of recommendations are shown as forces affecting the curriculum. These are: 1) The U. S. Office of Education recommendation publication entitled Civil and Highway Technology; 2) consultants represented by Dr. Norman Harris, of the University of Michigan; 3) The American Society for Engineering Education, as published in the Characteristics of Excellence in Engineering Technician Education, and employers of technicians, as represented by a tabulation of supervisors in the Michigan State Highway Department.

The publication of the Office of Education was difficult to quantify although a tabulation of recommendations was made. The report listed several fields as advisable and others as essential and it was adjusted to fit the definitions used in this chapter. For example, structural computations and estimating were included as mathematics and were shifted to technical specialties for this computation. It also listed statics, dynamics, and soil analysis as sciences and these were changed to engineering sciences to better match the categories of other groups.

The recommendations of Norman Harris were taken from interviews with him and his reply to the questionnaire used in this dissertation (Appendix A). Other consultants corroborating for recommendations were Mr. Raymond Stith and Douglas Libby, of the University of Dayton and Wentworth Institute respectively. The recommended core requirements are included in this category.

The employer's statement is a synthesis of research done at the Michigan State Highway Department by Mr. John Overhouse, of the Highway

Department. The supervisors of technicians were asked to quantify their recommendations and this was translated into equivalent credit hours.

All of the recommendations were translated into semester credits for comparison purposes and were proportionately adjusted to a uniform total of sixty-six semester credits.

Table XXIII compares the recommendations as percentages of the total effort with the actual percentages of surveyed effort. It is apparent that the greatest amount of congruency is noticed between the recommendations of the American Society for Engineering Education and the actual resultants. It may be inferred that the professional society is a more effective force on the curriculum than are the other groups.

TABLE XXII

CURRICULUM RECOMMENDATIONS IN MAJOR DIVISIONS TRANSLATED INTO EQUIVALENT SEMESTER CREDITS

	Equivalent Semester Credits			
	Office of Education	Consultants	A.S.E.E.	Employers
Mathematics	15	10	9	13.5
Sciences	9	10	6	0
Communications	6	5.5	6	6.5
General Education	3	4	9	2.5
Skills	6	4	6	16
Engineering Sciences	9	6.5	10	4.5
Technical Specialties	18	26	20	23
Total	66	66	66	66

TABLE XXIII

PERCENT OF CURRICULUM IN MAJOR DIVISIONS COMPARED WITH PERCENTS RECOMMENDED BY GROUPS

	Recommendations By				
	Actual Resultant Curricula	Office of Education	Consultants	A.S.E.E.	Employers
Mathematics	10%	22%	15%	14%	20%
Sciences	6	14	15	9	0
Communications	6	9	8	9	10
General Education	7	5	6	14	4
Skills	4	9	6	9	24
Engineering Sciences	15	14	10	15	7
Technical Specialties	52	27	40	30	35

CHAPTER IV

ANALYSIS OF FORCES BEARING ON THE CURRICULA

A study of the various groups and factors having an influence on the curriculum was made. The following independent variables are included: faculty, students, and the institutional organization. Throughout this chapter comparisons have been drawn between selected samples in order to determine possible co-relationships or associations between individual characteristics of the group and of the curriculum. In each case, the sample was selected to minimize the effect of other factors. Following the tehoretical framework of the dissertation, these items of faculty, students and institutional organization are defined as forces acting upon the curricula. The impact of the force is measured by the quantitative change in the general curricular description.

A. Faculty Characteristics

Each of the sets of questionnaires ask for information on the faculty. The first questionnaire asked about the number of years of teaching experience and the number of years of work experience related to the program. A controlled sample of institutions having representative inclusion of various organizational patterns and sizes was selected. Thirteen institutions comprise this sample. It is recognized that any measurement of these faculty characteristics would change from year to year and that one additional year of teaching experience would result from each succeeding year.

Therefore, the list of institutions was also checked for relative stability and assurance that they represented a typical instant in time.

It was found that the average faculty member had 7.3 years of teaching experience and 7.6 years of non-teaching experience. Since most of the non-teaching experience had to be gained prior to association with the civil engineering technician instruction, these figures have some special significance. It is apparent that a significant amount of work experience in the engineering field is normal for the faculty. The 7.6 years is probably larger than the number of years of professional non-teaching experience in liberal arts and other fields. The total range of such experience for reporting faculties was from two years to thirty years. There is little expectation that faculty would be hired immediately upon receiving a Bachelor's Degree.

Table XXIV lists the characteristics reported in the second questionnaire. The questionnaire asked to have "the general characteristics of the faculty responsible for the civil engineering technician curriculum by checking all appropriate boxes describing the faculty as the single person most representing groups involved."

It is apparent that most of the faculty are civil engineers; in fact, ninety-five percent of them have a Bachelor's Degree in civil engineering. At the same time it was reported that twenty-seven percent of the total groups have Bachelor's Degrees in other fields. Although certainly some faculty members have two Bachelor's Degrees, it is likely that institutions in this case would not respond describing the single person, but listed characteristics of additional faculty. Of major importance is the fact that fifty-five percent have Master's Degrees in civil engineering and sixty-eight percent are licensed by the state as registered professional

TABLE XXIV

FACULTY CHARACTERISTICS

Characteristics checked as describing the faculty as the single person most representing the civil engineering staff	Number of Institutions	Percentage of all Institutions
B.S. in Civil Engineering	26	95%
B.S. in Other Fields	7	27
M.S. in Civil Engineering	15	55
M.S. in Other Fields	5	18
Journeyman or Equivalent	1	4
Registered Engineer	18	68
Registered Land Surveyor	10	36%
More than two years experience in:		
Contract Construction	8	29%
Highway Department	15	57
Other Government Departments	0	0
Teaching, Education and Research	19	71
Industry, Manufacturing	4	14
Surveying	13	48
Private Practice, Consulting Engineer	15	57
Architectural Practice	3	10
Railroads	0	0
Sanitary Engineering	3	10%

engineers. Both of these percentages are much higher than the percentages for the total population of all civil engineers. The fact that thirty-six percent are registered as land surveyors would be normal, since about one half of the registered civil engineers are also licensed to practice land surveying. Licensing as a civil engineer includes granting of authority to conduct engineering surveys, while licensing as a land surveyor is required for the resolution of conflicts in property surveys.

The overall selection of programs under the definitions for this paper has screened out those programs not directly related to supervision by civil engineers. As a consequence, only one program had a faculty member listed as a journeyman in the construction trades. Respondents were then asked to check those fields in which the representative faculty member had more than two years of work experience. On this tabulation, institutions having checked more than four categories were eliminated. This was done under the assumption that they were probably checking the characteristics of several faculty members. The characteristics of most representative faculty members were desired in order to draw conclusions between the characteristic and the inclusion of technical specialty courses. It was also thought to be desirable as a means of interpreting results of this paper.

The table is self explanatory as a general description; however, a few comments might be made. It is interesting that no faculty reported having railroad work experience and that only a few came from the fields of sanitary engineering and affiliation with architects. The seventy-one percent having previous teaching and research experience is not a reliable figure, because this probably includes their experience in the program. Another question to pursue in the future might be the determination of those who join the faculty from other teaching experience, such as civil engineering departments of universities. The faculty have a fairly broad range of work experience, although the number having had contract construction experience was somewhat lower than would be expected.

FACULTY AND CURRICULUM CHARACTERISTICS

A measurement of the significance of associations between selected faculty characteristics and selected curriculum characteristics was made. It is difficulty to prove a causal relationship; however, the significance of these relationships is still of value in helping to predict the abilities of a civil engineering technician. A sub-group of institutions, whose faculty have a common characteristic, such as a work experience in surveying, was compared with another sub-group not having the surveying experience, to determine any difference in the surveying instruction. Two opposite theories could explain associations. It is possible, for example, that the faculty member having had surveying experience would logically teach and require more surveying. It is also possible that the engineer, having had work experience in a given field, might assume that such a field would be the function of the engineer, and might not require or teach it for the technician. A future study to resolve this conflict of theories might be conducted by interviewing or surveying faculty members. Such a procedure is not included in this paper because it will be possible to show what the association between selected factors is without explanation. This type of information would be of value in predicting the characteristic of the civil engineering technician.

A controlled group of twenty-one programs was selected for the first analysis. Ten of these had faculty with surveying experience and eleven of them had faculty without surveying experience. The other variables were held constant. Since almost all of the institutions required a basic knowledge of surveying, this was not included in the analysis. Four areas were selected within the surveying field. These were areas where approximately one-half of the institutions required such study. The compilation of required courses in comparison with faculty experience yielded the following distribution:

		Cadastral		Laws		Photogrammetry		Celestial	
		Req'd.	Not Req'd.	Req'd.	Not Req'd.	Req'd.	Not Req'd.	Req'd.	Not Req'd.
Survey	a)	8	2	6	4	7	3	8	2
No Survey	b)	5	6	4	7	2	9	2	9

Since proper analysis requires more than five units in such 2 X 2 tables, the four sub-headings were combined to give the following results:

	Required	Not Required	Total
Survey	29	11	40
No Survey	13	31	44
Total	42	42	84

Chi-squared calculation, using Yates' correction, was made. The value of chi-squared was 10.24, indicating a highly significant association with the 0.1 level of significance. Apparently there is a strong relationship between the inclusion of such surveying specialties and the surveying experience of the faculty.

A completely opposite result was determined from a similar calculation of highway department experience and the extent of required highway courses. The figures for these courses were:

Experience	Bridge Design		Highway Design		Highway Drawing		Asphalt	
Highway Dep't.	2	10	8	4	9	3	9	3
No Highway Dep't.	4	5	7	2	5	4	5	4

Experience	Required	Not Required	Total
Highway Dep't.	28	20	48
No Highway Dep't.	21	15	36
Total	49	35	84

Again, a summary of the four courses was made involving twelve institutions whose faculty had highway department experience and nine without such experience. The value of chi-squared for this association is 0.05. No association exists.

A third comparison was made with six institutions whose faculty had construction and architectural experience, with thirteen whose faculty did not have such experience and these were compared with the following construction related courses:

Experience	Heavy Constr.		Light Constr.		Resid. Constr.		Constr. Organiz.	
Construction & Architecture	5	3	4	4	2	6	5	3
No Construction or Architecture	4	9	2	11	1	12	4	9

Construction	16	16	32
No Construction	11	41	52
Total	27	57	84

The value of chi-squared for this association was 6.29, a significant co-relation at the one percent level of significance.

The null hypothesis that there is no difference in the curricula of institutions having diverse faculty experience must be accepted in the case of highway work and rejected in the other two situations. Clearly this data does not support a general statement that faculty will teach more extensively in the fields of their own experience. However, the high degree of correlation in the surveying courses and experiences would support a special statement that specialized topics of surveying are taught in approximately half of the total number of institutions reporting. Those institutions which have faculty with two or more years of experience in surveying will include the more specialized topics of cadastral or land surveying, surveying law, photogrammetry and celestial observations for azimuth.

Courses in construction methods and organization are more likely to be taught in institutions whose faculty has had two or more years of experience in contract construction. Apparently these faculty members feel that the technician can assume many of the functions formerly assigned to engineers. The opposite case is observed in highway work. Although the data is too limited to derive general conclusions, it would seem that the highway engineers who have joined technician faculties feel that bridge design is not an appropriate subject for the technician. This particular point was examined in more detail by interviews with Michigan State Highway Department engineers. They feel that bridge design is presently organized in such a way as to minimize the role of the technician. Apparently the geometric decisions are a matter of policy set by the Bureau of Public Roads and other codes. There is little room for judgment or technical knowledge in making decisions concerning width, height, slopes and other geometric facts. Decisions regarding materials are a management decision, based more on economics than on engineering. Decisions regarding sizing of individual members and stress analysis are currently being done through a computer for those routine sections that may otherwise be assigned to the technician. Interviews with twenty-five supervisors with the Michigan State Highway department on all subjects proved inconclusive in several respects. These interviews are included in the abilities and show that the number of supervisors prefer a greater degree of specialization is just about the same as those who prefer less specialization. The number who prefer more practical work is about the same as the number requiring more theoretical work. These interviews, coupled with the correlation of highway experience and courses, present a dilemma. Apparently there is not a clear agreement and understanding by highway engineers of the function and role of the technician. At the same time highway departments are often the sponsors and driving force behind the establishment of civil engineering technician programs. This has been the case in at least five states, Michigan, Minnesota, Georgia, Massachusetts, and New York.

The influence of the technical faculty on the extent of general education was considered with the hypothesis that technical faculty having Master's Degrees might have different emphasis than that of the faculty with Bachelor's Degrees. Eight institutions whose faculty had Master's Degrees in civil engineering were selected and compared with another group of eight not having the Master's Degree. The two groups were selected to control other variables, such as institutional organization. The general education curricula of these institutions were tabulated as follows:

	Speech	Political Sc.	History
Faculty with M.S. in Civil Engineering	6	2	5
Faculty with B.S. in Civil Engineering	6	4	3

There is not observable difference in the selected courses and, therefore, it can be concluded that the Master's Degree for technical faculty does not influence the extent of general education courses in the curriculum. An effort was made to determine whether such a correlation would exist with any other characteristics of the technical faculty and no association could be determined. The institutional organization has been proved to have little effect on this and the only other possible force having a significant effect on general education might be the characteristics of the general education faculty. This was not studied in this paper.

B. Student Characteristics

General descriptive information about student bodies was obtained from the first questionnaire. It is, therefore, representative of civil engineering technician programs in the United States. The institutions were asked to check prerequisites for a student entering the program from a list of possible categories. The tabulation of these results is shown at the end of this section in Table XXV.

The magnitude and direction of force exerted by the students in civil engineering technology was measured. This part of the report deals only with students in three programs located in Michigan. These three programs constitute a form of a national sample, since one institution, Lansing Community College, is a public community college; the second, Ferris State College, is a public technical institute; and the third, Michigan Technological University, is a program run by a four year engineering college. Only a limited generalization, however, can be made from this sampling of the actual students.

ANALYSIS OF STUDENT CHARACTERISTICS

High school graduation is required for almost all programs, regardless of the type of institution. Only one of the surveyed programs does not require the diploma. It is quite possible that some institutions will accept an older student who can demonstrate ability on an equivalence test, but this would be an exception to the stated policy.

Previous work experience, related to the civil engineering field, is not required by any programs, as might be expected, and twelve reported that this is not even asked. The eight that indicate a desirability of such experience probably do so in theory only since it is not reflected in any recruiting brochures submitted with the individual reports. Related to this student characteristic is the fact that five of the twenty reports include work experience during the program. This co-op work is almost always related to the state highway department; such organizations have been directly responsible for the initiation of many programs.

A cut-off score of ability is required in about half of the programs, and seven have a required interest or aptitude test for entrance. A further examination reveals that the testing is not restricted to any certain organization pattern. The community colleges, and to a lesser extent, the private technical institutes, require some tests; it is not just these programs offered by universities that have admissions tests.

Male sex is rarely required and it is not even listed as being desirable by more than half of the schools. Since more than ninety-nine percent of the students actually are male, it would seem that social pressures are responsible for the lack of female students. An examination of a typical curriculum shows that a few dirty experiences may be required, but does not show any need for unusual strength. Concrete mixing and testing is dusty, but not any more of a problem than is encountered in cooking a big meal or in cleaning up blood in an emergency room. The female student should also be able to do surveying, since there is no inherent problem. Many girls successfully study surveying in our engineering colleges. It is too bad that more female students cannot be persuaded to enter a civil engineering technician program; they would probably even have an advantage in some of the areas, such as drafting and specialized testing. The 1958 tabulation of graduates of such programs showed 171 male and a single (1) female. The more recent studies did not break down the enrollment by sex, but some general statements indicate that the trend is not changing. High school counselors probably have enough difficulty in recommending engineering for girls and do not even attempt to recommend civil engineering technology.

In Table XXV a tabulation of four high school courses is made to get some indication of the type of high school curriculum that would best fit the requirements of the technology program. Drawing and shop courses, in comparison with physics and chemistry, show that a greater emphasis is placed upon the college preparatory courses. It is not likely that a student would take both sets of courses, since the time simply will not allow both, because of the allied courses in each case. The American Society for Engineering Education recommendations for any engineering technology entrance list a required physical science and enough mathematics that would rule out the student's having taken a typical shop course in high school (without taking additional courses before beginning the technology courses). This policy statement makes no reference at all to drawing or shop courses. It is quite apparent that the student should come from the same college prep classes as those of the engineering student, although possibly having lower grades. This probably accounts for some lack of enrollment in the civil technician and other engineering technician programs. Pride among peers certainly could make it difficult to choose the technician program. This factor would be lessened after a few years of separation and the consequent opportunity for other motivating factors, such as interest in application to specific problems, to affect the student decision. Nevertheless, it is quite clear that the successful student will have taken mostly academic courses in high school.

TABLE XXV
STUDENT CHARACTERISTICS

Characteristics of Students	Number of Institutions Reporting		
	Required	Desirable	Not Asked
High School Graduation	19	1	0
Previous Related Work Experience	0	8	12
Co-op Work During Program	5		
I.Q. or Ability Test Score	9	4	7
Interest or Aptitude Test	7	5	8
Male Sex	2	7	11
High School Drawing Course	2	7	11
" " Shop "	0	6	14
" " Physics "	6	9	5
" " Chemistry "	2	10	8

TABLE XXVI
CURRICULUM CHARACTERISTICS BY INSTITUTIONAL ORGANIZATION

	Type of Institution		
	Public 2 Yr.	Private T.I.	4 Year
Average Length of Institution in Months	18.0 mo.	18.0 mo.	18.2 mo.
Mean % of Curric. in Tech. Spec. Credits	52.5%	50.0%	55.7%
Mean % of Curric. in Gen. Educ. Credits	15.7	8.7	10.5
Difference in %'s	36.8	41.3	45.2

STUDENT MOTIVATION AND DIRECTIONS

Appendix E shows the actual responses of students to the question concerning their reasons for entering the program. The responses are summarized in Table XXVII. These represent the answers of students in the Michigan programs. A total of ninety-two students were interviewed. In order to get a true feeling without providing leading questions, the results are categorized from general statements. The open ended question was used to increase the validity of responses.

TABLE XXVII

REASONS GIVEN FOR ENTERING MICHIGAN PROGRAMS

Motivation for Entering Program:	Number	Percent
Immediate Needs of Money (Co-op Job Income)	15	16%
Transfer Credit Towards B.S. in Engineering	6	7
A Means to Any Education Beyond High School	17	18
Co-op, Needed a Job and an Education	31	34
Desire for Future Employment as Technician	23	25
Totals	92	100%

Only twenty-five percent of the students clearly indicated that they desired to become technicians. It might be expected that this would be the logical reason, and that most students should have checked this. The actual reasons for students entering any college program are complex and contradictory at times. In spite of information presented to students and information regarding any program, it has been shown that extraneous reasons, such as proximity to a girl friend, are often the real reason for student decisions. The fact that only twenty-five percent of these technician students in Michigan responded to the logical goal is a statement of fact. It might be deplored as poor counseling, but the reasons for students entering other programs, such as civil engineering or education, could be equally complex.

The shortsightedness of many students is apparent in the sixteen percent indicating an immediate need of funds and the eighteen percent indicating that this was a means to any education. In other words, the opportunity was there, so they took it.

The seven percent indicating a desire for work toward a degree in engineering would have desires for all transfer courses. Other students reaching some success in the technician program would decide later that they would desire a four year college education.

The complex goals of students in the programs would indicate that they have conflicting directions and thus, their resultant force on the curriculum is nullified. A very complete study of technician students' goals was reported in the book, "Managing Technician Manpower."[1] Although none of these students were in civil engineering technology, it is interesting that they also found a complex set of goals.

NUMBER OF STUDENTS

Several sources of data are available on the number of students actually in such programs. However, the data does not indicate a clear trend. One of the reasons for this is in the national failure to accept a given definition of civil engineering technicians and another reason would be the difficulties of making a total survey of all programs. Certain groups of programs, such as those run by specialized organizations,

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[1]Teamwork in Technology: Managing Technician Manpower, Brady et al, Technician Manpower Associates, 1959, pp. 67-77.

are difficult to contact. Table XXV shows a summary of these various tabulations.

TABLE XXVIII

SELECTED STATISTICS OF ENROLLMENT IN CIVIL ENGINEERING TECHNICIAN PROGRAMS

Enrollment of:	In the Year Beginning September		
	1957	1960	1962
Full Time Civil Technician Students	1,599	12,299	12,699
Civil Technician Graduates	379	1,754	1,772
All Full Time Engr. Technician Students	41,032	86,780	92,255
" " " " " "	39,815		
Graduates of All Programs	12,985	15,887	14,977
" " " "	13,432		

Sources:

1. Michael, Bernard: Department of Labor, Scientific and Technical Personnel in Industry, 1960, N.S.F., 1961.
2. The Long Range Demand for Scientific and Technical Personnel, N.S.F., 1960.
3. Patrick, Phillip, Tenth Survey of Engineer Technician Enrollments, University of Dayton, 1965.
4. Organized Occupational Curriculums, Office of Health, Education and Welfare, 1959.
5. Organized Occupational Curriculums, Office of Health, Education and Welfare, 1965.

The salaries of technicians have been reported each year by the Southern Technical Institute and the most recent listing for civil engineering technician graduates[1] shows an average starting salary in 1965 of $466 per month and a present salary of $559 per month for 1960 graduates. These are lower than the corresponding amounts for other engineering technicians.

C. Institutional Organization

A variety of United States institutions offer civil engineering technology. Of the thirty-five institutions offering programs within the scope of this paper and having at least twenty-five students or Engineers' Council for Professional Development accreditation, thirteen are public community or junior colleges, six are public technical institutes, five are private technical institutes, and eleven are four-year colleges or universities. In addition to these institutions, some other organizations conduct similar programs (such as highway departments).

In an effort to determine whether the organization pattern has any significant effect upon the operation of the program, a detailed analysis was made of the programs. Four leading institutions were selected to represent the public two year colleges: New York City Community College, Oregon Technical Institute, Broome Technical Community College, and Lansing Community College. Four were selected from the private technical institutes: Wentworth Technical Institute, Cogswell Polytechnical College, Milwaukee Institute of Technology, and Franklin Institute of Boston. Finally, four

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[1]Paul V. SMith, "Salary Survey Shows Growing Value of Engineering Technician Graduates," Technical Education News, February, 1966, p. 1.

of the university connected programs were selected: Southern Technical Institute, Iowa State University, Pennsylvania State University, and Michigan Technological University. Southern Technical Institute is now the Georgia Institute of Technology.

Table XXVI, Page 116, shows the only significant difference in the programs by categories. The programs affiliated with four-year institutions have the greatest difference in effort between applied specialty courses and general education courses. The community colleges have the least difference. Technical specialty courses are those relating to civil engineering, such as highway design and surveying. It does not include manual skills, such as general drafting, and it does not include engineering science, such as strength of materials. General education includes English, social sciences, humanities, and economics, even if there is an applied slant given to the course, such as in technical report writing or human relations in industry.

An examination of all other characteristics does not indicate any other consistent and significant variation. The entry standard and requirement, the size, the accreditation, and the types of faculty are similar. It should be noted that the private technical institutes have more Engineers' Council for Professional Development approved programs per number of institutions; however, in the group of institutions having true programs of satisfactory size, the accreditation tendency is the same.

The analysis of individual courses and study areas was tabulated in the preceding sections in such a way as to observe variations that would correlate with institutional organization.

CHAPTER V

CURRICULUM RECOMMENDATIONS

It is considered necessary to include a summary of interviews and correspondence with employers and educational consultants. All of the comments, suggestions and recommendations, except as noted, were in open-end interviews. The listing of study areas (Appendix A) was used as the basic survey guide. These were all personal interviews, except those noted.

Mr. George Langsner, Assistant State Highway Engineer, California Division of Highways, was asked for a recommendation on the relative merits of highway and a general civil engineering technician program. He noted in answer, "We would prefer a civil engineering technician as broader than a highway technician. The Los Angeles City College has an excellent civil engineering technician program - even in highways." He preferred the broader training even for specialists in the highway department. In more detail he recommended study in analytic geometry and at least fifty-four hours in calculus. He recommended a significant amount of time in these other fields: computer programming, English, speech, general education, portland cement (but not asphalt), statics, physics, strength of materials, structural steel design, reinforced concrete design, highway design, hydraulics, drainage design, heavy construction, light construction and construction organization, drawing and steel detailing, surveying, photogrammetry, and some free electives.

Various officials of the Michigan State Highway Department have made recommendations to this paper. In addition, they conducted a survey of their own personnel and made the following recommendations:

Type of Training: (depth of training in subject)

A questionnaire survey was made in the Road and Bridge Division to establish which subjects the technician should know. The results of this survey are shown on the attached bar graphs. Taking six terms as maximum in our two year training program and setting term values to the bar graph, the most important subjects are offered for:

Construction	1 term
Structures	1
Materials of Construction	1
Applied Mechanics	2
Mathematics	6
Drawing	5
Mapping	2
Surveying	3
Highways	2
Soils	
Drainage	1
Costs	1
Contracts	1
English	3

Mr. William H. Wisely, Executive Secretary of the American Society for Civil Engineers, was asked whether the society had taken any position on the subject of civil engineering technicians. He stated that they had not done anything up to this year; however, he stated that a task force was appointed at their last executive meeting (April, 1966) to study the subject.

Mr. Norman Harris, of the University of Michigan, had many valuable suggestions and opinions. He felt that the program should be for eighteen to nineteen months, with co-op being desirable, but not absolutely essential, and that the faculty should have a degree in engineering and significant work experience. He went through the list of study areas and made the following particular comments: that architectural design should not be included, but that most other subjects on the first page of the questionnaire should be included and that these should be combined into a basic core course. He had no comments to make on the second page of the questionnaire since civil engineering is not his field of specialty.

Douglas Libby, of Wentworth Institute, and Raymond Stith, of the University of Dayton, were interviewed at length. They were optimistic about the future of civil engineering technology. They did not feel that the definition should include the factor of working directly or indirectly for the engineer; they preferred a statement about working in broad civil engineering fields. Mr. Stith made a very strong argument for having five or six specialties or options within civil engineering technology. He stated that one of the problems in getting acceptance of technicians is their lack of depth in a specialty and stated, "I believe that more would be accomplished by offering only one of the specialties than by offering a combination of them."

Mr. Kenneth Fishbeck is a Consulting Engineer (Lansing, Michigan) and a member of the State Department of Public Instruction and on the Advisory Committee for Education. Mr. Fishbeck had previously been an engineer for the City of Lansing for a long period of time and is in the sanitary field of engineering particularly. His thoughts on the training of technicians are based on that background, as well as his consulting engineering practice which he has been doing for the past five or six years. Mr. Fishbeck's primary interest was that a technician have a thorough grounding in mathematics and, secondly, in English grammar. The mathematics could extend into analytical geometry or possibly into calculus.

He would hire technicians to do drafting work and surveying work in his field and would expect them to be able to manipulate mathematical functions and to do routine calculations for either the drafting or the surveying, both of which would involve considerable use of trigonometry and algebra. The English requirement would be that the person would be able to correctly understand given directions and make correct reports, using proper grammar. The actual composition of final reports to the client would be done by the engineer, not by the technician. A knowledge of drafting principles would be required, particularly the fundamental understanding of projections and the ability to help clarify surveying work that was done by the technician. Some possible building inspection work where the technician would be required to interpret the blueprints to the contractor would be infrequently required. A technician hired to do drafting work would be required to know much more about the principles of drafting. However, most of the drafting work involved with the consulting practice in sanitary engineering is apparently done by the engineer. The work done by the technician would be the routine work wherein only the knowledge of tools to be used and the scaling ability would be required. The technician should know something about the properties of materials in order to be able to visit a construction site as a representative of the consulting engineer and correctly interpret what is going on. A knowledge of physics is also of importance. It would give him the understanding of the principles involved in the design of structures related to sanitary engineering. It would be very desirable for a technician in this field to know something of chemistry in order to do some chemical tests, but again, this would be infrequent and possibly is done more now by the engineer than by non-engineers who are working for him. The composition of consulting the engineering offices of Mr. Fishbeck and those similar in practice is thus:

1. Principal or partner who is registered engineer.
2. Two or three graduate engineers to about one or two high school graduates.
3. Two technicians.
4. One clerical worker.

He said that it would be desirable to have as much cultural background as possible, meaning political science or history, but that this was certainly to be held secondary to the basics of mathematics, English and physics. A consultant would be very interested in getting a technician who is trained to be immediately useful as a draftsman instead of having to do any on-the-job training. The consultant would particularly not want to do any on-the-job training of his technical personnel; therefore, applied courses, such as architectural drafting and the like, would be very useful, but not important as the mentioned basic courses. We got off on a long discussion of the high school training of these technicians. High school graduates whom he has hired were not able to perform routine calculations and understand directions properly. He also felt that there was not a class distinction between the engineers who work for him and the technicians or high school graduates trained in some particular field, but rather that the natural aptitude of a person determined whether he would be good in applied things or whether he would be able to understand the theory. He felt that there were quite a few people whom he had employed who would not understand the theory very well and, consequently, would not be able to get a B.S. in Engineering, but who could apply the technical knowledge very well and with a high degree of skill. Of course, we would classify these people as technicians.

Mr. John McDermott is a Consulting Engineer, structural field, (Lansing, Michigan) and a member of the Engineering Society's Education Committee. The first thing that Mr. McDermott said in our interview was that he would like to be able to hire people who had a knowledge of mathematics. In exploring this further, he said he would like to have non-engineers who knew how to apply trigonometry and analytical geometry and algebra with rapidity and accuracy. He was also interested in having employees of technician capacity who understood English. His interest in English was along the composition lines. He wanted technicians who were able to write reports to the engineer and, upon occasion, to the client. These reports would concern the status of the job, results or routine testing, the summarization of computations, and so forth. He held everything else secondary to the knowledge of mathematics and English. In the structural field, or in the consulting engineering field of highway design, there is a sizeable need for technicians to do the drafting work and the routine computations involved in such structural and highway design. There are many sets of computations done on calculating machines which are routine. They can be done, under supervision, by someone not understanding the theory behind the calculations. These calculations represent a large amount of time in the designing office and it was suggested that the technicians be trained to do this. This work is now being done to a large extent by graduate engineers. Mr. McDermott thought it would be fine to have technicians who would be able to do this work. However, there are no such trained people available at the present time. The type of calculations involved use the knowledge of algebra, analytical geometry, and trigonometry and are based on parabolic curves and offsets to highway curves, as such. Mr. McDermott mentioned that there are probably very few technicians in the field now because not many have been trained. However, there is an opportunity here for wider use in technicians.

Mr. Elmer Manson, of a Lansing, Michigan architectural firm, is the past president of the Michigan Society of Architects. Mr. Manson was very interested in the technicians theory, the idea of training people to do applied work in the architectural field. However, he explained at great length what would probably happen to people in this field: that the construction industry represents a large section of our national economy, possibly fifteen to twenty percent of the gross national product. Accounting for that much money are a large number of people working in this field. In the designing or the architectural end of this building industry, the number of people involved is rather small compared with the number of people involved with the contraction end. He mentioned that a person working as a technician would very likely work for an architect for a few years and not, in most instances, become a permanent employee; rather, that person would have opportunities to go into contraction as a contractor, or go to work for a contractor. He might also have opportunities to go to work for an equipment supplier as a salesman or representative or a manufacturer. Since these opportunities would be available to only one-third or so of the technicians working for an architect, a small number would continue working for the architect.

His breakdown of his firm, which he suggested was probably typical of most architectural firms, was that there would be about three registered architects in charge of the firm, two more graduate architects, about three technicians (people who would do some drafting and some inspection of construction and some routine calculations) and about one or two clerical workers. The technicians, as he was visualizing them, had been, in the past, older people who had worked in the contracting business and had accumulated practical knowledge which they brought to the architectural firm. The point he wanted to establish was that he felt that a person should be trained to be useful in all fields. If there then was time, the individual could specialize in one field, say the drafting area. However, Mr. Manson felt there was too much opportunity for the person to do other types of work in the building field to specialize him for only one particular operation, even though the student or technician would feel that he wanted to learn only architectural drafting, for instance, and go right to work. Mr. Manson felt that the chances were very great that this technician would not stay in this one narrow field for longer than three or four years. In order to get this person to be useful in all these fields, he stressed a necessity for teaching them mathematics. The mathematics would positively include algebra and trigonometry. It would be very desirable if it included analytical geometry. Mr. Manson also thought that one term of calculus would be extremely helpful and should be required of any student who was capable of getting a passing grade in it. He felt the calculus would help them to understand a number of physical things in the building field. Knowledge of differentiation and integration would be very helpful, not in applying them, but other things in the building field. The calculus in this sense would not be a prerequisite for a more advanced course, nor would it lead to further mathematics for the person, but it would be a tool to help him understand physics particularly. The student should also have physics. These two seemed to be the most important subjects. Thirdly, chemistry would be very desirable. English would also be a necessity. The English was not as important to Mr. Manson, however, as the mathematics, physics and chemistry. A knowledge of drafting principles was fine; however, he did not feel that too much time should be spent on drafting courses, except as an elective course for the few students with very high aptitude in this field. A knowledge of surveying principles would be required and the ability to use surveying tools. However, training to become a proficient surveyor would not be justified for a technician in the building field. Mr. Manson said he would be cautious of costs data and trying to teach unit costs at the present time. The basic principles of taking off material, making lists of material and quantities and how to estimate would be very desirable. However, he thought that the units to be used might change and the unit costs would certainly change. At any rate, a person, to be proficient in this field of cost estimating, would have to be working in it constantly to develop the necessary background of information. Therefore, this could not be efficiently taught in a course.

Mr. E. B. Holden and Mr. Hunter are members of the Warren Holmes Architectural Firm, of Lansing, Michigan. Mr. Holden is the educational consultant for the firm and Mr. Hunter is their field representative in charge of all inspection of projects. These gentlemen were interested in the technician and felt that the architectural profession could use such a person who would be trained in applied building procedures. All that was established in this interview was that there is a need for such a person, but the actual curriculum was not covered. This will be done in a succeeding interview.

Mr. James Carr, of the Michigan Department of Aeronautics, is definitely interested in technicians. However, their total work course is rather small and the number of technicians they would hire would probably be less than ten in a period of two years or so. However, there was a need for this limited number of people. These people would do routine calculations in the design of airports and would do field inspections and some

surveying, some of the design (actually of minor parts of systems), some of the lighting design and some of the soil sampling. An interview is set up in the future at an indefinite date with the Department to cover the exact curriculum desired.

Mr. Harry Conrad, of Chrisman Company, Lansing, Michigan, is an educational liaison between the contractors and the engineering societies. Mr. Conrad is very active with the student chapters of engineering societies at Michigan State University and throughout the State of Michigan. He thought that this technician field was very interesting to the contractor although at the present time very few contractors have in their employ a person who would qualify under the usually acceptable definition of a technician. The work that could be done by a technician would be take-offs of materials, planning of our equipment and material purchasing, but not the actual purchasing. The planning of construction, the limited amount of surveying and coordinating and expediting, is a big industry and the potential for technicians is quite large. Therefore, since very few are being used at the present time, it would seem that this would be a good field for development. As far as curriculum goes at the present time, in Mr. Conrad's thinking, the mathematics would be very important up to algebra and trigonometry. Mathematics should apply and should extend to arithmetic in the way of rapid computation and rapid calculation methods. The other principles of knowledge of building materials and building procedures would be important, including contracting costs and specifications, as well as drafting. Drafting would be more important to the contractor than one would generally suppose. The contractor does not make many drawings, but he has to interpret them and make many sketches from the drawings provided to him.

CHAPTER VI

RELATIONSHIP OF THE TECHNICIAN TO THE ENGINEER

Engineering endorsement of the technician stems from three basic activities relating engineers and their technical assistants. Employment standards and expectations, accreditation of technician curricula, and the certification of the student or graduate all involve the engineer to some degree. This relationship, therefore, is concerned directly only with the technician who works for an engineer. There will probably be a lesser degree of involvement with the industrial technician, as usually defined; possibly a negligible relevance to many self-employed technicians. Varying social and educational groups attribute different motives for the endorsement ranging from attempts to control the functions of the technicians, protecting the job security of engineers, or stratification of society, to desires of improving standards, keeping technicians abreast of new developments, or helping the technician to advance and be recognized. The first thesis of the paper is a belief that the overriding purpose of endorsement is not to limit the technician, but rather to facilitate more extensive and significant use of technicians.

This will have implications for the selection of students, certainly, but it is not clear now whether entrance requirements will generally encourage people with more manual abilities, older applicants seeking retraining, students failing in science or engineering, or any identified aptitudes. The implications for the curriculum will be a continuing questioning and analysis, but certainly not control, since there is no such tight control of the engineering curricula. There is even little uniformity of objectives or methods in engineering colleges.

The theme of "Engineering Endorsement of Technicians" implies that there is little concern with the technician who has no contact or relationship with engineers. It is concerned most directly with the engineering technician or the assistant to an engineer and not with the industrial technician, who might be more closely related to the skilled trades, and probably will have no significance for the technician who is self employed (such as a television repairman). The engineering technician, however, represents a category that other technicians might enter at some future time. The industrial technician can quite conceivably change his orientation in the future more toward the engineer. If this is a potential shift for a technician, then this paper is concerned with that technician. The endorsement of the technician stems from several areas of contact and relationship between the engineers and technicians. These are: the employment relationship, advisory committees for technical programs, the accreditation of technician curricula by agencies involving engineers, and the proposed certification of the technician now being sponsored by the National Society of Professional Engineers.

The most direct reason for endorsement is probably the employment situation wherein the technician will be working for an engineer and, therefore, the engineer is quite concerned about the education of the technician. He will probably set some of the employment standards or criteria for employing the technician and he certainly will be the main source of judging the technician on his job. This is also shown in the fact that most advisory committees for technician schools include engineers, and engineers help in setting up technician curricula. The State of Michigan, in approving technician curricula, specifies that the need must be demonstrated. This invariably implies that the employment personnel or sources of jobs for the technicians be consulted prior to setting up the program, and that they be used in a continuing capacity in advisory committees.

This is not to say that the engineers have the only voice in technician curricula. The education societies, professional educators, administrators, school boards, vocational people, and many other sources are used to set up the programs, and are also represented on these advisory committees. It could not be construed, therefore, that policies would be dictated by engineers. As a matter of fact, engineers and engineering societies are not in a position to dictate policy even on the engineering curricula. This is demonstrated by an examination of any university catalog and is quite noticeable in the engineering journals, such as The American Engineer.

The second area of interest is the accreditation of the technician curricula. This accreditation is available from several sources, or rather, there are several types of accreditation available for these programs. The regional, North Central accreditation is sought by most colleges, as well as secondary schools. This is an accreditation of the institution, including its technician programs. These colleges that are accredited by regional accrediting agencies must demonstrate that they have certain minimums in their faculty quality, certain salary scales, certain schedules, certain financial backing, availability of sufficient library and laboratory facilities and meet other check points. This is not too dissimilar from accreditation by a State association of colleges. The accreditation by the Engineering Council for Professional Development is available for curricula, not for institutions, and the items to be checked by the E.C.P.D. would be similar to those for the regional accrediting associations. Of course, there is also informal accreditation in the form of sponsorships or statements approving certain programs or certain institutions that would always occur for any institution. These are usually based upon the success of the graduates. All of the other accrediting sources also examine the success of graduates from an institution or a curriculum.

The third area of endorsement is the certification of the technician, proposed by the National Society of Professional Engineers, which would recognize certain standards of ability and experience by technicians. This is not intended to be run by the engineering society. They are starting it because there is no technician society available now. This in the future would be run by the technicians themselves. This type of certification does exist in Canada at the present time. This is being done for many reasons. The main point seems to be that the engineer wants to have some idea of a technician's abilities when he hires one and also this would provide recognition and prestige for the technician. Other motives have been ascribed to the engineers for their interest in technicians, such as the idea of establishing lines of demarcation between the engineering technician and the skilled mechanic or the instilling of an attitude of "professionalism" towards unionization.

It is necessary to distinguish between the contrasting motives here to determine the implications of this engineering endorsement for the education of the technicians. Whether the interest lies predominantly with establishing technical abilities or whether it lies with establishing professional attitudes is a major problem in the study of technician education. Paul Robbins, executive director of the National Society of Professional Engineers, in urging the establishment of a technician committee and certi-

fication, stated:

> "There are many in the profession who feel that the requirements for engineering fail to distinguish between work which requires four or more years of college education and that scientific and engineering work which could be done with less or more specialized training. Many of the N.S.P.E.'s current activities have direct bearing on concerns for the engineering-technician. Unfortunately, there are those that see the development of the engineering-technician at the level of the trade school, while engineering and scientific efforts are becoming more complex requiring specialization in science for specific tasks."

Other statements have been made recently by sociologists and educators that the engineer intends certification as a device to keep the technician from threatening the job security of the engineer. At a recent conference of technician instructors, some statements were made that the certification will tend to stratify society further and to hold people in certain areas.

Apparently the question is whether or not these methods of endorsement are a means of identification or of stratification and cubby-holing people. It seems likely that the same argument could be applied to any college-level professional curriculum or semi-professional programs in technical institutes and other schools, as well as to any vocational programs in high schools or community colleges. There is no evidence to indicate that there is any more tendency towards stratification in our discussion of endorsement of technicians than there is in any other professional or semi-professional programs. There is a much greater tendency towards stratification in the vocational programs, such as the apprentice training and on-the-job training programs using skilled labor.

American Society of Civil Engineers

The American Society of Civil Engineers is the basic founder society in the civil engineering field. It is the oldest and most comprehensive organization of civil engineers and would be the logical organization to take a professional interest in civil engineering technicians. The National Society of Professional Engineers was the organization that had the greatest interest in engineering technicians in general; however, matters of curriculum are not within their purview. A thorough inspection of the publications of the A.S.C.E. showed no reference to civil engineering technicians. Neither the monthly magazine, Civil Engineering, nor any of the fifteen regular technical journals of the society made any reference to civil engineering technicians. For this dissertation, therefore, the following questions were addressed to Mr. William H. Wisely, Executive Secretary of the American Society of Civil Engineers:

> Is there an official society position or statement of policy regarding civil engineering technicians?
>
> Would civil engineering technicians be significantly different from other engineering technicians in general philosophy of education or utilization?
>
> Do you think that the society members have any particular concerns or questions regarding the utilization or training of such technicians?

Mr. Wisely responded for the society with the following statement:

> "Your inquiry is most timely, as our Board of Direction acted only three months ago to create a Task Committee on Civil Engineering Technology, which will, "...study the programs extant for the education of civil engineering technicians, and develop recommendations covering a program by which ASCE might recognize and serve such subprofessional personnel." At the same time, a task group in our Committee on Engineering Education is studying procedures for ECPD accreditation of civil technology curricula...

The following comments will help answer your specific questions:

1. There is one documented issue of policy acted on by the Board of Direction on civil engineering technicians. This policy is stated in the enclosed letter on "Policy Regarding Training of Civil Engineering Technicians," adopted by the Board of Direction in 1962. Otherwise, there are no overall ASCE statements of policy on the subject. The importance and need for these trained specialists is recognized, however, and the desire to support the development of these individuals is the reason for the present concern in ASCE. Of some assistance may be the general breakdown of technicians' grades adhered to by many firms which you will find listed in the enclosed copy of the "1963 Salary Survey."

2. Except for emphasis on civil specialization interests, there does not seem to be any reason that a civil engineering technician training program should be radically different in philosophy from that for other fields. We expect that this question will be thoroughly discussed in the task committees.

3. One concern of several Society members recently has been why many two-year programs are being extended to four-year programs, and what makes the four-year programs different from present first-degree courses in engineering curricula. The topic of engineering technology curricula received treatment in the ASEE "Preliminary Report of the Study of Goals of Engineering Education." Some discussion of this problem appears in the enclosed copy of "Comments on the Preliminary Report," prepared by the ASCE Committee on Engineering Education for the February, 1966 Board of Direction meeting. These are being revised somewhat and a new set will become available following the May Board of Direction meeting.

4. We have no specific comment on the NSPE certification procedure for engineering technicians. The concern of ASCE with certification has been minor. Either technician certification does not cause a great deal of attention among civil engineers or it is presently well handled by NSPE."[1]

The society is apparently just beginning to show a concern for the functions and role of the civil engineering technician. They are more concerned with the education of the civil engineer and details of this concern, as transmitted in the curriculum, have an indirect bearing on the education of the technician.

---

[1]William H. Wisely, letter dated May 4, 1966.

CHAPTER VII

STATEMENTS OF EMPLOYERS AND TECHNICIANS IN MICHIGAN

Forty graduates of civil engineering technician programs from Lansing Community College and from Ferris State College were surveyed through the cooperation of the Michigan State Highway Department. The curriculum at each institution is near the average for all institutions. Both of these programs were established as co-op programs, wherein the student would work for the Michigan State Highway Department. The opinions of such technicians on the job, on curriculum matters, was obtained by open questions and interviews. In addition, thirty-eight employers of these technicians were asked for curriculum recommendations.

A. Statements of Graduate Technicians

Technicians who had completed the Civil Engineering Technology Program at Lansing Community College or at Ferris State College in Michigan and who were working as technicians at the Michigan State Highway Department were asked:

1. Has your schooling provided you with adequate background to accept the responsibility assigned to you on your permanent assignment?
2. What do you feel could be done to improve the program?

The responses are given in Appendix C and it is apparent that the graduates are generally satisfied with the education they obtained. The suggestions for improvements include some desires for more practical work, such as "neat draftsmanship," and a similar number asking for more theoretical work, such as "more math and English."

B. Statements of Supervisors

The following questions were asked of the supervisors of both graduate technicians and the student technicians in the program:

1. Would the graduate's early work performance indicate that his academic background adequately prepared him to grasp the duties and knowledge of his position?
2. Did the graduate possess sufficient experience in the performance of the practical skills to begin productive work with little or no additional training?
3. How might the academic training be changed to better prepare the graduate for your area of operation?

The responses to these questions are listed in Appendix D. The responses indicate a general satisfaction with the academic background. The changes suggested by some respondents conflicted with changes suggested by others. The individual replies are shown in Appendix D.

CHAPTER VIII

CONCLUSIONS

The title of this study, "A Compilation and Study of Civil Engineering Technology Curricula in the United States with Analysis of the Forces Bearing on the Curricula," leads to two areas for conclusions: 1) those constituting the compilation of curricula and 2) those analyzing forces bearing upon the curricula.

The first set of conclusions constitutes a curricular definition of the civil engineering technician in the United States. It also includes the relationship of the technician to the civil engineer and the existence of civil engineering technicians as an identified group. The second area for conclusions will bring out the variations in curricula and the relative importance of various forces affecting the curriculum.

A. Compilation of Curricula Conclusions

1. The following courses are required in almost all programs and are taught to a sufficient extent to indicate solid achievement and, therefore, all graduate civil engineering technicians have an operational understanding of these fields: trigonometry, algebra, slide rule usage, English composition, non-calculus physics and mechanics, geology or soils, statics, non-calculus strength of materials, mechanical drawing and lettering, plane surveying and route surveying.

There is an eighty percent probability that the graduate will have studied the following additional fields: some additional physics topics, portland cement and concrete, elementary structural steel design, adjustment of surveying instruments and topographic surveying.

There is a fifty to eighty percent probability of the technician having an understanding of the following fields: analytic geometry skills, use of desk calculators, speech, general education in history and political science, asphalt cements and concrete, specifications and codes, hydraulics, elementary reinforced concrete design, timber design, highway design, drainage design, construction organization, cost estimating, descriptive geometry, sketching, inking, structural steel drawing and detailing, cartography, highway drawings, cadastral surveying, use of stadia and law related to construction.

A wide dispersion of effort is recorded on many other subjects and, as a consequence, the employer cannot be assured of reasonable probability that the technician has had such education.

2. Very little research has been conducted on the subject of curriculum for civil engineering technicians of any definition. The technique of asking for classroom hours spent on individual subjects has not been previously used in engineering technician research. This type of questionnaire has proved to be somewhat difficult to answer. Several comments received in writing with the responses have indicated this difficulty; however, the faculty in well established programs have been able to provide this information. It gives a much better picture of the curriculum than would simple statements of whether or not a subject is included. For a study of any larger size and scope, such a survey technique would require processing by computers. This technique has clearly indicated the disparity and divergence of apparently similar programs. With the exception of a few subjects, such

as English, a large range in classroom hours exists in all fields of study. This indicates that the graduates of various programs might have large differences in the extent of their understandings, abilities and skills on any given subject.

3. All of the civil engineering technician programs are equivalent to two college years in length. Some of them last longer because of co-op work experience and a very small number are less than eighteen months in actual length because of concentration of time. These are eight hour a day programs, running for more than twelve months without vacation and sponsored by federal funds as a retraining program or by a state highway department.

4. The graduate civil engineering technician has sufficient skills and understanding of technical specialties to justify placement in engineering organizations; however, he is not a highly specialized technician. Some of the widely used definitions of engineering technician have called for a high degree of specialization in a narrow range of fields, making the comparison with an engineer who has a high degree of specialization in a wide number of fields and with the industrial technician who would have a shallow level of specialization in a large number of fields. The curricula in actual use, therefore, does not lead to the highly specialized technician. In this sense the civil engineering technician is unlike the electrical engineer or chemical engineering technician. The potential employer must expect various levels of skills with the probabilities previously described. The definitions assumed for this dissertation eliminated some areas of specialization, such as those that would be in building construction, but this was done on the basis that the technician would be working as a contractor, a land surveyor or in some other fashion

for someone other than a civil engineer. There are some exceptions to this. Some institutions do specialize within civil engineering technology to such an extent that the technician would know as much about the selected field as the graduate civil engineer; however, such programs are in the minority.

5. Surveys conducted by various agencies on the number of programs, students and graduates lack clarity of definition. Most such surveys conducted either by the United States Department of Health, Education and Welfare or by the American Society for Engineering Education have been primarily concerned with broad groups of engineering technicians. The actual number reported does not show a clear trend or pattern for civil engineering technology.

Most of the work of the federal government has combined several types of technicians under the heading of civil engineering related programs.

6. There has been no leadership providing unity in the civil engineering technician programs. The few specific instances, such as the publication of the U.S. Office of Education on curriculum for civil engineering technicians, were superficial.

The National Society of Professional Engineers has been concerned with certification of all engineering technicians and the American Society of Civil Engineers has appointed a committee to study the problem in 1966. However, there is no clearly identified relationship between civil engineers and civil engineering technicians at the present time. Interview responses of graduate civil engineering technicians and the engineers they work for indicate a reluctance on the part of the engineer to assign much technical responsibility to the technician. This is further substantiated in the general tendency to insist that surveying and routine design are the proper fields for the engineers to study.

An examination of various publications from the federal government indicates lack of understanding of some specific aspects of civil engineering. Examples of this are the assumption that such a program could possibly be taught in high school, the occupations of chainmen and rodmen being included, which are definitely non-skilled, and the inclusion of architectural draftsmen, an occupation having little to do with the field of civil engineering.

7. There is no evidence to indicate at the present time that civil engineering technicians have a clear identity and role accepted by all interested parties.

B. <u>Conclusions Regarding Forces Affecting the Curricula</u>

1. Overall direction, as observed in major academic categories, is given by the federal government, consultants, The American Society for Engineering Education and ECPD accreditation, and by employers.

2. The technical faculty certainly develop and are responsible for detailed organization of assigned subjects and, consequently, are the most important force in determining detail within a technical subject. The technical faculty, however, have little influence on the content of general education courses.

Some technical faculty groups have a significant effect upon the technical curriculum, while others apparently do not. A highly significant association to the curriculum is recorded with those having a surveying experience, some influence was measured with those faculty having construction experience, and no relationship was noted with the faculty having highway experience. It was not possible to study other technical fields of experience.

3. The effect of students upon the curriculum is apparently not significant, except that certain student characteristics are taken into account in the curriculum planning. Male sex and high school algebra are expected of the student and the curriculum is planned accordingly. Interviews with students indicate a high degree of conflict in individual goals and a net component force that is negligible.

4. The organization of the institution offering civil engineering technology has no recorded influence on the major curriculum categories.

A difference in the emphasis on certain individual study areas was noted with correlation to the institutional organization. These included a heavier emphasis on calculus by university programs, smaller emphasis on reinforced concrete design and timber design, and indeterminant analysis by university programs, heavier emphasis on economic and fiscal courses by technical institutes and universities, greater emphasis on descriptive geometry and inking in community college programs, greater emphasis by community college programs on plat making and cartography.

5. Recommendations of employers form no clear pattern and, as a consequence, have little effect upon the curriculum.

6. The theoretical framework of mechanics used to analyze the forces and directions was useful for terminology and general understandings, but all attempts at quantification were unsatisfactory. Therefore it was not possible to test the hypotheses described on page ten. Plans to calculate values of energy, force, and related mechanical concepts failed to be consistent. The problem is essentially one of proper units. As an example, forces for support were measured in terms of dollars, and governmental forces could then be compared but the extent of faculty force could not be given an objective value in these units. Several contrived devices would yield results, however preconceived values were necessary. This judgement factor would invalidate the results. Similar difficulty was encountered in the determination of directions. A continuum scale of goals involving the type of education was also unsatisfactory. A quantity of 1.00 assigned to classical liberal arts and 10.00 for manual skills, with intermediate values for sciences, thinking skills, and understandings, yielded results that reflected the values of the assigned numbers. This again was quite interesting but hardly informative. In order to use the mechanics calculations, an absolute scale is necessary. It must be possible to determine the ratio of separate forces, and to derive the net or resultant direction when different forces affect a given mass.

The theoretical constructs would be of value when someone is able to construct objective scales. In the meantime the systemis helpful to the person having familiarity either with force systems, or with engineering. The thesis should be more understandable to this audience in these terms than it might be in psychological or sociological terms.

C. General Conclusion Regarding the Future of Civil Engineering Technology

Civil Engineering Technology is not established as a stable identifiable curriculum in the United States. Unless strong leadership is soon demonstrated by the civil engineering profession, there is a considerable risk that such programs will disintegrate. This will be a severe blow to the efficient utilization of technical manpower in the country, to the ability of the profession to continuously adopt improved techniques and knowledge, and to the positions of many technicians. This is also a considerable problem for the civil engineers, since it would be a step toward the possible elimination of civil engineering as a separate profession.

This conclusion results from several facts documented in this study. These are the confusion in role definition as demonstrated in published statistics and definitions, the fact that some programs have been discontinued in the past four years, the lack of recognition of the technician in industry and civil service, the lower salaries of these technicians in comparison with other engineering technicians, the reluctance of interviewed employers to assign specific technical responsibilities sufficiently, and the almost total disregard of the field by civil engineering organizations.

RECOMMENDATION

It is strongly recommended that The American Society of Civil Engineers involve its membership in a campaign to define and promote usage of civil engineering technicians. No other organization has the ability to provide effective leadership and acceptance of the technicians.

Some other organizations have a degree of interest and influence, but their effectiveness would be limited by inadequate contact with civil engineers, the employers of the technician. The United States Office of Education and the Department of Labor have done some work in promoting the effective utilization of engineering manpower, but have no direct knowledge of the functional requirements of the technician. Individual highway departments and other employers know what tasks might be assigned to the technician but cannot exert a national unifying influence. Other societies such as the American Society for Engineering Education would have less contact with the users of Civil Engineering Technicians.

This overall recommendation can be broken into the following parts:

1. It is urged that the Society involve the entire membership in preparing an acceptable definition of the technician in terms of required courses of study, and any other required characteristics.
2. Society promulgation of the definition is recommended so that the various programs can be more predictable in studies while maintaining a desirable degree of individuality.
3. The Society should then make a major effort to promote the increased use of technicians, together with other interested organizations. It is suggested that a series of conferences and publications could be part of such a campaign.

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APPENDIX

APPENDIX A

Responses to this questionnaire were received from the following institutions:

1. Mohawk Valley Technical Institute, Utica, New York
2. Staton Island Community College, Staton Island, New York
3. New York City Community College, Brooklyn, New York
4. Wentworth Institute, Boston, Massachusetts
5. Cogswell Polytechnical College, San Francisco, California
6. Southern Technical Institute, Marietta, Georgia
7. Oregon Technical Institute, Klamath Falls, Oregon
8. Iowa State University, Ames, Iowa
9. Ferris State College, Big Rapids, Michigan
10. Vermont Technical Institute, Randolph Center, Vermont
11. Broome Technical Community College, Binghamton, New York
12. Franklin Institute, Boston, Massachusetts
13. Lansing Community College, Lansing, Michigan
14. City College of San Francisco, San Francisco, California
15. Pennsylvania State University, Wilkes Barre, Pennsylvania
16. Pasadena City College, Pasadena, California
17. Pueblo College, Pueblo, Colorado
18. Worcester Junior College, Worcester, Massachusetts
19. Chowan College, Murfreesboro, North Carolina
20. Milwaukee Institute of Technology, Milwaukee, Wisconsin
21. Arlington State College, Arlington, Texas
22. Hillyer College, Hartford, Connecticut

The following institutions responded with the indication that they did not have a program fitting the definition; however, they provided some valuable information:

1. Long Beach City College, Long Beach, California
2. Pensacola Junior College, Pensacola, Florida
3. Southern University, Baton Rouge, Louisiana
4. Utah State University, Logan, Utah

In addition to these twenty-six institutions, questionnaires sent to four other programs were not returned. Therefore returns were made by twenty-two of twenty-six; eighty-five percent of the twenty-six eligible programs in 1962.

What is a Civil Engineering Technician? A Highway Technician, or a Surveying Technician? What jobs can he do, or what is he good for? Where does this Technician fit, and what is his future?

An answer to these kinds of questions will help define the Technician in the family of occupations related to Civil Engineering. This definitive information is needed for counseling prospective students, and to encourage more students to enter this type of curriculum. Planning and legislation are sometimes hampered by need for more specific information about these programs, and above all the Civil Engineer could make more effective use of Technicians if he knew what can be expected of the graduate.

In an effort to help answer these questions, and to compile doctoral dissertation data, I am asking you to contribute information. I will send you a copy of the results of this study hoping that it will be of value to you. The information will be helpful to the societies and institutions interested in advancing the cause of engineering technicians.

1. Please fill out and return this questionaire.

2. Please send with the reply any catalog, brochure, or other material describing your curriculum related to civil technology.

3. Let me know for the report, of any developments or facts that promote this field of technology.

A stamped return envelope is enclosed for your reply. I hope to hear from you soon, before we all get involved with fall classes, family plans, and football. Thank you for your attention.

Richard L. Rinehart, P.E.

Department Head - Civil Technology
Lansing Community College

September 3, 1962

Civil Engineering Technology and Related Curricula Study
R. L. Rinehart, Lansing Community College, 419 N. Capitol Ave., Lansing, Michigan

Name of responding Institution:

Address:

Name of person directly supervising civil related technology

How many months of fulltime classroom student status are needed to complete the curricilum, assuming a student has all entering prereqisites?
_______ months

How many months of other requirements, such as co-op, are there?_______ months

Please check the prerequisites for a student entering your program:

	Required	Desirable	Not Asked
High School Graduation	__	__	__
Related work experience	__	__	__
I.Q. or ability test score	__	__	__
Interest or aptitude test	__	__	__
Male sex	__	__	__
High School Algebra	__	__	__
" " Geometry	__	__	__
" " Trigonometry	__	__	__
" " Drawing	__	__	__
" " Shop Courses	__	__	__
" " Physics	__	__	__
" " Chemistry	__	__	__
" " English 4 yr.	__	__	__
Other, please list:			

Approximately how many graduates do you expect from this program between now, September 1962, and August of 1964 ? _________

Since teachers are as important as curriculum and books, it will be helpful to have a brief description of the technical instruction staff. Please estimate the following information for teachers of technical courses and planners for this curriculum:

Years of Teaching Experience And Field of Specialty	Years of Work Experience Related To Program and Specialty Field	College Degrees	License & Certificate

Please list any developments or facts that will promote this field of technology:

Please indicate the total number of hours of class meetings that you expect to require of the civil related technician student for the next year or so, in each of the study areas shown. One course might contain several areas, or several courses might apply to one area. An effort has been made to establish mutually exclusive categories. Some overlap certainly remains, but please do not include any hours in duplicate. The total number shown should equal the total number of actual class hours in the curriculum.

Area Of Study Classroom Hours In:	Lecture	Lab, Practice
Algebra, notation, manipulation & solving equations	____	____
Geometry, Plane and Solid	____	____
Trigonometry, Plane and Spherical	____	____
Analytic Geometry	____	____
Differential and Integral Calculus	____	____
Differential Equations and Advanced Work	____	____
Statistics and Probability	____	____
Computer Programming and Appreciation	____	____
Sliderule Usage and Logarithms	____	____
Use of Desk Calculators and Related Machines	____	____
English Composition and Technical Report Writing	____	____
Public Speaking and Speech Improvement	____	____
Reading IMPROVEMENT and Other Language Work	____	____
Political Theory, Political Science, Internat. Relations	____	____
Local State and Federal Government	____	____
Social Sciences, Sociology, Anthropology, etc.	____	____
Psychology, Social Psychology, Human Relations	____	____
Economics Theory, Not Business Economics	____	____
History, Geography, Humanities	____	____
Chemistry, General Inorganic and Organic	____	____
Atomic and Molecular Structure and Forces	____	____
Portland Cement and Concrete Properties	____	____
Asphalts, Tars, and Bituminous Concretes Properties	____	____
Geology, Aggregates, and Soils Study	____	____
Metallurgy, Heat Treat, Properties of Metals	____	____
Timber Properties, Grading, Characteristics	____	____
Study of Ceramics, Plastics, Glass and Other Materials	____	____
Statics Theory and Graphics, Forces	____	____
Dynamics Study and Kinetics or Kinematics	____	____
Thermodynamics	____	____
Electricity and Electronics	____	____
Light, Sound, and Other Physics Topics	____	____
Strength of Materials and Other Applied Mechanics	____	____
Steel Structural Design Principles and Practice	____	____
Reinforced Concrete " " "	____	____
Timber " " "	____	____
Indeterminate Structural Analysis, and Structures	____	____
Architectural Design, Not Drawing, Buildings	____	____
Design of Bridges and Engineering Structures	____	____
Highway and Geometric Design	____	____
Specifications, Codes, Understanding and Interpretations	____	____
Other Design Areas, Not Construction Methods and Not Included on the Next Page	____	____

Area of Study	Lecture	Lab
Hydraulics and Fluid Mechanics	___	___
Hydrology, Ground Water and Surface Water	___	___
Meteorology	___	___
Drainage Design, Sewers, Culverts, Ditches etc.	___	___
Biologies, Bacteriology, etc.	___	___
Water Supply and Treatment, Distribution Systems	___	___
Sewage Treatment, Collection, Testing	___	___
Public Health and Sanitation	___	___
Heavy Construction Methods, Earthmoving, Highways	___	___
Light Construction Methods, Architectural Construction	___	___
Residential Construction Methods, Carpentry	___	___
Construction Organization, and Planning	___	___
Welding Principles and Practice	___	___
Law Related to Construction, Contracts, Agency etc.	___	___
Other Construction Practices and Skills	___	___
Mechanical Drawing, Lettering and Principles	___	___
Descriptive Geometry	___	___
Sketching, Renderings, Perspectives	___	___
Inking, Use of Lettering Machines	___	___
Scribing and Etching, Work on Plastics	___	___
Structural Drawing, Steel, Detailing	___	___
Structural Reinforced Concrete Drawings, Bar Sched.	___	___
Architectural Drawing	___	___
Topographic and Hydrographic Drawing	___	___
Cartography, Map Making, Projections	___	___
Making of Land Plats	___	___
Highway Plans and Profiles Drawing	___	___
Drawing Mass Diagrams	___	___
Making Charts and Diagrams and Display Graphs	___	___
Plane Surveying, Use of Conventional Equipment	___	___
Adjustment of Transits and Levels, Minor Repairs	___	___
Geodetic Surveying, 1st or 2nd Order Surveying	___	___
Use of Optical Micrometer Instruments, Auto. Levels etc	___	___
Rpute Surveying, Curves, Slope Staking etc	___	___
Topographic and Hydrographic Surveying,	___	___
Cadastral, Prpperty Surveys, Land Description Systems	___	___
Law Related to Property Rights	___	___
Photogrammetry, Ground and Aerial, Procedures and Princ.	___	___
Celestial Observations, Techniques and Theories, & Calc.	___	___
Othér Surveying such as Construction Staking	___	___
Use of Stadia	___	___
Economic Analysis, Interest, Amortization, etc	___	___
Planning Principles and Devices for Programming	___	___
Cost Estimating, Direct and Indirect	___	___
Accounting and Business Management and Control	___	___
Ethics, Professional Practice	___	___
Philosophy, Theology	___	___
Individual Study, Thesis, Projects or Reseafch	___	___
Other Fields of Engineering such as Traffic, Specify Type	___	___
Other Required Course Areas, Please Specify	___	___
Hours of Free Electives Not Included Above	___	___

If you are contemplating any changes of emphasis from the above curriculum please indicate here the changes that are possible.

APPENDIX B

Responses to this questionnaire were received from the following institutions:

1. Boise Junior College, Boise, Idaho
2. Chaffey Junior College, Alta Loma, California
3. Skagit Valley College, Mount Vernon, Washington
4. Purdue University, Indianapolis, Indiana
5. San Bernardino Valley College, San Bernardino, California
6. University of Houston College of Technology, Houston, Texas
7. Erie County Technical Institute, New York
8. Chicago Technical College, Chicago, Illinois
9. Hartford State Technical Institute, Hartford, Connecticut
10. Ohio College of Applied Science, Cincinnati, Ohio
11. North Dakota State School of Science, Wahpeton, North Dakota
12. Michigan Technological University, Houghton, Michigan
13. Farmingdale Technical Institute, Farmingdale, New York

In addition, questionnaires were sent to the twenty-two institutions listed in Appendix A.

The following institutions were identified with civil engineering technology in the Guide to Organized Occupational Curriculums in Higher Education, 1962 - 65, and responded that they did not have a civil engineering technology program, as such:

1. Mason City Junior College, Mason City, Iowa
2. Grand Rapids Junior College, Grand Rapids, Michigan
3. Perkinston College, Perkinston, Mississippi

	Number	Per Cent
Institutions, with defined programs, responding:	27	77 %
Institutions, with defined programs, not responding:	8	23 %
Total of institutions having a defined program in 1966:	35	100 %
Institutions responding: "No defined program".	3	
Total of Questionnaires sent out:	38	

April 6, 1966

Dear Sir:

What is a Civil Engineering Technician? A Highway Technician, or a Surveying Technician? What jobs can he do, or what is he good for? Where does this Technician fit, and what is his future?

An answer to these kinds of questions will help define the Technician in the family of occupations related to Civil Engineering. This definitive information is needed for counseling prospective students, and to encourage more students to enter this type of curriculum. Planning and legislation are sometimes hampered by need for more specific information about these programs, and above all, the Civil Engineer could make more effective use of Technicians if he knew what can be expected of the graduate.

In an effort to help answer these questions and to compile doctoral dissertation data, I am asking you to contribute information. I will send you a copy of the results of this study, hoping that it will be of value to you. The information will be helpful to the societies and institutions interested in advancing the cause of engineering technicians.

Please fill out and return this questionnaire. A stamped return envelope is enclosed for your reply. Please fill out and return it today. This will allow me to tabulate and return a summary to you by April 30, 1966. I plan to submit the information to the A.S.C.E. and the A.S.E.E. to promote an official society position encouraging increased utilization of Civil Engineering Technicians.

Richard L. Rinehart, P.E.
President

Name of Reporting Institution ______________________________

Would you please indicate the general characteristics of the faculty responsible for the civil engineering technician curriculum by checking all appropriate boxes (describing the faculty as the single person most representing the group involved:

Education: (& Qual.)

- ____ B.S. Degree in Civil Engineering
- ____ B.S. Degree in other fields
- ____ M.S. Degree in civil engineering
- ____ M.S. Degree in other fields
- ____ Journeyman or equivalent education
- ____ Registered Engineer
- ____ Registered Land Surveyor

Experience: (More than 2 yr.)

- ____ Contract Construction
- ____ Highway Department
- ____ Other Government Departments
- ____ Teaching & Education & Research
- ____ Industry, Manufacturing
- ____ Surveying
- ____ Private Practice, Consulting Engr.
- ____ Architectural
- ____ Railroads
- ____ Sanitary Engineering

APPENDIX B

Please check those courses on study areas that are required of students and those that are optional. Several subjects may be included in a single course, and all of those resulting in a measurable and demonstrable skill or understanding should be checked. In case of doubt, it may be assumed that at least 20 classroom hours are usually required for such a level of skill or understanding.

Area of Study	Required	Optional
Trigonometry, Plane and Spherical		
Analytic Geometry		
Differential and Integral Calculus		
Differential Equations and Advanced Work		
Statistics and Probability		
Computer Programming and Appreciation		
Sliderule Usage and Logarithms		
Use of Desk Calculators and Related Machines		
English Composition and Technical Report Writing		
Public Speaking and Speech Improvement		
Reading IMPROVEMENT and other Language Work		
Political Theory, Political Science, Internat. Relat.		
History, Georgraphy, Humanities		
Chemistry, General Inorganic and Organic		
Atomic and Molecular Structure and Forces		
Portland Cement and Concrete Properties		
Asphalts, Tars, and Bituminous Concretes Properties		
Geology, Aggregates, and Soils Study		
Metallurgy, Heat Treat, Properties of Metals		
Timber Properties, Grading, Characteristics		
Study of Ceramics, Plastics, Glass and Other Materials		
Statics Theory and Graphics, Forces		
Dynamics Study and Kinetics of Kinematics		
Thermodynamics		
Electricity and Electronics		
Light, Sound, and Other Physics Topics		
Strength of Materials or Other Applied Mechanics		
Steel Structural Design Principles and Practice		
Reinforced Concrete " " "		
Timber " " "		
Indeterminate Structural Analysis, and Structures		
Architectural Design, Not Drawing, Buildings		
Design of Bridges and Engineering Structures		
Highway and Geometric Design		
Specifications, Codes, Understanding and Interpretations		
Other Design Areas, Not Construction Methods		

APPENDIX C

RESPONSES OF TECHNICIAN GRADUATES WORKING AT THE MICHIGAN STATE HIGHWAY DEPARTMENT - 1964

I. <u>Has your schooling provided you with adequate background to accept the responsibility assigned to you on your permanent assignment?</u>

Apparently not, for it is now possible to become a technician without completing the program. So it is questionable whether this background is necessary, but I do feel that a graduate technician is more qualified to do the work.

Yes, but more attention could be given to inspection phases and finaling of a job.

Yes, except possibly in the practical field of construction.

Schooling gives you a broad background into your work and the knowledge needed in it; however, I feel that experience in the particular job assignment is the best basis of judging one's ability to accept responsibility.

The knowledge of procedures and all of my schooling have been very valuable in my permanent assignment.

I worked one summer after completion and the training was adequate.

The schooling was somewhat short in the area of cost analysis of the earthwork, etc., but our surveying skills were ample for our work.

Formal education is a background for learning not for accepting responsibility. It did serve its purpose.

As far as instrument work the training was adequate, but it was not adequate pertaining to inspection work.

Yes.

Yes, according to service ratings, etc. given by superiors.

Yes, it has and it also provided me with adequate knowledge to pass examinations at the I level.

Yes, the schooling provided me with the background I need.

Yes.

Yes, my schooling provided adequate background for my permanent assignment back in 1960.

Yes.

Yes and no.

Yes.

No, because I was assigned to a chemistry lab. The schooling is hinged around surveying and drafting.

Yes.

Yes.

Yes.

Yes it has.
Yes, but working half days and going to school half days did not leave enough time for study.
More than adequate.
Courses in reinforced concrete and structural theory would have been highly beneficial.
Yes.
Partially yes. As I was one of first to graduate some courses were inadequate. Believe they have been adjusted now.
Yes.
Yes. I feel I can research any subject or math problem that I cannot remember.
Yes.
Yes! the math and surveying have been very helpful.
Yes.
Yes.
The program prepared me in my permanent assignment by giving me the educational background necessary to meet the assigned responsibilities of my position in the section.
Yes, except a better course in structural design.
Yes.
Yes.
Yes, the schooling was more than adequate for the job I am doing. The only trouble I had was from the lack of experience.
Yes, although more field work while in school should be required with closer supervision. Problems in the book and problems in the field differ to a great degree.
Basically, yes. Particularly we should have covered more specific traffic considerations. Perhaps two terms of courses related to all problems of highway design. I also feel more basic English is needed.

2. <u>What do you feel could be done to improve the program?</u>

Offer chemistry, physics as an alternate to surveying or structural drafting. Have three ways or fields a student could go into.
More emphasis could be placed on figuring research volumes and grades.
The curricula is very good as far as the program is concerned.
Satisfactory.
I think that the curriculum I had was fine except I think more emphasis should be put on architectural drawing.
I believe the curriculum in college is very good.
Confine drawing to civil engineering drawing. At LCC two entire terms were spent drawing nuts, bolts, gears and machinery parts and were entirely useless for a civil technician.
Teach technical courses so that they can be accredited and transferrable.
Make the following courses transferrable by adding calculus: Physics, strength of materials.
Not qualified to answer, as I am not familiar with present curriculum.

More surveying equipment is needed. Time and equipment is dominated by those with better than average ability. Often, those in the class who need the help more are not getting it.
Have unit heads of the various departments outline a curriculum for their unit. Let student select his third year (last two terms) curriculum on the basis of this outline and talk with department or unit heads.
Have a class in which you start at the beginning of a job and follow it through in its entirety (staking, inspection, finaling).
I feel the program should require more mathematics. Calculus and analytic geometry should be required for two or three terms.
A good engineering type physics at Ferris State for the program. Otherwise quite thorough.
Not acquainted with present curriculum.
The curriculum could be improved by giving the technicians training in computation of costs not only in equipment but also in earthwork, drainage, and all other related items.
More math and less English would aid in understanding the engineers as well as the work in most fields.
Inform the student technicians about inspection work and its responsibilities.
Make more of the required courses transferrable to a four year engineering degree.
Good, although I believe courses such as Intermediate Algebra, Trigonometry, etc. be completed by potential participants so that the student would be able to grasp certain first year courses, that is, survey, etc., readily, which require a fore knowledge of this type of math.
I think the curriculum was very satisfactory.
A more varied choice of C.T. courses. Like classes in Traffic.
Very adequate.
No changes.
Fine.
The curriculum since I went to school has changed a lot, so I can't say whether it could be improved or not.
Have more courses in the areas of traffic engineering, route location and planning.
More work related courses.
I believe the current curriculum is very good and much improved than the program in its infancy. However, more practical knowledge in some courses of study would be advisable.
Possibly add a little math.
I personally feel that the courses offered are O.K. but the faculty at LCC could be improved.
The training I received at Ferris was very good and I do not think it should be changed.
After the first three or four terms, specialized courses should be on the agenda, because by that time most know which department they are going to enter and could then take the preparatory courses.
Not enough expected from the students. More thorough courses should be offered in the natural science field.

Greater emphasis on neat draftsmanship.

To be more beneficial to the department I would require more intensive drafting classes, route surveying, since 90% of graduates will be using these talents to a large degree.

Was adequate.

Add more courses dealing with traffic, such as traffic operations, signs, surveys, standards and designs.

APPENDIX D

RESPONSES AND SUMMARIES OF SUPERVISORS OF TECHNICIANS INTERVIEWED AT THE MICHIGAN STATE HIGHWAY DEPARTMENT, 1964

1. Did the graduate's early work performance indicate that his academic background adequately prepare him to grasp the duties and knowledge of his position?

Yes - Student Highway Technician B
Yes - as Junior Instrumentman
Yes - as Junior Instrumentman
Yes - with normal guidance - Instrumentman A
Yes - Junior Instrumentman or road constructor
Yes - Instrumentman A
Yes
Yes
Yes
Yes
Yes - Draftsman in Bridge Design
Yes - Engineering Draftsman
Yes - Engineering Draftsman
Yes
Yes - He was mentally alert and quick to learn.
Yes - Student highway Technician A or Instrumentman A
Yes - Technician with traffic division in District Office
No - Bridge Constr. Aide A.
Yes - Graduate started out on a survey crew working under an experienced instrumentman. As he gained in experience he was given more responsibility. At present he is senior instrumentman on five miles of expressway.
He deomonstrated immediately that the choice of Highway Engineering Drafting was his selection for a future vocation.
Student Highway Technician A. Required above normal supervision. Academic background appeared to be adequate for the field of photogrammetry.
He graduated in 1959 and was transferred to my squad in November, 1961. He handled the position of Engineering Draftsman I very well.
Instrumentman I - His academic background was suitable except for practical seasoning, which is as expected.
Only portions of his academic background were of value in his new position.
Property Technician A. Right of Way terminology a weak point.
The graduate's present position is Lab. Aide A and his academic background is more than adequate to perform the required duties.
Yes, as a Highway Laboratory Technician I in charge of field work for our Roughometer Program.
He was well prepared for his position as Junior Instrumentman academically.
Yes - Bridge Construction Aide I.

Not quite enough preparation. Fundamentals started to sink in in about 9 months after start of work.

Yes - Junior Instrumentman

The employee's academic background, together with previous experience in this position during one working period, made him very capable as a Highway Laboratory Aide.

Yes

Yes - Highway Laboratory oide A on a resistivity crew. (Bridge Construction Aide A). Employee was able to perform the duties for this position and learned new routines quite rapidly.

The graduate was well prepared for Road Construction duties. He was able to handle the instruments, take neat notes and had the engineering knowledge. In a few weeks he was able to handle a construction crew and slop stake a roadway. During the summer I had occasion to use him as a bituminous street inspector in which he adapted readily and kept neat and accurate notes. He was also able to work on the final computations of the project and did an excellent job.

The graduate was quick to learn his duties as instrumentman and inspector on Bridge Construction - indicating a good academic background.

It was hard to tell, since the employee acting as a Junior Instrumentman depended too much on being told what to do instead of taking the initiative and doing things on his own. He performed his duties adequately under these conditions.

This man has worked as an inspector since leaving the training program. Service ratings and personal observation indicate a good background.

Yes - Student Highway Technician A or Instrumentman A.

Traffic Technician - No. Perhaps courses in traffic work should be taught in the program.

APPENDIX E

RESPONSES OF STUDENTS IN CIVIL ENGINEERING TECHNICIAN PROGRAMS ON INTERVIEWS CONDUCTED AT THE MICHIGAN STATE HIGHWAY DEPARTMENT

I. In order of importance to you at that time, list the reasons why you entered the program.

Money (lack of).

Education, dependable job with a future, was seeking a job where my education would benefit both myself and my job.

To continue schooling.

An interest in road and bridge development.

It gave me a goal; nothing better in sight; couldn't afford full time.

Because I like construction work and hoped I might get into it.

It was a job with a chance to gain some knowledge along with a chance to go to school, in addition to helping me get some of the courses for pre-engineering.

I felt that everyone needed a college education. I decided to go into engineering. I could not get a scholarship, so I investigated into different programs because I didn't have the money to attend past high school. My brother discovered the program so he and I took the exam.

I wanted to go to college and I just didn't have enough money. This program was my big chance to get a good start in life.

It was to get a partial college education. Because I like construction work.

It looked like a good idea at the time; to better myself.

Needed a job; I wanted to go to school.

Chance for an education; needed a job.

I entered the program because I felt that it would be hard for me to find a better paying job while I was going to school.

Needed a means of employment and to better future outlook.

Needed the money and a steady job; didn't want to go into military service.

Job security; further my education.

It offered a job and some chance of advanced schooling.

Interest in civil engineering; insufficient funds to acquire a degree on my own; a desire to go to college.

To gain further education in work I was interested in and to gain money for that education.

Practical training in engineering, salary, working with state engineers.

I wanted to further my education and I liked engineering; therefore, I took the test. And without this program it would have been a little more difficult for me to enter college on account of funds.

To get more education, to have a job.

Good chance to further my education, chance to pay my own way through school, good future.

To further my education; as a means of working my way through college, the program ends in a permanent position; I wanted to work for the State.

The education, better working conditions, more chance of advancement.

Getting into college, earning more money to get through school.
I needed a way to finance my education.
An opportunity to make some money while attending school. Learning valuable through experience, plus the cycles in school.
Educational advancement, job security and on-the-job training, unlimited future for construction work, broad field open after graduation.
To obtain experience; for further schooling; for the money.
Desire to continue my education and financially unable.
Good way to get education, sure job when not in school in summer or fall, pays good for not having experience.
The program allowed me assurance of income to finance my education; being state employed seemed to be a secure investment in the future.
A good place for employment; job security and advancement; fair wages.
To return to the State Highway Department. I was on land surveying with the Conservation Department and was frozen in my position. More promotional potential.
I wanted to begin to get a college education when I graduated; I needed financial help to go to college; I believed engineering would be my vocation.
It gives me a chance to earn my education; it offers a secure future; it does not obligate me in case I find I don't like the work.
I liked to work out of doors and I was always interested in surveying.
It sounded like an interesting job and it was out of doors. It was a job that would give a person a lot of security and he could advance according to his own skill.
A job opportunity, a college opportunity, chance to get into design work, salary offered, interesting work.
I'm interested in this type of a career; the work cycles are a way to pay for the schooling, etc.
It was a way to be able to go to college as soon as I graduated; it was the only way I could afford to go to college other than working for one or two years before entering.
Interested in surveying; program offered a plan to pay my own way through college.
The program offered a chance which I might not have had otherwise to get an education in a field of study that I am interested in.
I didn't like the school I attended last year; I figured that I would like the outside work; a government job is always a secure one.
I wanted to use my abilities in this field and to give all I've got to it and one day make something out of it. I also might add that I can express and bring out my ideas.
Job security (immediate); college education (especially base for further college work); long range job security.
Appeared interesting. Means of work experience along with an education.
I want this type of work but I really didn't know if I wanted to be an engineer. Money.
It was a good opportunity to make money and to go to school at the same time; the program is in a field I like.
A secure job for life, an education.
I had no other plans; I like outdoor work.
I wanted to be in an engineering program, but could not afford and didn't want to be an engineer.

Interested in possibilities of program; wanted to further education; like types of work offered.
More education; working and studying give a person more experience.
I was interested in civil engineering; I needed a job for the summer; it sounded good.
As security before going into engineering; needed job for money.
Interesting field, chance to earn money while going to school.
Education; expense (cost of going to college); for the job with MSHD.
A need to finance the greater part of my education; a strong interest in outdoor work; at the time I was interested in only a two year program.
Sounded like a good job; removed any doubt as to what I would be doing; gave me a good chance to go away to school.
To get an education at my own expense; to gain some technical skills which would provide future security.
Work periods provide means of financing education; I wish to work in some engineering field; I feel that field experience is very valuable to an education.
Since I was supporting myself fully while in school, I needed a reliable source of income when on vacation from school and it wouldn't hurt to try the program. Also I wanted to try a different than what I was interested in.
Job security; furtherance of education; practical experience.
Financial reasons; engineering field; security.
At the time, I was interested in an engineering position rather than a job where the same routine occurs day after day. The student Highway Technician program gave me an excellent opportunity.
I wanted to go to a college. The Highway Technician Program provided a financial solution; I enjoy mathematics and math is an important part of our program; therefore, it sounded as though I would enjoy the subjects.
Something different.
I wanted to test my ability in college; I wanted to try a new line of work to see if I liked physical or mental work. I prefer a combination of the two.
Education; to see if I would be interested in civil engineering.
It offered a job in a field that I was interested in; it provided a chance for me to continue my education.
Financial reasons; desire to get an education.
Didn't have the money to attend college; like outside work.
Educational opportunity; an opportunity to select the most interesting of a choice of jobs.
Income to help pay school expenses, etc.; a start of a college education; on the job training - an asset to learning.
I liked to work with math; I liked outdoor work; I saw a chance of a good, secure job; I was told of the good chances of advancement; I was interested in surveying and engineering; did not have the money for a four year program.
I wanted more education; I had to work my way through; I felt that the work was close to my interests; I had nothing else going for me.
Because I thought I would better myself with more education and improve my job opportunities.

Better job; job security.
Earn enough money to go to school.
The program was ideal in fitting my education and finances together. Also the fact that it was possible to work outside on construction work.
Recent failure in pre-engineering; FSC's more liberal enrollment requirements; enjoyed work as rodman; needed the work-school feature to finance the education; thought credits might transfer to engineering school if successful at FSC.
Outside work; interesting work.
It was a good job; interesting.
A chance for higher education; opportunity to earn money; desire to leave my father's house.
My primary interest for a vocation was drafting; state employment offered a good secure future; I had been rejected for induction at GMI and, in view of my desire and upon my counselor's advice, therefore, applied for entrance into this program.
Interest; security.
I didn't know what else to do, but wanted to accomplish something worthwhile; chance to go to college; chance to pay for my own education; good job opportunity.
Job opportunity; education; money to invest.
To get some kind of an education; to obtain a permanent position upon graduation, because I thought that working for the Highway Department would be interesting; to have a job in the Lansing area.

2. Did the graduate possess sufficient experience in the performance of the practical skills to begin productive work with little or no additional training?

No - But this is not expected. He could understand instruction and absorb the training readily. This justifies the Technician Program.

No

Yes - He came with previous experience in our work.

Yes - The graduate was not given a great deal of responsibility at the beginning. As explained above, he worked under a more experienced instrumentman. However, his work was fully productive. Naturally, like any academic training, he required considerable assistance to fully understand and use the basic instruction received in the program. In our type of work any new employee must undergo an extensive training period.

Yes

Yes

Yes

I believe so, and they also seem to require less supervision in the performance of the duties.

Yes - See statement made in question #1. (Graduate was well prepared for Road Construction duties. He was able to handle the instruments, take neat notes and had the engineering knowledge. In a few weeks he was able to handle a construction crew and slope stake a roadway. During the summer I had occasion to use him as a Bituminous Street Inspector in which he adapted readily and kept neat and accurate notes. He also was able to work on the final computations of the project and did an excellent job.

Because the graduate had spent no time during his schooling in Bridge Construction, he required some additional training.

The graduate seems to possess sufficient experience in the performance of the practical skills but did not readily show it. Some of this can be attributed to the fact that the technician was not the "take-charge type individual."

Specifically no, as he had experience only in Traffic. Generally I believe the reverse would hold true.

Yes

On drafting work - yes; on other types or classes of work - no.

No! Experience was needed to gain confidence in his own abilities and talent to organize and perform the work.

He was not in my squad when he started. All technicians and college graduates require additional training.

This employee's potential or value was not real until his academic skill was related to a practical outlook to highway survey work.

Yes - but the majority of the practical skills can't be used without a knowledge of right-of-way terminology.

Yes - the graduate, in addition to experience gained from on-the-job training, possessed valuable skills acquired outside of the Department, which considerably increased his ability to perform the assigned work without additional training.

He was a good rodman. However, he did not display qualities of leadership.

In rodding yes, in instrument work, no.

3. <u>How might the academic training be changed to better prepare the graduate for your area of operation?</u>

No suggestions.
Better correlation of related subjects. For example, the relationship and application of land surveying with the theory of route surveying.
Present arrangements appear to be satisfactory.
As much work in computation as practical.
Seems good now, just keep up to date.
More emphasis on reports and notes.
More emphasis on reports and notes.
Need at least one Traffic course.
I cannot suggest any improvement. I would like to emphasize the knowledge of mathematics and structural engineering fundamentals makes him a valuable asset. Training in drafting alone is virtually worthless.
If all the graduates were of the same caliber as this one, there should be no change at all. This employee is an excellent one.
More strength of materials.
Fine as is.
Emphasize the importance of accuracy and correctness.
By placing less emphasis on fast promotions. It seems to me that these technicians expect to be promoted too quickly.
More training in principles of concrete.
Based on one graduate, the academic training appears adequate.
Perhaps a little more concentration on developing drafting skills.
Consider it satisfactory.
Seems to be sufficient.
Encourage the men to go to college four years and get an engineering degree.
No change.
I would like more information about the curriculum being followed by the Technicians' Schools before I can comment on it.
Engineering and surveying and math should be stressed more.
By placing less emphasis on fast promotions. It seems to me that these technicians expect to be promoted too quickly.
It appears that a lot of material that could be used, especially if one were preparing for the registration exam, is touched on only slightly. Material that actually applies to our work is too frequently only vaguely touched.
Photogrammetry is a highly specialized field and requires specialized training with courses designed accordingly, such as surveying, design and math.
I would give them drafting every term.
By permitting him to gain his skill with field relationship.
Cover administrative and right-of-way terminology in more detail.
No change necessary, at least as shown by the work of this employee.
Stress that, as a technician, he will be expected to direct others.
More emphasis on practice and theory of standard practice of note keeping.
More academic training in traffic engineering would better prepare the graduate for this area of operation.