TESTING THE EFFECTIVENESS OF TRAFFIC ENGINEERING SHORT COURSE INSTRUCTION

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ABSTRACT

TESTING THE EFFECTIVENESS OF TRAFFIC
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INSTRUCTION

By

Adrian Harold Koert

There is a shortage of well-trained traffic engineering practitioners in communities and counties in Michigan as well as throughout the United States. Michigan cities in all population groups fall below national standards in numbers of traffic engineering personnel. No city in Michigan under 50,000 population employs a full-time traffic engineer. The function is usually assigned to a police officer or member of the engineering department who has little or no background in traffic engineering. The situation is similar in most Michigan counties.

To increase information, knowledge and skills traffic engineering short courses have been presented on an intermittent basis in Michigan for the past twenty-five years. These courses have varied in content, structure, length and methods of instruction. Little can be determined as to the effectiveness of these courses.

Adrian Harold Koert

The purpose of this study was to test the effectiveness of traffic engineering short course instruction.

Description of the Methods, Techniques and Data Used

Three traffic engineering short courses were selected for analysis in this study. Forty-five students, fifteen from each of these courses, plus a control group of fifteen persons comprised the subjects whose grades in tests, given during the short courses were analyzed. Each of the forty-five students took a pre-test at the beginning of the course, a post-test after each of the five morning sessions, and a final test at the end of the course. The control group took the pre-test and the final test. In the first three morning sessions the method of instruction was varied in each of the three classes.

Three specific hypotheses were tested to determine whether there were significant differences in learning among groups receiving instruction in the short courses and those receiving no instruction, whether changes in the method of instruction affected the learning process and whether there were relationships between course grades and the educational and experiential background of those attending the courses. Course grades of the students were compared to the passing grade established by a panel of experienced traffic engineers. The analysis of variance statistical technique was used to test the three hypotheses.

The Major Findings

1. A significant difference at the .05 confidence level was found in the mean grade scores obtained on the final test by persons receiving instruction in the short courses compared to those who received no instruction. Those receiving instruction had a mean gain score of 31.35 points; those receiving no instruction 0.07 points.

2. Three different instructional methods were rotated among the three short courses groups. The three instructional methods were a lecture plus problems worked both by the instructor and the students, lecture plus problems worked by the instructor only and lecture plus problems worked by the students only. The test of the relative effectiveness of these methods was indeterminate. Significant results were obtained on the instructional methods at the .05 confidence level but because there were interactive effects of the other variables no conclusions could be made.

3. Significant results were obtained at the .05 confidence level when the grade scores of groups with differing educational backgrounds were analyzed. Those who had received college degrees had higher grade scores than those who had not attended college.

4. The results obtained by comparing student grade scores with their experiential background were so varied that no clear conclusions could be reached.

5. The comparison of student grades with those established by a panel of experienced traffic engineers as the passing grade showed that twenty-nine of the forty-five students in the three short courses achieved a passing grade of 70 per cent or more.

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Adrian Harold Koert

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CHAPTER I

THE PROBLEM

There is a shortage of professional traffic engineers in the United States as revealed by a 1964 survey taken by the Institute of Traffic Engineers. This study indicated a need for 1,400 traffic engineers at that time. The Institute reported:

> All indications--including expanding highway programs, population and travel growth, rapid development of urban areas--are that the deficiency of trained traffic engineers will grow for some years to come. Qualified job applicants are hence in the fortunate position that they can often select not only the type of employment but also the general location in which they wish to work.[1]

A number of reports has indicated the problem to be as critical, if not more so at the technician level. A 1967 survey by Miller[2] indicated the supply of traffic

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[1]Institute of Traffic Engineers, A Career in Traffic Engineering (Washington: Institute of Traffic Engineers, 1969), p. 4.

[2]William H. Miller, "Traffic Engineering Technicians Need Study for the Period August 1967 Through August 1977 in the State of Illinois and Surrounding Areas," Urbana, University of Illinois, 1968. (Mimeographed.)

engineering technicians in the state of Illinois to be two-thirds of the existing need.

A study by Grecco[3] indicated a need for technicians based on a ratio of 2.1 technicians to each traffic engineer. The American Association of Junior Colleges reported:

> A definite need exists for traffic engineering technicians throughout the country. The need varies from one section to another; it will be greatest in metropolitan areas and in the vicinity of the central office of state highway departments, although opportunities exist elsewhere.[4]

Based on nationally accepted standards there is a shortage of traffic engineering personnel in Michigan. In 1961 the President's Committee for Traffic Safety recommended:

> 1. Cities over 100,000 population . . . the establishment of a traffic engineering unit comparable in authority and influence to other major divisions of the departments of public works . . .
> 2. Cities between 50,000 and 100,000 population . . . at least one full time traffic engineer . . .
> 3. Cities less than 50,000 population . . . the functions be assigned to an engineer . . . with qualifications necessary to perform the functions of the traffic engineer.[5]

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[3]William L. Grecco, "Education of Traffic Engineering Technicians" (paper read at the Institute of Traffic Engineers annual meeting, September, 1972, New York, New York).

[4]Adrian H. Koert, <u>Traffic Engineering Technician Programs in the Community College</u> (Washington: American Association of Junior Colleges, 1969), p. 7.

[5]"Report of Committee on Engineering," President's Committee for Traffic Safety, Washington, 1961.

The National Safety Council has recommended a ratio of four professional traffic engineers for each 100,000 population in cities.[6]

Cities in Michigan fall far short of these recommendations. Of 7 Michigan cities over 100,000 population, 3 do not have a professional traffic engineer. Of 14 cities between 50,000 and 100,000 population 10 do not have a professional traffic engineer. None of the 65 Michigan cities between 10,000 and 50,000 population employs a full-time traffic engineer. Similarly, only 4 counties in Michigan employ a full-time traffic engineer in the County Road Commission despite the fact that there are 10 counties with more than 150,000 population.[7]

The traffic engineering function in those Michigan cities and counties who do not employ a professional traffic engineer is assigned to various public officials including police officers, administrative officials, city and county superintendents. Most of these have little knowledge of engineering. The function is also assigned to city and county engineers who have little traffic experience.

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[6]John E. Baerwald, Traffic Engineering Handbook (Washington: Institute of Traffic Engineers, 1965), p. 750.

[7]Based on survey by author.

A sample of 498 persons engaged in traffic engineering activities in Michigan indicated that 35 per cent held an engineering degree. The majority of those who did not hold a degree had not participated in a traffic engineering short course or conference.[8]

The lack of knowledge and training in the traffic engineering field is serious. This lack exists despite the fact that for many years short courses and conferences have been given by colleges, universities and the highway department in Michigan. As indicated, many persons have not participated in these courses. Of special concern, however, are those persons who did participate. The question arises whether they benefited from these courses.

Traffic engineering courses have been presented on an intermittent basis throughout the country since World War II. The courses vary in content, structure, length and in methods of instruction. In most cases little attention has been given to designing courses based on task analyses, learning objectives or in evaluations based on learning objectives. Most short courses are lecture oriented with experts in various phases of traffic engineering presenting a subject. There is generally an opportunity for class questions and discussion but few courses are involved in problem solving despite

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[8]"Traffic Workers Training Needs" (unpublished study, Highway Traffic Safety Center, Michigan State University, 1967).

the need for traffic engineers to solve problems in their everyday work. There is little indication that any attempts were made to measure what was learned during the course.

Analyses of short courses by the author indicated that many short courses appeared not to have accomplished major goals for the following reasons:

1. They were poorly designed.
2. Instructors were often untrained.
3. Courses had no clearly defined objectives.
4. There was no control of entering behavior of students.

Statement of the Problem

The purpose of this study was to test the effectiveness of traffic engineering short-course instruction given to persons in charge of traffic engineering in their communities and counties. The study was designed to determine whether a carefully designed traffic engineering short course with measurable instructional objectives could produce significant measurable results in terms of increased knowledge and/or skills as indicated by comparing the difference between post-test and pretest scores.

Eight subject areas in the field of traffic engineering were selected for presentation in a series of short courses:

(1) Traffic volume data collection and analysis;

(2) Intersection capacity analysis;

(3) Traffic signals;

(4) School children travel protection;

(5) Traffic accident analysis;

(6) Intersection traffic controls;

(7) Revisions to the Manual on Uniform Traffic Control Devices.[9]

(8) Traffic speed regulation.

The eight subject areas given in the previous paragraph were selected after a review of the training needs of persons doing traffic engineering work in communities of less than 50,000 population in Michigan. This review of needs included interviews with persons doing traffic engineering work in these communities, discussions with Michigan Department of State Highways district traffic engineers who were acquainted with

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[9] U.S., Department of Transportation, Manual on Uniform Traffic Control Devices for Streets and Highways (Washington, D.C.: Government Printing Office, 1971), p. 5. (Hereinafter referred to as Manual on Traffic Control.)

traffic problems in the smaller communities and by reviewing answers to questions included in critiques submitted by students in past short courses.

Five of the eight subjects given above were selected for testing:

(1) Traffic volume data collection and analysis;

(2) Intersection capacity analysis;

(3) School children travel protection;

(4) Intersection traffic controls;

(5) Traffic speed regulation.

The five subjects were selected because they represented areas where specific techniques were being taught which were most suitable for testing and because they were being taught by one instructor who had prepared detailed teaching material for these topics.

Study Design and Data Collection

The traffic engineering short course material was based on a review of the existing literature. Each subject used for testing was introduced with one or more learning objectives. Pre-tests and post-tests were given in May, 1972. These tests were designed to measure whether the students had mastered the objectives of each subject area. A comprehensive history of each student's occupational background and education was obtained to measure relationships between these items and learning that took place in the short course program.

Dr. Stephen L. Yelon, Associate Professor at Michigan State University and co-author of the book Learning System Design,[10] reviewed the instructional objectives and test questions used to measure these objectives. An advisory panel of seven traffic engineers rated the tests to determine what would be considered a passing grade.

Hypotheses

The following hypotheses were selected for testing in this study:

Hypothesis 1:

There are no significant differences in learning among groups receiving instruction in traffic engineering short courses and those receiving no instruction as measured by the differences in pre-test and final test scores achieved by persons in each of these groups.

Hypothesis 2:

There are no significant differences in learning among groups receiving three different methods of instruction in the traffic engineering short courses as measured by the differences in the pre-test, post-test and final test scores achieved by the students.

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[10] Robert H. Davis, Lawrence T. Alexander, and Stephen L. Yelon, Learning System Design (East Lansing: Michigan State University, 1972). (Hereinafter referred to as System Design.)

Hypothesis 3:

> There are no significant differences in learning among students attending the traffic engineering short courses with differing educational and experiential backgrounds as measured by the differences in the pre-test, post-test and final test scores achieved by the students.

A fourth test of the effectiveness of the short-course instruction was made by comparing student scores with those established by a panel of experts as the minimum passing scores. No hypothesis was established for this fourth test of effectiveness of the short-course instruction.

Limitations

The traffic engineering short courses upon which this study was based were offered in three locations in southern Michigan: Southfield, Ann Arbor and Kalamazoo. This afforded opportunities for a wide range of persons to attend from counties and the smaller communities in Michigan. No control was exercised as to whom could attend the course. Those attending were either volunteers or were selected by their superiors.

Five subject areas: traffic volumes, intersection capacity, school travel protection, intersection control and speed regulation were selected for testing. These five subjects, while of primary importance to the students attending, comprise only about one-third of the subject areas that would be included in a comprehensive course for traffic engineering technicians.

One instructor was used to present the five subject areas which were used in testing the students. This had the advantage of eliminating variables which could have arisen from the individual approaches of a number of instructors. It had the disadvantage of not permitting an assessment of whether the methods used could be successfully applied by other instructors.

Unfortunately, no large pool of instructors who are acquainted with the learning system design approach used in the short courses is available in Michigan or elsewhere.

Importance of the Study

The passage of the Highway Safety Act of 1966 intensified interest in highway safety problems.[11] The Act resulted in the promulgation of highway safety standards. Of the first group of sixteen standards four are of concern and interest to traffic engineers:

1. Standard 4.4.9 - Identification and Survelliance of Accident Locations
2. Standard 4.4.12 - Highway Design, Construction and Maintenance

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[11] U.S., Public Law 89564 "Highway Safety Act of 1966," U.S. Congress.

3. Standard 4.4.13 - Traffic Control Devices
4. Standard 4.4.14 - Pedestrian Safety[12]

The purpose of Standard 4.4.13 - Traffic Control Devices is stated: "To assure the full and proper application of modern traffic engineering practice . . . in reducing the likelihood and severity of traffic accidents."[13]

The Manual on Uniform Traffic Control Devices indicates the importance of traffic engineering in the use of traffic control devices:

> Qualified engineers are needed to exercise the engineering judgment inherent in the selection of traffic control devices, just as they are needed to locate and design the roads and streets which the devices complement. Jurisdictions with responsibility for traffic control, that do not have qualified engineers on their staffs should seek assistance from the State Highway Department, their county, a nearby large city, or a traffic consultant.[14]

In many cases, because of the shortage of qualified engineers, cities and counties often cannot obtain competent assistance from outside sources. To meet the intent of the highway safety standards and the Manual on Uniform Traffic Control Devices, many jurisdictions must rely upon traffic engineering short courses to upgrade their own personnel.

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[12] U.S., Department of Transportation, Highway Safety Program Standards (Washington, D.C.: Government Printing Office, 1969).

[13] Ibid.

[14] U.S., Department of Transportation, Manual on Traffic Control, p. 5.

Scope of the Study

The study was limited to five traffic engineering study areas of primary importance to those with traffic engineering responsibilities in small communities and counties. It provides a guide to the development of other traffic engineering subject design methods and provides an indication of the effectiveness of these methods.

Definition of Terms

Traffic Engineering.--The definition used is that adopted by and included in the Constitution of the Institute of Traffic Engineers: "Traffic Engineering is that phase of engineering which deals with the planning, geometric design and traffic operations of roads, streets and highways, their networks, terminals, abutting lands and relationships with other modes and types of transportation for the achievement of safe, efficient and convenient movement of persons and goods."[15]

Traffic Engineering Practitioner.--For purposes of this study a traffic engineering practitioner was any person who by virtue of his job assignment is responsible for traffic engineering activities in a county or city,

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[15]Constitution of the Institute of Traffic Engineers as amended, 1967.

but whose education and experience did not qualify him as a professional traffic engineer.

This definition is broader than the definition for a traffic engineering technician: "One who, in support of and under the direction of professional traffic engineers or scientists, can carry out in a responsible manner either proven techniques, which are common knowledge among those who are technically expert in traffic engineering technology, or those techniques especially prescribed by professional traffic engineers."[16]

Traffic Engineering Short-Course Training.--For purposes of this study, traffic engineering short-course training was training given to traffic engineering technicians by instructors who are professional traffic engineers. The length of the course was thirty hours of classroom instruction.

Learning System.--A learning system is defined as "an organized combination of people (instructors and students), materials and procedures all interacting to achieve a goal. The elements of a learning system are arranged according to a specific plan with an interdependent arrangement of the component elements."[17]

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[16] Grecco, "Engineering Technicians."

[17] Davis, Alexander, and Yelon, System Design, ch. XII, p. 6.

Course of Study.--For purposes of this study course of study referred to the performance, objectives, subject outlines, lectures, problems and the testing used with students who attended one of three short courses given in Southfield, Ann Arbor or Kalamazoo, Michigan by the Highway Traffic Safety Center of Michigan State University during April and May, 1972.

Entering Behavior.--For purposes of this study entering behavior is that information obtained from students who attended one of the three short courses as given by answers to a questionnaire on experience and education completed by each student.

Organization of the Remaining Chapters

Chapter II contains a review of the literature. The review of the literature consists of task description, traffic engineering short course material, traffic engineering as it relates to traffic accidents and learning system design.

Chapter III contains a more detailed description of the course of study as well as the techniques used in evaluating this course of study.

Chapter IV contains the findings based on test results and the entering behavior of students.

Presented in Chapter V are the summary, conclusions, recommendations for further study and a discussion.

CHAPTER II

REVIEW OF THE LITERATURE

The review of the literature revealed several areas which related to the development of effective traffic engineering short-course instruction. These areas are classified into:

(1) Task description

(a) the traffic engineering function

(b) the traffic engineering technician function

(2) Guides available to traffic engineering technicians

(3) Traffic engineering short-course material

(4) Traffic engineering as it relates to accident reduction

(5) Learning system design

Task Description

The purpose of traffic engineering short courses is to assist those persons responsible for traffic engineering services in their communities who are called upon to perform services for which they are often not equipped by training or experience. These people are not professional traffic engineers, although many are engineers and can be classified as traffic engineering technicians.

Traffic Engineering

Traffic engineering is a relatively young science, having begun in the early 1920's. Its beginnings are described as follows:

> The Traffic Engineering Profession. Although the first traffic signal was installed as early as 1912, it was almost 10 years later before the position of Traffic Engineer was established in any city. Seattle, Chicago, Pittsburgh and Philadelphia were among the first to designate traffic engineers.
>
> The traffic engineering functions in the 1920's were much more limited in scope than is the case today. The management of the traffic signals was the major function. Most of the modern techniques of making traffic regulations or for planning streets and highways were still unknown. Traffic signs usually followed local design, since national standards for uniform design and application of traffic control devices had not been developed.
>
> The Institute of Traffic Engineers, founded in 1930, is the professional society for traffic engineers. Its membership as of March 1, 1965, was 2,350. The Institute cooperates with the American Association of State Highway Officials, the American Public Works Association, the Highway Research Board, and others in developing standards for traffic control devices, and in the preparation of manuals, handbooks and standards of traffic engineering practices.[18]

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[18] Norman Kennedy, *et al.*, *Fundamentals of Traffic Engineering, 6th Edition* (Berkeley: University of California, 1966), ch. I, p. 2. (Hereinafter referred to as *Traffic Engineering*.)

Its progress has been noted by Oppelander who stated:

> During the past thirty years the profession of traffic engineering has advanced from the art of breaking up traffic jams to the science of optimizing the safe movement of persons and vehicles within the limitations of human and natural resources available.[19]

Because of its youth and the changing demands of highway transportation the science of traffic engineering has changed rapidly and continues in a condition of flux:

> Traffic engineering is a by-product of the Motor Age, population growth and urbanization. As motor vehicle registrations skyrocketed and urban centers grew, difficulties of providing safe, orderly and efficient street and highway transportation increased rapidly. Resulting complications required use of traffic engineering principles.
>
> The motor vehicle has greatly changed our way of life. In six decades the motor vehicle more than any other development has multiplied the magnitude and complexity of traffic problems. One result has been rapidly increasing emphasis on traffic engineering which has as one of its responsibilities "making modern transportation work."
>
> The remarkable growth of professional traffic engineering over the past four decades is tacit recognition that the application of sound traffic engineering principles is essential to meet transportation needs.[20]

The difficulties of those attempting to prepare texts, courses or other material related to traffic

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[19]Joseph C. Oppelander, "Functions and Technician Training" (paper read at the Institute of Traffic Engineers annual meeting, August, 1963, Toronto, Canada). (Hereinafter referred to as "Technician Training.")

[20]Profiles of Progress (Washington, D.C.: Institute of Traffic Engineers, 1970), p. 2.

engineering are due to the youthfulness of this science. A large body of theory is not available to the traffic engineering field. " . . . the analyst in many fields is able to describe and predict the interrelationships between the phenomena of interest to him by using theoretical methods, the highway transportation engineer must often rely on observation and measurement to arrive at a solution."[21]

A number of persons have attempted to define traffic engineering and over the years these definitions have changed as the science changed and the scope of its activities broadened.

Traffic engineering developed in the 1920's when "the management of the traffic signals was the major function."[22] As late as 1967 it was implied that its major function continued to be the management of traffic control devices (traffic signs, signals and markings). In a guide prepared for county road engineers it was stated:

> If traffic control was nothing more than installing traffic signals and signs at designated locations, this procedure might serve the purpose intended. But as noted earlier, traffic engineering is a

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[21]Donald G. Capelle, et al., An Introduction to Highway Transportation Engineering (Washington, D.C.: Institute of Traffic Engineers, 1968), p. 36. (Hereinafter referred to as Highway Transportation.)

[22]Kennedy, Traffic Engineering, ch. I, p. 2.

> science that has evolved after many years of study and research. There are, for example, as many reasons for not utilizing traffic control devices at certain locations as there are for using them. The official responsible for county traffic operations must know the difference. He must also know how to utilize these devices to obtain maximum effectiveness, and how to gather, analyze, and use traffic data for decisions affecting traffic control operations.[23]

In 1955, Matson, Hurd and Smith published the first comprehensive textbook on traffic engineering. Though much progress has been made in the traffic engineering field since that date, this text is today the only comprehensive textbook on this subject. Traffic engineering as defined by Matson, Hurd and Smith in this textbook is:

> . . . that branch of engineering which is devoted to the study and improvement of the traffic performance of road networks and terminals. Its purpose is to achieve efficient, free, and rapid flow of traffic; yet, at the same time, to prevent traffic accidents and casualties. Its procedures are based on scientific and engineering disciplines. Its methods include regulation and control, on the one hand, and planning and geometric design, on the other.[24]

In 1961 Blunden proposed that traffic engineering be defined as, "the science of measuring traffic and travel, the study of the basic laws relating to traffic

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[23] Manual on County Traffic Operations (Washington, D.C.: National Association of County Engineers, 1966), p. 5.

[24] Theodore M. Matson, et al., Traffic Engineering (New York: McGraw Hill Book Company, 1955), p. 3. (Hereinafter referred to as Traffic Engineering.)

flow and generation, and the application of this knowledge to the professional practice of planning, designing and operating traffic systems to achieve safe and efficient movement of persons and goods."[25]

The latter two definitions closely paralleled the definition of traffic engineering adopted by the Institute of Traffic Engineers in 1968:

> Traffic Engineering is that phase of engineering which deals with the planning, geometric design and traffic operations of roads, streets and highways, their networks, terminals and abutting lands and relationships with other modes of transportation for the achievement of safe, efficient and convenient movement of persons and goods.[26]

Traffic engineering has progressed from a narrow science concerned mainly with "the management of traffic signals"[27] to all phases of highway transportation as they relate to the use of the roadway either by vehicle drivers or by pedestrians. This has led some to suggest the term "highway transportation engineer" as more definitive than traffic engineer. Capelle has suggested this in the title of the book, <u>Introduction to Highway Transportation Engineering</u>. In the introduction he stated:

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[25]Kennedy, <u>Traffic Engineering</u>, ch. I, p. 3.

[26]Constitution of the Institute of Traffic Engineers.

[27]Kennedy, <u>Traffic Engineering</u>, ch. I, p. 2.

> These are the responsibilities of the highway transportation engineer, although his title, in practice, may be traffic engineer, planning engineer, transportation director or some other similar specialty.
>
> A broad approach to highway transportation is essential if this public service is to provide for the safe, efficient and convenient movement of people and goods. Road network considerations, terminal requirements, the relation of the highway system to other modes of transportation and the interrelationship of road systems to abutting land uses must be considered by engineers in the planning, design, operation and administration of the system.[28]

The human aspects of traffic engineering have been recognized by a number of persons. The traffic engineer is concerned with the relationship between the driver and the vehicle as they function on the highway. The human aspect goes beyond this, however. Koert stated:

> Many persons both in and out of the profession believe that in many ways traffic engineering is a form of human engineering rather than being part of the classical civil engineering branch of the profession. The traffic engineer has continuing contacts with people and almost everything he does influences the daily lives of people through his various manipulations of traffic, signs, signals, and markings.[29]

In a discussion of traffic engineering activities in Profiles of Progress, an Institute of Traffic Engineers publication, it is stated:

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[28] Capelle, Highway Transportation, p. 9.

[29] Koert, Technician Programs, p. 3.

> The traffic engineer in all of his work is concerned with operations and their relationships to environment and community development. One of his major concerns is people, in groups and as individuals--their needs, desires, actions, characteristics, capabilities, limitations.
>
> Traffic engineers base decisions on analysis of facts, sociological and human factors, and application of engineering and statistical principles.
>
> Few professions have such a vital role in everyday life. Everyone who uses a public way--by passenger car, mass transit vehicle, truck or afoot--is affected by professional activities and decisions of traffic engineers.[30]

Capelle stated that the "highway transportation engineer must plan and provide facilities and operating controls for a system which has a tremendous impact on our economy and culture."[31] Matson, Hurd and Smith recognized years ago the implications of both the social sciences and the physical sciences to the traffic engineer:

> Since traffic is composed of "man and his machine," the traffic engineering field must recognize and be governed by both the social and physical sciences in the solution of its problems. While the strict disciplines of engineering are applicable to the physical aspects, the conventions and vagaries of the human element are ever present and are frequently found to be critical factors in the making of the final decisions.
>
> Because both the physical and social sciences are involved, the research and theoretical problems as well as the practical applications require for their analysis and treatment mathematics, statistics, and physics, on the one hand, and city planning, psychology, government, and economics, on the other.

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[30]Profiles of Progress, p. 2.

[31]Capelle, Highway Transportation, p. 49.

> While traffic engineering involves the strict disciplines of science, it is also subject to new departures and scholarly theorizing in many of its aspects which are not crystallized.[32]

The functions and activities of those engaged in traffic engineering are important in determining the knowledge one must have to function adequately. Various persons have stated the activities and functions of the traffic engineer differently. The difficulty arose due to the changing nature of traffic engineering activities from a beginning in traffic operations, that is, the science of using traffic control devices to obtain the best possible use from the existing street system to the task of planning, providing facilities and operating controls for a highway transportation system.

Sessions divided traffic engineering into two major functions. He stated:

> The traffic engineer has two major functions. One is operations: helping motor vehicle occupants and pedestrians to get from where they are to where they want to be with safety and without needless delay.
>
> The goal is not simply to move traffic, but to move it with a purpose--to serve the community's best interests.
>
> But, existing streets are only part of the traffic engineer's responsibility in the city today. His knowledge is being utilized more and more in the planning and design of new facilities.[33]

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[32] Matson, Traffic Engineering, p. 7.

[33] Gordon Sessions, Getting the Most From City Streets (Washington, D.C.: Highway Research Board, National Academy of Sciences, 1968), p. 1.

The changing nature of the traffic engineering function is emphasized in Profiles of Progress:

> Today traffic engineering has a vital part in functional design and traffic operations of the Interstate Highway System and in coordinating feeder traffic therewith. The traffic engineer works on fitting freeways, shopping and industrial centers and terminals into the fabric of communities to benefit urban life and development. Traffic engineers design and operate main highway control-and communication systems and develop ways to stretch capacity and improve safety and existing roads and streets.
>
> The traffic engineer innovates and otherwise uses ingenuity in coping with burgeoning urban and suburban developments and resulting transportation problems including proper relationships of transportation to urban development. He also checks traffic flows and adjusts operational controls to meet changing needs. His is a fluid, rapidly advancing profession--dynamic and absorbing.
>
> Tomorrow he may control vehicle movements electronically. He now maintains surveillance over critical traffic flows by closed-circuit television, and applies remedies aided by split-second computer service. His job becomes more complex each year. By nature, education and experience, he accepts new problems as stimulating challenges.[34]

Oppelander has discussed traffic engineering functions in relation to the training of traffic engineering technicians. He listed eight functions:

1. Surveys and studies related to transportation planning,
2. Transportation planning and programming,
3. Surveys and studies related to traffic operations,
4. Traffic control and driver aids,
5. Parking and standing,
6. Street use,
7. Design, and
8. Miscellaneous functions.[35]

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[34] Profiles of Progress, p. 3.

[35] Oppelander, "Technician Training."

The most comprehensive attempt to define traffic engineering functions was done in the introduction to <u>Fundamentals of Traffic Engineering</u>. The practice of traffic engineering was divided into main functions and sub-functions as follows:

1. <u>Studies of Traffic Characteristics</u>. Traffic studies must be conducted to obtain data on transportation and traffic trends for entire regions, and on traffic conditions at specific locations. Studies cover the following fields:
   a. Vehicular and human factors.
   b. Traffic volumes, speeds, delay.
   c. Traffic stream flow and capacity of streets and intersections.
   d. Travel patterns, trip generation factors, origins and destinations.
   e. Parking and terminal factors.
   f. Mass transit systems.
   g. Accidents.
2. <u>Traffic Operations</u>
   a. Regulations
   b. Control Design
   c. Warrants
3. <u>Traffic Planning Functions</u>
   a. Comprehensive regional transportation studies "to provide comprehensive and continuing guidance to the development of transportation facilities which will meet the standards and goals of the community."
   b. Long-range plans for highway networks, generally based on comprehensive regional studies.
   c. Long-range plans for mass transit systems, also resulting from regional studies.
   d. Long-range plans for off-street parking and terminals.
   e. Research into the factors underlying transportation systems and the behavior of the users of such systems.
4. <u>Geometric Design Functions</u>
   a. Design of new highways to carry expected volumes at suitable speeds. Geometric features of alignment, grade, cross section, access control, intersections and interchanges must be based on traffic engineering analysis.

b. Redesign of existing highways and intersections to increase capacity and safety.
c. Design of off-street parking and terminals.
d. Establishment of standards for subdivision designs, driveway standards, and access control.

5. Administration
a. Organization of general government to assign responsibility for traffic engineering functions to a specific office.
b. Organization of this office to carry out its duties.
c. Day-by-day operation of the office.
d. Contact with public officials, the general public, other interested agencies, committees and groups.
e. Advance administrative planning, such as budgeting, personnel requirements, and proposals for administrative or organizational changes.[36]

The Traffic Engineering Technician

The literature contains few references to the traffic engineering technician. The Institute of Traffic Engineers does not provide for the admittance of technicians to membership. There are four membership grades in the Institute. The two highest grades, fellow and member, have qualification requirements which can be met only by professional traffic engineers. The other two grades, associate and student, have qualification requirements which imply future attainment of professional status.[37]

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[36] Kennedy, Traffic Engineering, ch. I, p. 2.

[37] Constitution of the Institute of Traffic Engineers.

As the traffic engineering profession has become more complex the need for technicians has increased. Oppelander stated:

> The growth of a scientific profession is accompanied by the increasing need for properly qualified technicians. The engineering technician is now required in the discipline of traffic engineering to permit more efficient use of its professional personnel and to help ease the shortage of traffic engineers.[38]

As the complexities of urban traffic increase, more sophisticated traffic control measures have been developed. This also has increased the need for technicians to supplement the work of the traffic engineer. Bonniville stated:

> Advanced systems for measuring traffic flow and providing responsive traffic control strategies have been placed in operation or are planned in most large urban areas. These systems present added traffic operations roles for engineering technicians.[39]

The traffic engineering technician is a person who does semi-professional work under the direction of an engineer. His work falls between that of the craftsman and the professional. Grecco defined this relationship when he stated:

> The technician must comprehend the work of both the professional and the craftsman as he must work with both. Broadly defined, he must perform in the gap

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[38] Oppelander, "Technician Training."

[39] Jack Bonniville, "Engineering Technicians: Manpower for Traffic Operations," Traffic Engineering, XLIII, No. 1 (October, 1972), 22.

> where responsibilities exceed the competence of the craftsman and yet the responsibilities are too repetitive and ordinary to require the training of the professional engineer or scientist.[40]

A definition of an engineering technician is provided by the Institute for the Certification of Engineering Technicians as follows:

> An engineering technician is one who, in support of and under the direction of professional engineers or scientists, can carry out in a responsible manner either proven techniques, which are common knowledge among those who are technically expert in a particular technology, or those techniques especially prescribed by professional engineers.
>
> Performance as an engineering technician requires the application of principles, methods, and techniques appropriate to a field of technology, combined with practical knowledge of the construction, application, properties, operation, and limitations of engineering systems, processes, structures, machinery, devices, or materials, and, as required, related manual crafts, instrumental, mathematical or graphic skills.
>
> Under professional direction an engineering technician analyzes and solves technological problems, prepares formal reports on experiments, tests, and other similar projects or carries out functions such as drafting, surveying, technical sales, advising consumers, technical writing, teaching or training. An engineering technician need not have an education equivalent in type, scope, and rigor to that required of an engineer; however, he must have a more theoretical education with greater mathematical depth, and experience over a broader field than is required of skilled craftsmen who often work under his supervision.[41]

In relating this definition to the traffic engineering profession, Grecco stated that "the traffic engineering technician would then apply his knowledge

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[40] Grecco, "Engineering Technicians."

[41] Ibid.

and skill in the manner prescribed above for safe, efficient and convenient movement of persons and goods."[42]

Most definitions and discussions of the status of engineering technicians have implied that the technician works under the direct supervision of an engineer. This need not be true of the traffic engineering technician. Koert has suggested, that in some cases, a somewhat different arrangement might be used:

> One potential field for employment which has hardly been tapped, is the growing list of suburban areas around central cities. These communities, whose traffic and transportation problems equal in complexity, if not in numbers, those of the central city, often operate without any qualified people competent to resolve their problems. In view of a growing shortage of traffic engineers these communities could benefit greatly by employing traffic engineering technicians who might work under the direction of a city manager or director of public works.[43]

The job description of the traffic engineering technician has shown that he performs work similar to that of the traffic engineer but is not responsible for final decisions. A typical job description appeared in the publication <u>Traffic Engineering Technician Training in the Community College</u>:

> A traffic engineering technician does semiprofessional work under the direction of an engineer related to the following:

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[42]<u>Ibid</u>.

[43]Koert, <u>Technician Programs</u>, p. 6.

1. The collection, tabulation and analysis of data
2. The investigation of traffic and parking problems
3. The preparation of engineering drawings and sketches
4. The operation and maintenance of traffic control devices and traffic measuring equipment

He shall be qualified to perform the following tasks:

1. Conduct and/or supervise field investigations of traffic problems
2. Collect and/or supervise the collection of traffic data
3. Tabulate and analyze traffic data
4. Prepare preliminary recommendations for the correction of traffic problems
5. Prepare preliminary plans and specifications
6. Operate and maintain traffic control devices and traffic measuring equipment[44]

Guides Available to Traffic Engineering Technicians

Very little formal training has been available to the traffic engineering technician. In 1972 Grecco noted that there were four two-year community college programs.[45] In addition to these programs many schools offer one- or two-week short courses. The lack of training for technicians and those persons responsible for traffic engineering in communities that do not employ a traffic engineer is met, partially, by a number of guides on traffic engineering. The first of these, Traffic Engineering and the Police, was published in 1946.[46] This was

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[44] Ibid., p. 4.

[45] Grecco, "Engineering Technicians."

[46] Franklin M. Kreml, Traffic Engineering and the Police (New York: National Conservation Bureau, 1946).

followed by a series of one- or two-page pamphlets entitled, Getting Results from Traffic Engineering.[47] These ordinarily consisted of a traffic engineering problem and the steps that had been taken to correct or alleviate the problem. Its intent was to assist others in attacking problems of a similar nature. Although it may not have represented a highly scientific approach, it enjoyed considerable popularity among traffic persons in the 1940's and 1950's.

Other publications were:

(1) Traffic Engineering Guide for Cities under 50,000 Population[48]

(2) How To Get the Most Out of Our Streets[49]

(3) Manual on County Traffic Operations[50]

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[47] Getting Results Through Traffic Engineering (New York: Association of Casualty and Surety Companies, 1958).

[48] Traffic Engineering Guide for Cities Under 50,000 Population (Chicago: National Safety Council, 1955).

[49] How to Get the Most Out of Our Streets (Washington, D.C.: U.S. Chamber of Commerce, 1954).

[50] Manual on County Traffic Operations, p. 5.

(4) How to Implement a Program of Traffic Engineering and Roadway Improvements in Your Community[51]

One of the publications which goes into considerable detail is the Manual of Traffic Engineering Studies.[52] Now, in its third edition, this book shows the latest methods of collecting, tabulating, and analyzing various kinds of traffic data required for the study of traffic engineering problems. The publication is limited to methods of making studies and does not attempt any comprehensive discussion of the application of these studies. All of these various publications have been of assistance to those responsible for traffic engineering programs in the smaller cities and counties.

Traffic Engineering Short-Course Material

A considerable amount of material has been developed and published which has been of use in the preparation of traffic engineering short-course materials. Some of these are general references which cover the broad field of traffic engineering while others are devoted to specific areas of the field.

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[51] How to Implement a Program of Traffic Engineering and Roadway Improvements in Your Community (Chicago: National Safety Council, 1965).

[52] Donald E. Cleveland, et al., Manual of Traffic Engineering Studies (Washington, D.C.: Institute of Traffic Engineers, 1964). (Hereinafter referred to as Engineering Studies.)

A basic work is the Traffic Engineering Handbook. The third edition was published in 1965 by the Institute of Traffic Engineers and is currently being revised to reflect changes and developments. The purpose of the Handbook is to present in one volume a concise treatment of the basic fundamentals of a rapidly expanding science. Designed to provide a valuable day-to-day reference for practicing traffic, highway, and transportation engineers and planners, the Handbook also serves as a guide to students and nonprofessionals. The Handbook has nineteen chapters devoted to the following subjects:

Vehicle, Highway and Travel Facts
Vehicle Operating Characteristics
The Driver
The Pedestrian
Traffic Characteristics
Traffic Accidents
Traffic Studies
Highway Capacity and Levels of Service
Traffic Markings and Markers
Traffic Signing
Traffic Signalization
Parking
Loading and Unloading
Speed Regulations
Other Operational Controls
Roadway Lighting
Geometric Design of Roadways
Long Range Urban Traffic Planning
Traffic Engineering Administration[53]

Another comprehensive work, published in outline form is Fundamentals of Traffic Engineering. Its purpose, as its authors state, "is to provide an outline for

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[53]Baerwald, Engineering Handbook, p. 750.

University courses in the fundamentals of traffic engineering. The chapter headings of this book are as follows:

Introduction
Transportation Characteristics
Human and Vehicular Characteristics
Volume Studies and Characteristics
Spot Speed Studies
Travel Time and Delay Studies
Roadway and Intersection Capacities
Parking Studies and Characteristics
Accident Characteristics and Analysis
Mass Transit Systems Characteristics and Studies
Transportation Demand Studies
Comprehensive Transportation Planning
Traffic Laws and Ordinances
Uniform Traffic Control Devices
Traffic Signs and Markings
Traffic Signals
Intersection Channelization
Intersection Control
Pedestrian Control
Speed Zoning and Control
Curb Parking and Control
One-Way Streets and Unbalanced Operation
Geometric Design of Streets and Highways
Off-Street Parking and Terminals
Roadway Lighting
Traffic Engineering Administration
Computer Applications in Traffic Engineering[54]

A comparison of these chapter headings with those of the Traffic Engineering Handbook show that the two publications cover approximately the same materials for different purposes.

Traffic Engineering,[55] despite its publication in 1955 and the possible obsolescence of some material, is a valuable guide to the development of traffic engineering

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[54] Kennedy, Traffic Engineering, ch. I, p. 2.

[55] Matson, Traffic Engineering, p. 3.

short courses and is the only comprehensive textbook of traffic engineering ever published. Because of the complex treatment of some materials, it should not be used as a textbook for short courses.

A number of publications widely used by traffic engineers present authoritative information. These are the following:

1. Highway Capacity Manual[56]--This is the most widely accepted study of highway capacity and its 380 pages present a comprehensive study of capacity measurements ranging from freeways to local streets.

2. Manual on Uniform Traffic Control Devices for Streets and Highways[57]--Published by the Federal Highway Administration and developed through the work of hundreds of highway and traffic engineers, this is the definitive work on the subject of traffic control devices.

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[56] Highway Capacity Manual--1965 (Washington, D.C.: Highway Research Board, National Academy of Sciences, 1965).

[57] U.S., Department of Transportation, Manual on Traffic Control.

3. Manual of Traffic Engineering Studies[58]--This publication discusses the various studies useful in studying traffic engineering problems and shows how to collect, tabulate and analyze traffic data.

4. A Policy on Geometric Design of Rural Highways[59]--A Policy on Arterial Highways in Urban Areas[60]--These two publications are the most useful sources of information on geometric design principles for rural and urban streets and highways.

Traffic Engineering As It Relates to Accident Reduction

The definition of traffic engineering adopted by the Institute of Traffic Engineers stated that the purpose of traffic engineering included providing for the safe movement of persons and goods.[61] Throughout the years

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[58]Cleveland, Engineering Studies.

[59]A Policy on Geometric Design of Rural Highways (Washington, D.C.: American Association of State Highway Officials, 1965).

[60]A Policy on Arterial Highways in Urban Areas (Washington, D.C.: American Association of State Highway Officials, 1957).

[61]Constitution of the Institute of Traffic Engineers.

considerable emphasis has been given by traffic engineers to the safety of the public highways and much research has been done in this area. The review of this research is confined in this paper to those topics which were tested in the short courses: traffic volumes, intersection capacity, school travel protection, intersection control and speed regulation. Since capacity is directly related to traffic volumes, it is not considered separately.

Traffic Volumes

Accident rates based on traffic volumes may be used as a measure of street efficiency. The ability to predict the accident rate as traffic increases would be an important tool in the evaluation of street and highway systems.[62]

In the 1930's Vey attempted to relate accident rates to traffic volumes.[63] A number of other investigators have since concluded that there is a significant relationship between traffic volumes and traffic accident experience.[64]

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[62]Gilbert T. Satterly, Jr., and Donald E. Cleveland, Traffic Control and Roadway Elements--Their Relationship to Highway Safety--Traffic Volume (Washington, D.C.: Automotive Safety Foundation, 1969), p. 1.

[63]Arnold H. Vey, "Improvements to Reduce Traffic Accidents," Transactions of the American Society of Civil Engineers, CIV (1939), 474-84.

[64]David W. Schoppert, Predicting Traffic Accidents from Roadway Elements of Two-Lane Highways with Gravel

In comparing traffic accidents to traffic volumes both the average daily traffic (ADT) and hourly volumes have been used. A number of studies have been made of the relationship between average daily traffic and accidents with somewhat varying results. Baldwin concluded in 1941, on the basis of data obtained from nine states, that the accident rate for two-lane rural roads without intersections increases with volume up to 8,000 to 9,000 vehicles a day and as the volume increases beyond that point the accident rate decreases.[65] Raff confirmed these results with data from six other states.[66] Other studies have shown there is no point at which the accident rate decreases while volumes increase.

Some explanation for these conflicting results may be found in a 1966 study of accident data from three states (Louisiana, Ohio and California) for 16,600

Shoulders (Washington, D.C.: Highway Research Board, National Academy of Sciences, 1957), pp. 4-27; P. D. Cribbins, et al., "Effects of Selected Roadway and Operational Characteristics on Accidents on Multilane Highways," Highway Research Record 188 (Washington, D.C.: Highway Research Board, National Academy of Sciences, 1967), pp. 8-25.

[65]David M. Baldwin, "The Relation of Highway Design to Traffic Accident Experience" (paper read at American Association of State Highway Officials annual meeting, December, 1946), pp. 103-09.

[66]Morton S. Raff, "Interstate Highway Accident Study," Highway Research Board Bulletin, LXXIV (1953), 18-45.

sections of rural roadway of varying lengths up to approximately 20 miles. The study in total covered 55,500 miles of roadway and 118,000 accidents and revealed that the use of highway sections of varying length to analyze the relationship between accident rates and ADT influences the outcome of the analysis.[67] A correlation was found to exist between section length and those factors which cause traffic disturbances or interferences. For example, section lengths tend to be shorter in those locations having more intersections and driveways. Further, short segments tended to have high volume and high accident rates while long sections had low volumes and low accident rates. Hence, it was found that the accident rates were dependent on section length. All of the previous studies mentioned had used highway segments of varying lengths.

For tangent sections of four-lane divided roadway, both the 1941 and 1966 studies showed that the accident rate increases with increases in average daily traffic. No point of decrease was found up to 20,000 vehicles per day, a free-flow volume.

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[67] S. R. Byington, "Interstate System Accident Research," Public Roads, XXXII, No. 11 (December, 1963), 256-66.

School Travel Protection

The safe travel of students to and from school, particularly at the elementary and middle (or junior high) school level, is of great parental concern, probably out of proportion to the seriousness of the problem. While school-age children (5-14) are the victims in 40 per cent of pedestrian accidents in the United States, these accidents generally are not school-trip or school-area related. In Los Angeles in 1959, it was found that pedestrian accidents to children going to or from school occurred at a rate of 11.5 per 100,000 trips.[68]

A similar analysis of school-child pedestrian accident data for Detroit showed that 9.5 per cent of the accidents involved children going to or from school.[69]

Recent studies have not established the value or benefit, insofar as safety is concerned, of marking or signing pedestrian crossings at intersections.

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[68] Charles A. French, "Pedestrian Progress of Los Angeles Pupils," Safety Education, XL (October, 1960), 48.

[69] Detroit Police Department, The Child in Detroit Traffic, Traffic Safety Bureau, 1963.

A five-year San Diego study[70] of 400 intersections, each of which had one painted and one unpainted crosswalk across the major thoroughfare, indicated that 177 accidents occurred in the painted walks and 31 in the unpainted. This is a ratio of 5:1. The ratio of the pedestrian volume on the painted to the unpainted was 2.6 to 1. The preliminary findings of a follow-up study made three years later showed little change in these ratios. A three-year before-and-after study[71] in Vancouver, British Columbia, indicated that pedestrian accidents increased 86 per cent at 55 intersections after marked crosswalks were provided. Rear-end collisions increased 32 per cent.

In Toronto, Ontario, a study was made of 170 intersections with specially marked pedestrian crossings.[72] These crossings were marked with over-the-roadway illuminated signs, signs back of the curb, advance pavement marking legends and crosswalk markings. A comparison of pedestrian accidents at these locations

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[70] "To Paint or Not to Paint," Public Works, C, No. 4 (April, 1969), 70-72.

[71] "What Not to Expect from Crosswalk Signals," Civic Administration, Canada, XIX, No. 5 (May, 1967), 32-33.

[72] Morris Rotman, "The Toronto Pedestrian Cross-over Program," Traffic Engineering, XXXI, No. 5 (February, 1961), 11-16, 54.

for a seven-month period before the special devices were installed and two comparable periods, one and two years after, showed no change the first year and a slight increase in accidents (57 to 64) the second year. However, by the second year there had been a one-third increase in the number of pedestrians using the crossings.

Although studies to date have not shown any substantial safety value in marking crosswalk locations, they do show a relatively lower risk of crossing in a crosswalk area to crossing outside such an area (jaywalking). Studies in London[73] have shown that the risk to a pedestrian is less, 50 per cent or more, when street crossings are made at an established crosswalk. The greatest risks were in crossings made near, but not in, the crosswalk area, and the smallest were for crossings in a signal-controlled crosswalk.

The physical separation of the travel paths of pedestrians and vehicles at a crossing location with an overpass or underpass has an obvious potential for minimizing pedestrian accidents. It is equally obvious that this potential can be realized only if the grade

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[73] A. M. Mackie and S. J. Older, "Study of Pedestrian Risk in Crossing Busy Roads in London Inner Suburbs," Traffic Engineering and Control, VII, No. 6 (October, 1965), 376-80.

separation is used by pedestrians. This usage depends on whether the grade separation is judged convenient by pedestrians.[74]

Intersection Control

Accidents at intersections are a national problem in highway safety. About 24 per cent of fatal accidents listed in a national tabulation were classified as "intersectional."[75] In urban areas, approximately 41 per cent of total accidents, and 39 per cent of fatal accidents, were reported as intersectional. In rural areas, the data showed that 27 per cent of total accidents, and 17 per cent of fatal accidents, were at intersections. These statistics, while clearly indicating that intersectional accidents are a problem in highway safety, illustrate only a portion of the problem since intersectional influence can extend far beyond the intersection itself.

A major problem is in the definition of what constitutes an intersectional accident. Some reporting agencies, for example, define an intersectional accident as one which occurs within the intersection crosswalk

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[74] Road Research Laboratory, Research on Road Traffic (London: Her Majesty's Stationery Office, 1965), pp. 390-405.

[75] National Safety Council, Accident Facts, National Safety Council, 1968.

limits. Other agencies charge all accidents within 100 or 200 feet of an intersection as being intersectional.

Such arbitrary definitions have severe limitations. A rear-end collision, at the extreme end of a continuous backup of traffic from a signal, might occur a quarter mile from the point of control. Yet the condition of standing vehicles stemmed from the intersection, and the method of intersection control could have been a contributing factor. Any improvement in the signal operation to reduce congestion and lengthy backup could not be fully evaluated from the safety standpoint unless accidents of the above type were considered.

In Skokie, Illinois, accident records have been classified and tabulated in terms of both conditions and contributing elements.[76] Data from that municipality showed 34 per cent of all accidents involved intersections of two major traffic routes, 17 per cent involved intersections of a major route with a local street, and 8 per cent involved intersections of local streets. Thus, intersections were found to be a factor in 59 per cent of all accidents in that city.

The yield sign is used to regulate traffic flow at low-volume intersections and at intersections where the accident rate is above the average of other

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[76] Paul C. Box, "Traffic Control at Minor Intersections," Municipal Signal Engineer, XXXI, No. 1 (January-February, 1966), 21-26.

intersections of the same type. Yield signs were found to be an effective measure at previously uncontrolled, isolated, urban, low-volume intersections in Berkeley, California, where accidents were reduced 44 per cent at a total of thirteen intersections, and in Seattle, Washington, where a 52 per cent reduction at a total of thirty intersections was achieved.[77] The yield sign also appeared to be effective at several low-volume, low-speed rural intersections. An accident warrant for yield-sign use at local intersections was postulated to be three right-angle accidents per year.

Traditionally, the stop sign has been installed along major routes to control intersecting local or collector streets. Under lower volumes, as in rural and some suburban areas, the two-way stop may also regulate intersections of two major routes. A third use is at local/local type intersections having severely restricted sight distance on one or more approaches.

Major/local type intersections were studied at 150 locations along California divided highways.[78]

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[77] James H. Kell, "Yield Signs: Warrants and Applications," Traffic Engineering, XXX, No. 7 (April, 1960), 15-17.

[78] J. W. McDonald, "Relation Between Number of Accidents and Traffic Volume at Divided Highway Intersections," Highway Research Board Bulletin 74, 1953, pp. 7-17.

Most locations were in rural areas, with Stop sign control of cross-roads, 84 per cent of which had an entering ADT of less than 1,000 and the major route ADT's ranged from 6,300 to 24,200. Accident reports involving the intersection for one-fourth mile each side along the major route were included. The study conclusions were:

a. Accident rates at intersections are much more sensitive to changes in minor road volume than in major road volume.

b. No direct relationship exists between intersection accident rates and the sum of entering volume. (The existence of such a relation is implied when intersections are compared on the basis of "accidents per million entering vehicles.")

c. Low crossroad volume intersections have higher accident rates per crossroad vehicle than do higher crossroad volume intersections. This is evidence that a reasonable concentration of cross traffic, through the closing of low-volume crossroads is an effective method of reducing the number of intersection accidents.

d. Evidence was found that crossroad volumes above 2,400 ADT produce high accident rates per crossroad vehicle.

Speed Regulation

An examination of the results of changes in speed control and observed behavior reveals a striking difference between European and American experience.

Studies of speed in Europe have shown, almost without exception, that the speed of vehicles can be considerably reduced by installing a speed limit. Experience in the United States on urban or rural roads indicates that drivers do not drastically alter their speed pattern with changes in posted speed limits. One possible explanation is that the European experience generally deals with the application of speed limits for the first time; studies of U.S. experience usually deal with revision of existing speed limits.

In 1958 and 1959 a speed limit of 40 MPH was imposed on selected sites on 100 miles of main roads in the London area.[79] Before-and-after observations of the effects of the speed limit were made on two groups of roads: One group not previously controlled and the other previously limited to 30 MPH. It was found that the 40 MPH limit did not affect vehicle speeds on roads that had been limited to 30 MPH but

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[79] D. H. Blackmore, "Effect on Vehicle Speeds of Imposing a 40 MPH Speed Limit in the London Area," Traffic Engineering and Control, III, No. 11 (March, 1962), 678-79.

where there had previously been no limit the average speed of cars was reduced 3 MPH.

In another study a 50 MPH speed limit was imposed on trunk roads during week-ends in 1960-61.[80] Speed limits had not been imposed previously. Speed measurements showed a reduction of 3 MPH in the mean speed of cars and over 2 MPH in the speed of light commercial vehicles. The percentage exceeding 50 MPH was cut in half.

Motorist response to urban speed limits was studied on 22 miles of St. Paul, Minnesota, arterial streets.[81] The researchers found little response to speed limit changes established by the 85th percentile techniques.

In studies on a Texas highway drivers were almost completely insensitive to speed controls.[82] In a more recent study in transition areas between rural

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[80] D. H. Blackmore, "Effect of 50 MPH Speed Limit on Vehicle Speed Traffic Engineering and Control," Traffic Engineering and Control, V, No. 8 (December, 1963), 466-67, 471.

[81] Donald E. Cleveland, Traffic Control and Roadway Elements--Their Relationship to Highway Safety, Revised, Speed and Speed Control (Washington, D.C.: Highways Users Federation for Safety and Mobility, 1970), p. 6.

[82] N. J. Rowan,"A Study of the Effects of Posted Speed Limits on Traffic Speed"(Texas A&M College, unpublished, 1959).

and urban conditions the same author found that drivers responded to changing roadway conditions. Other studies have confirmed these findings.[83]

A "before-and-after" study of speed distribution was made in Columbia, South Carolina to determine the effects on speed of increasing the posted speed limit of an urban arterial street.[84] Data were collected on a one and one-half mile section of arterial streets where the speed limit was raised from 35 MPH to 40 MPH based on an engineering study.

The study found that the change in speed limit did not significantly change the mean speed, the 10 MPH pace, or the percentage of vehicles within this range. But a reasonable speed limit based on the 85th percentile speeds did produce a speed distribution closely approximating a normal distribution. This was confirmed by a report on Illinois experience.[85] At thirty locations speed limits were raised varying amounts up to 65 MPH

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[83] John E. Baerwald, "The Influence of Speed and Speed Regulations on Traffic Flow and Accidents," _International Road Safety and Traffic Review_, IX, No. 1 (Spring, 1961), 51-64, 66.

[84] Robert A. Roberts, "The Influence of Speed Limits on Urban Speed Distribution Parameters," _Traffic Engineering_, XXXVIII, No. 3 (December, 1967), 15-17.

[85] Warren L. Kessler, "The Effect of Speed Zone Modifications Occasioned by the Illinois Speed Law," _Traffic Engineering_, XXIX, No. 10 (July, 1959), 18-23, 43.

based on engineering studies. The 85th percentile speeds decreased less than 1 MPH; however, driver observance of the limit improved from 38.5 per cent to 84.6 per cent.

Rural speed studies in the Mid-west indicated that the great majority of drivers operate at a reasonable speed with or without regulation.[86]

Learning System Design

The instructional methods used in the three traffic engineering short courses which served as a basis for this study were based on a learning design system.

The design of any learning program is crucial to its effectiveness. Leonard C. Smith, director of the National Safety Council Training Institute, has stated that "unless the training method is compatible with training objectives, optimum results are not possible."[87] The learning design must also take into account the availability of resources. Davis *et al*. stated:

> Three major resources are needed in designing a learning system: human, institutional and instructional. However, the availability of these resources is usually limited. Every teacher is limited in what he can accomplish by a set of constraints. His students differ in their preparation for the course and in their ability to learn. Each teacher

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[86]Matthew C. Sielski, "What Should the Maximum Speed Limit Be?" *Traffic Engineering*, XXVI, No. 12 (September, 1956), 546-50.

[87]Leonard C. Smith, "Fit Training Methods to Objectives," *National Safety News*, January, 1972, p. 56.

> is limited by his own capabilities and interests. There may be insufficient classroom space or labs may be too old and poorly lighted. Finally, the supply of instructional resources, such as projectors, film strips, and workbooks may, also, be limited. In designing a learning system, one must take these constraints into account or else the resulting system will be less effective.[88]

Within the constraints outlined above the task of a short-course developer, and for that matter any developer of instructional material, is to answer three questions:

1. What is it that we must teach?
2. How will we know when we have taught it?
3. What materials and procedures will work best to teach what we wish to teach?[89]

To answer the first question "What is it that we must teach?": the course developer must establish the <u>learning objectives</u> of the course. A learning objective gives a description of the type of behavior expected from a learner after instruction. Mager emphasizes this point by stating: "The most important characteristic of a useful objective is that it <u>identifies the kind of performance</u> which will be accepted as evidence that the learner has achieved the objective."[90]

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[88] Davis, <u>System Design</u>, ch. I, p. 8.

[89] Robert F. Mager, <u>Preparing Instructional Objectives</u> (Palo Alto, Calif.: Fearon Publishers, 1962), p. vii. (Hereinafter referred to as <u>Instructional Objectives</u>.)

[90] <u>Ibid</u>., p. 13.

A useful learning objective has three basic components: terminal behavior, conditions and standards. Davis, *et al.*, described these as follows:

> Terminal behavior describes what the student will be able to do as a result of his having learned. Conditions describe the aids or restrictions of the test in which the student demonstrates the terminal behavior. Standards describe the minimal acceptable performance the student must demonstrate.[91]

Learning objectives are the guides to the entire instructional program. Without clearly stated learning objectives the teacher is handicapped in knowing what to teach, how to present the material and how to evaluate it. Davis, *et al.*, stated:

> Learning objectives are instruments or tools for clearly describing instructional outcomes. They assist the teacher to design instructional systems by guiding the selection and sequencing of subject matter content and the choice of instructional materials and procedures. Learning objectives enable a student to guide and manage his own learning. Learning objectives are criteria for assessing student achievement and for evaluating the quality of instruction.[92]

The foregoing states clearly how learning objectives assist the student, as well as the teacher, and for this reason it is important that the objectives of a course be defined at the beginning of the teaching. This is what enables the student to plan his own work throughout the course.

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[91]Davis, *System Design*, pp. II-28.

[92]*Ibid*.

There are two kinds of learning objectives:

(1) Terminal learning objectives which describe the expected outcome of a given unit of instruction;

(2) Enabling learning objectives which describe the subtasks which must be mastered to achieve the terminal objective.

Once the learning objectives have been clearly stated the design of tests to measure the student progress is simplified. The examination is essentially the means of determining whether the learning objectives have been achieved.

Gronlund stated the following six principles as a basis for developing useful achievement tests:

1. Achievement tests should measure clearly defined learning outcomes that are in harmony with the instructional objectives.

2. Achievement tests should measure an adequate sample of the learning outcomes and subject-matter content included in the instruction.

3. Achievement tests should include the types of test items which are most appropriate for measuring the desired learning outcomes.

4. Achievement tests should be designed to fit the particular uses to be made of the results.

5. Achievement tests should be made as reliable as possible, and should then be interpreted with caution.

6. Achievement tests should be used to improve student learning.[93]

Learning objectives should be stated in a manner which promotes the construction of meaningful tests. Thus, it is important that the learning objective not only state the expected terminal behavior, but also the conditions for demonstrating this behavior and the acceptable level of performance. Mager concluded his book, Preparing Instructional Objectives, by stating, "Once armed with objectives that communicate and an intent to demonstrate their achievement, you are ready to accomplish the next step in instructional programming, that of preparing your criterion examination."[94]

The developer of short courses is affected in the design of the course by a number of constraints. This has been particularly true in the presenting of traffic engineering short courses to persons engaged in this field in the smaller communities and counties. The author has made an extensive survey of prospective

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[93] Norman E. Gronlund, Constructing Achievement Tests (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1968).

[94] Mager, Instructional Objectives, p. 52.

students for traffic engineering short courses in Michigan. The survey showed that optimum attendance at short courses could be achieved when these courses were presented near the student's home and when he needed to be absent from the office no more than one day a week. The course could not take place over too long a period of time, six weeks at the most. These requirements place restrictions on the design of traffic engineering short courses. Suitable classrooms must be found, all materials and equipment must be transported to the short-course site and instruction is interrupted by periods when the student is engaged in other activities.

Other problems arise in the presenting of traffic engineering short courses because of the tradition in these courses that no student will be refused attendance because of entering behavior. Eklund has confirmed that this is generally true in short courses in analyzing the service function of a state university.[95]

Despite the problems that must be faced in developing and presenting short-course instruction, the success or failure of the effort may well depend on whether solutions are found to a number of problems common to all instructional efforts:

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[95] Lowell R. Eklund, "A Century of Service: An Historical Analysis of the Service Function of a State University" (unpublished dissertation for degree of Doctor of Public Administration, Syracuse University, 1956).

How can student interest be maintained?

How does teacher behavior influence student learning?

Is it a good practice to inform the student what he is expected to learn?

Should a teacher attempt to make learning easy?

How should practice be arranged for students?

In the book, Learning System Design, the following nine principles of learning were given to provide solutions to the questions given above:

1. A student is likely to be motivated to learn things that are meaningful to him.
2. A student is likely to learn something new if he has all the prerequisites.
3. The student is more likely to acquire new behavior if he is presented with a model performance to watch and imitate.
4. The student is more likely to learn if the media used in class is structured so that the instructor's messages are open to the student's inspection.
5. A student is more likely to learn if his attention is attracted by relatively novel presentations.
6. The student is more likely to learn if he takes an active part in practice geared to reach an instructional objective.
7. A student is more likely to learn if his practice is scheduled in short periods distributed over time.
8. A student is more likely to learn if instructional prompts are withdrawn gradually.
9. A student is more likely to continue learning if instructional conditions are made pleasant.[96]

[96]Davis, System Design, pp. VIII-26.

The following of these principles to the extent possible, given the conditions under which traffic engineering short courses must be presented, are important to the success of these courses.

Summary

The review of the literature related to traffic engineering short-course development was presented in Chapter II. This review examined writings describing the nature of the traffic engineering function, the position of the traffic engineering technician in the field, guides available to traffic engineering workers and material available to those designing traffic engineering short-course material. A review was also made of that literature which related traffic engineering functions to accident reduction in those subject areas which were included in this study. The final section of this chapter was a review of learning system design literature as it applied to short course instruction.

In Chapter III the methodology used in designing, organizing, presenting and testing the results of three traffic engineering short courses will be presented.

CHAPTER III

METHODOLOGY

The purpose of this study was to test the effectiveness of traffic engineering short-course instruction. The subject matter presented in the short courses was based on a review of the existing traffic-engineering literature and an analysis of student needs. Discussions of these needs were held with leading traffic engineers and with persons doing traffic engineering work in small communities.

In this chapter the content, the instructional methods, the location and the class schedules of the traffic engineering short courses are discussed. The selection of the sample of students used in this study and the testing method are explained. The methods used in tabulating and analyzing the data obtained in the study are set forth. Finally, the method used to determine a satisfactory passing grade is presented.

Hypotheses

Hypothesis 1:

> There are no significant differences in learning among groups receiving instruction in traffic engineering short courses and those receiving no instruction as measured by the differences in pre-test and final test scores achieved by persons in each of these groups.

Hypothesis 2:

> There are no significant differences in learning among groups receiving three different methods of instruction in the traffic engineering short courses as measured by the differences in the pre-test, post-test and final test scores achieved by the students.

Hypothesis 3:

> There are no significant differences in learning among students attending the traffic engineering short courses with differing educational and experiential backgrounds as measured by the differences in the pre-test, post-test and final test scores achieved by the students.

A fourth test of the effectiveness of the short-course instruction was made by comparing student scores with those established by a panel of experts as the minimum passing scores. No hypothesis was established for this fourth test of effectiveness of the short-course instruction.

Content of Short Courses

Eight subject areas in the field of traffic engineering were selected as being the most useful at this time to persons doing traffic engineering work in the smaller communities and counties:

(1) Traffic volume data collection and analysis;

(2) Intersection capacity analysis;

(3) Traffic signals;

(4) School children travel protection;

(5) Traffic accident analysis;

(6) Intersection traffic controls;

(7) Revisions to the Manual on Uniform Traffic Control Devices;[97]

(8) Traffic speed regulation.

Five of these subjects were selected as being the most suitable for testing:

(1) Traffic volume data collection and analysis;

(2) Intersection capacity analysis;

(3) School children travel protection;

(4) Intersection traffic controls;

(5) Traffic speed regulation.

To determine what constituted the most useful topics for inclusion in a traffic engineering short course, several steps were taken:

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[97]U.S., Department of Transportation, Manual on Traffic Control.

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1. The written critiques submitted by students who had taken traffic engineering short courses in the past five or six years in Michigan were reviewed. These critiques included questions on the subject areas the students considered to be most important to their work and on which they had the least knowledge.

2. District traffic engineers in various regions of Michigan were asked to state what the training needs of persons doing traffic engineering in communities in their district were. The district traffic engineers who participated in these studies were Ralph Shoemaker, Michael Jones, Edwin Miller and David Van Hine, all employed by the Michigan Department of State Highways.

3. The author visited persons in more than twenty communities ranging in population from 5,000 persons to 50,000 persons in the lower peninsula of Michigan to observe their traffic engineering operations and to discuss their training needs.

The five subject areas used for testing were those taught by the author. This was done to insure consistency in the instructional objectives, student outlines, teaching methods and the tests given to the students.

Course material was developed for each of these subjects. Instructional outlines consisted of three parts:

1. A statement of the objectives of the instruction. The student was told at the beginning of the instruction what he should expect to be able to do at the end of the instruction.

2. The material to be discussed based on the objectives of the instruction.

3. Test questions based on the objectives of the instruction.

The teaching material and methods of instruction were modeled after those discussed in the book Learning System Design.[98] The objectives and test questions contained in each subject area outline were reviewed by Dr. Stephen Yelon, a specialist in learning systems, of Michigan State University for the purpose of assuring that the test questions actually measured the objectives stated in the outlines.

In addition to course outlines, charts and slides were prepared to illustrate the instructional material.

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[98]Davis, System Design.

Instructional Methods

The lecture method of instruction was selected as the most suitable since it was assumed that most of the students attending the course would have little knowledge of the material presented. Lectures were illustrated with slides; discussions and questions were encouraged. Periodically during the lectures the material was reviewed and summarized.

The five subject areas selected for testing in this study were presented during the morning sessions. All of these morning sessions were taught by the same instructor to assure, insofar as was possible, consistency in the presentation of the course material.

At the conclusion of the lectures on traffic volumes, intersection capacity and school travel protection, there was a problem session based on the material discussed. The problem sessions were conducted in three different ways:

A. The instructor worked demonstration problems and problems were also done by the students.

B. The instructor worked demonstration problems. No problems were done by the students.

C. The instructor worked no problems. The students worked problems.

The three methods were rotated as follows:

	Group I (Southfield)	Group II (Ann Arbor)	Group III (Kalamazoo)
Lecture 1 (Volumes)	B	A	C
Lecture 2 (Capacity)	A	C	B
Lecture 3 (Schools)	C	B	A

Location of Courses

Following the completion of the course materials, sites were selected for presentation of the short courses:

(1) Wayne State University Extension Building, Southfield, Michigan;

(2) Conference Room, Municipal Airport, Ann Arbor, Michigan;

(3) Kalamazoo Valley Community College, Kalamazoo, Michigan.

Students attending these three locations were designated as the Southfield class, the Ann Arbor class and the Kalamazoo class respectively.

The classrooms were selected on the basis of their adequacy for the presentation of the short courses. Each was well lighted, ventilated and provided blackboard space and equipment for audio-visual presentation.

Class Schedules

Each of the three classes met one day a week for five weeks. Classes in Southfield met on five successive

Wednesdays, beginning April 26, 1972; in Ann Arbor on Thursdays beginning April 27, 1972; and in Kalamazoo on Fridays beginning April 28, 1972.

Selection of Sample

Subjects selected for testing in this study were traffic engineering practitioners who attended the short courses. These practitioners were obtained by means of a promotional campaign in the southern third of the lower peninsula of Michigan. Brochures, outlining the features of the short courses, were mailed to all counties and cities of more than 5,000 population in this area. Mailings to cities were addressed to the chief of police, city engineer and to the chief administrative officer, either the mayor or city manager. Mailings to counties were addressed to the chief engineer of the county road commission. A fee of $50 was charged for attendance at the course.

Twenty persons registered for the course in Southfield, eighteen in Ann Arbor and fifteen in Kalamazoo. To provide for three groups of fifteen students, a random selection was made from the twenty registered in Southfield and the eighteen students registered in Ann Arbor.

Testing of Students

At the first session after registrations and introductions were completed, each student was asked to take a pre-test on all of the five morning session subjects. They were asked to answer all questions on the test, guessing whenever necessary.

Upon completion of the pre-test, each student was asked to complete a questionnaire on his previous education and work experience.

At the end of each morning session, a post-test was given on the material covered in that session.

At the end of the fifth (and last) session, the class was tested on the material presented that day and on the material presented in the four previous sessions.

At the time the tests were administered, the students were assured that the results would remain confidential; they were further assured that the results of the tests would be revealed only to the individual student taking the test if he requested the information. Test results were reported to these students and all data were recorded by a student number. Students were urged to work independently and the author believes that little consultation occurred between students during the test period.

A control group of fifteen persons was selected from the same groups that received short-course promotional information. These persons were given the same pre-test used in the courses. They were given no instruction. Four weeks after taking the pre-test, the test was repeated. The questionnaire on work experience and education was also completed.

Tabulation and Analysis of Data

A computer data card was prepared for each of the forty-five students attending the three traffic engineering short courses and for the fifteen students who comprised the control group. The following information was entered on these cards for each of the sixty subjects in the study:

(1) Location where the student attended the course;

(2) Agency employing the student. There were four of these:

(a) Police department;

(b) Traffic engineering department;

(c) City engineering department;

(d) County road commission.

(3) Job held. These were classified into four types:

(a) Police officer (supervisory);

(b) Police officer (patrolman capacity);

(c) Engineer;

(d) Technician.

(4) Amount of time each person spent on traffic engineering in his present job assignment;

(5) Answers to fourteen questions regarding specific knowledge of duties regarding traffic engineering;

(6) Education of the student which was divided into five categories:

(a) High school graduate;

(b) Attended college;

(c) Attended college (with a major in engineering);

(d) Held a college degree;

(e) Held a college degree in engineering.

(7) Student's attendance at short courses in the last five years. This was divided into four categories:

(a) Traffic engineering courses;

(b) Police courses;

(c) Other courses;

(d) No courses.

(8) Test scores which were determined on the following basis:

(a) Objective-type questions were given one point each;

(b) Problem-type questions were given either five points or, in one case, ten points. On these questions, a student could receive zero to five or zero to ten points.

Test scores were tabulated as follows:

1. Pre-test, post-test and final test scores were recorded for each student for each subject.

2. Pre-test, post-test and final test scores were recorded for each student on the three problems included in the tests on traffic volumes, intersection capacity and school travel protection.

3. A summation of the individual scores on the five subject-matter tests was recorded for the pre-test, post-test and final test.

4. Differences between pre-test, post-test and final test scores were recorded.

Computer data control cards were then punched for programs which would produce one-way analysis of variance on the CDC 3600 computer. The one-way analysis of variance was used to compare the test scores of the three student groups, Southfield, Ann Arbor and Kalamazoo with each other and the control group. The one-way analysis of variance was also used to compare test scores of various groups of students to compare differences which could arise from differing educational and experiential backgrounds.

In each of the analyses, gain scores were used. These gain scores resulted from measuring the differences between pre-tests and post-tests and from measuring the differences between pre-tests and final tests.

The Latin square design was used to analyze differences in the problem test scores which might be due to the differences in instruction given in the subject areas: Traffic volumes, intersection capacity and school travel protection.

The Latin square design, as depicted in Figure 3.1, was used because it permits the experimenter to minimize the effects of two nuisance variables, variation due to rows and variation due to columns. In using this design, the rows in this study represented the three subject areas: Traffic volumes (a_1), intersection capacity (a_2) and traffic around the schools (a_3). The columns represented the three short-course groups: Southfield (b_1), Ann Arbor (b_2) and Kalamazoo (b_3). The three treatment effects were represented by the following:

c_1 lecture plus instructor working problems,

c_2 lecture plus instructor and students working problems,

c_3 lecture plus students working problems.

Short Course Classes

Topics of Instruction	b_1	b_2	b_3
a_1	c_1	c_2	c_3
a_2	c_2	c_3	c_1
a_3	c_3	c_1	c_2

Key: Topics of Instruction

a_1 Traffic Volumes

a_2 Intersection Capacity

a_3 School Travel Protection

Short Course Classes

b_1 Southfield

b_2 Ann Arbor

b_3 Kalamazoo

Instructional Methods

c_1 Lecture plus instructor working problems

c_2 Lecture plus instructor and students working problems

c_3 Lecture plus students working problems

Figure 3.1.--Latin square design used to analyze different instructional methods

The letter c in each of the squares in Figure 3.1 represented the fifteen scores made by the students in one of the subject areas (a) and in one of the short-course groups (b).

The specific scores used were those obtained from three problems, one of which was given in each of the tests on traffic volumes, intersection capacity and school travel protection. Two analyses of these scores were made: One in which the difference between the pre-test and the post-test was analyzed, and one in which the difference between the pre-test and final test was analyzed.

An .05 level of significance was used to determine the acceptance or rejection of the three hypotheses which were considered in this study.

Test Score Criteria

To determine whether the students' final grades constituted passing the course, some type of acceptable score on the tests had to be devised. Since most of the students taking the short courses were engaged in traffic engineering work to a greater or lesser degree, a practical approach appeared to be desirable. Seven professional traffic engineers in charge of departments which employ technicians were asked to review the short-course materials and the tests given. Each of these engineers was selected because he directed a major traffic engineering department and therefore would be in a position to evaluate persons seeking employment in this field. The engineers who made the evaluation of the test scores were:

1. Mr. Alger F. Malo, Director
   Department of Streets and Traffic
   City of Detroit

2. Mr. Harold H. Cooper
   Engineer of Traffic and Safety
   Michigan Department of State Highways

3. Mr. Richard J. Folkers
   Director of Traffic Engineering
   Oakland County Road Commission

4. Mr. John R. Gray
   Director of Traffic, Safety and Planning
   Macomb County Road Commission

5. Mr. John E. Robbins
   Director of Parking and Traffic Engineering
   City of Ann Arbor

6. Mr. Jere E. Meredith
   City Traffic Engineer
   City of Saginaw

7. Mr. Allen T. Hayes
   City Traffic Engineer
   City of Lansing

Each of these persons was asked to state an acceptable percentage grade for each of the tests given on the five subjects. They were asked to do this on the assumption that they were hiring these persons to do work in the individual areas at the technician level and that technical qualifications in these areas were to be determined by the scores obtained on the tests. The criterion established was that a passing grade represented the minimum grade acceptable for employment in relation to the subject area being graded. The minimum passing grades which the panel of traffic engineers recommended are given in Table 3.1. A passing grade for each subject and for the entire course was determined by obtaining the mean of the grades recommended by each panel member.

TABLE 3.1.--Minimum passing grade scores recommended by advisory panel of traffic engineers (expressed in percentage)

Panel Member	Topic					
	Volumes	Capacity	Schools	Inter-sections	Speed	Total
Cooper	75	70	70	75	75	
Folkers	70	70	70	70	70	
Gray	75	75	75	75	70	
Hayes	80	85	70	80	70	
Malo	50	50	50	70	70	
Meredith	80	75	70	65	70	
Robbins	70	50	70	70	70	
Mean	71.4	67.9	67.9	72.1	70.7	70
Number of Points on Test	14	27	15	8	10	74
Points Needed to Pass	10	18	10	6	7	52

The test grades achieved by the students were compared with those recommended by the advisory panel as passing grades and the percentage of students passing each subject was determined as was the percentage of students achieving a passing grade on the five tests.

Summary

In this chapter the methods and procedures used in presenting three traffic engineering courses used as a basis for this study were discussed. The bases for sample selection, testing of students and the tabulating and analyzing of data were explained.

In Chapter IV the results of the study are presented.

CHAPTER IV

ANALYSIS OF RESULTS

The study was designed to test the effectiveness of traffic engineering short courses. The methodology for this testing was described in Chapter III. The results of the analyses of the data obtained in this study are presented in the ensuing pages.

The analyses of the data which are presented in this chapter are the following: (1) the differences in learning as measured by comparisons of pre-test, post-test and final test scores given to three groups of students taking traffic engineering short courses and to one group receiving no instruction; (2) the differences in learning as measured by comparisons of pre-test, post-test and final test scores resulting from three different instructional methods; (3) the differences in learning as measured by comparisons of pre-test, post-test and final test scores resulting from differences in students' educational and experiential backgrounds; and (4) the learning each student achieved as measured by post-test and final test scores compared to minimum passing grade scores as established by a panel of experts.

The total number of subjects in the final statistical analysis was sixty, fifteen in each of the three instructional groups and fifteen in the control group.

The data collected from the study subjects included pre-test, post-test and final test scores; educational level; attendance at short courses; time spent on traffic engineering; type of employing department, job classification and the nature of the subjects' traffic engineering experience.

Data Preparation and Analysis

Computer data cards were punched for sixty subjects. The data were prepared for one-way analysis of variance (ANOVA) on the Michigan State University Control Data Corporation 6500 Computer and on the CDC 3600 Computer. The analysis of variance procedure was used to compare differences in learning among the three short-course groups receiving instruction and the group which received no instruction. The analysis of variance method was also used to compare differences in learning with education and experience levels of the students in the three short courses.

The differences in learning resulting from the three instructional methods were compared by applying the Latin square design statistical method to the data. The variables used in this analysis were the three instructional groups: Southfield, Ann Arbor and Kalamazoo; the three traffic engineering subject areas; traffic volumes; intersection capacity and school travel protection; and the three instructional methods: lecturing plus problems worked by the instructor and the class, lecturing plus problems worked by the instructor only and lecturing plus problems worked by the class only. The fourth variable was the test score obtained by each student on the problem included in each of the tests on traffic volumes, intersection capacity and school travel protection.

There being no computer program available for the Latin square design used in comparing the three instructional methods, this analysis was made manually.

The comparison of student grades to those recommended by a panel of experts as being the minimum passing grade was performed without the use of computer programs.

Differences Among Groups Receiving Instruction and Those Not Receiving Instruction

The following is the null hypothesis which was tested for each of the four study groups:

Hypothesis 1:

> There are no significant differences in learning among groups receiving instruction in traffic engineering short courses and those receiving no instruction as measured by differences in pre-test and final test scores achieved by persons in each of these groups.

At the beginning of each short-course session a pre-test was given to each of the fifteen students. This test was repeated at the conclusion of the sessions four weeks later. The same tests were administered to a control group of fifteen persons with the same time interval between the tests. The control group differed from the short-course groups only in that this group received no instruction between the two sets of tests.

The maximum possible score on the tests was seventy-four points. On the pre-test all four groups had a mean test score varying between 21.27 and 24.80 points. On the final test the three groups who had received instruction had mean test scores varying between 51.80 and 57.53 points. The control group had a final test mean score of 23.07 points.

The mean gain score was obtained by subtracting the mean pre-test score from the mean final test score. All four groups had a positive gain score but the three groups receiving instruction had mean gain scores varying between 27.47 points and 33.86 points while the control group had a mean gain score of 0.07 points.

The mean pre-test, final test and gain scores of the Southfield, Ann Arbor, Kalamazoo and control groups are presented in Table 4.1.

To determine whether the differences in the mean test scores were significant, they were examined through the use of the analysis of variance. The .05 level of confidence was selected as the basis for accepting or rejecting the null hypothesis. The critical value of the F-statistic in this test at the .05 confidence level with three and fifty-six degrees of freedom is 2.78. The F-statistic computed from the analysis of variance was 40.72 with an associated confidence level of less than .0001 as given in Table 4.2. Therefore, the null hypothesis of no significant difference in the mean test gain scores of the four groups was rejected.

To determine where the significant differences in the mean test gain scores were, the Scheffé technique was applied to the data given in Tables 4.1 and 4.2. Two tests were computed as described below.

Because of the apparent large difference between the three mean gain scores of the three groups receiving instruction and the control group, the test scores of the first three groups were contrasted with the fourth group.

The .05 confidence interval obtained in the Scheffé analysis with an F-statistic of 2.78 and three

TABLE 4.1.--Mean grade scores of four groups who took traffic engineering short-course pre-tests and final tests

Group	Mean Test Scores		
	Pre-Test	Final Test	Gain
Southfield	24.33	51.80	27.47
Ann Arbor	24.80	57.53	32.73
Kalamazoo	21.27	55.13	33.86
Control	23.00	23.07	0.07

Key: The scores in the table are numerical based on a possible point score of 74.

Gain score represents the difference between the pre-test and the post-test score.

TABLE 4.2.--Analysis of variance of the gain scores of four groups who took traffic engineering short-course pre-tests and final tests

Source of Mean Squares	Sum of Squares	Degrees of Freedom	Mean Square	Computed Value of F	Significance
Between Groups	11363.61	3	3787.87	40.72	< .0001
Within Groups	5209.12	56	93.02		
Total	16572.73	59			

Note: The critical value of F at the .05 confidence level is 2.78.

and fifty-six degrees of freedom was $26.48 \leq \hat{\psi} \leq 36.08$ representing the contrast between the first three groups and the fourth group. Since the contrast at no point in the interval equals zero there was a significant difference between the first three groups and the fourth group.

A second test was made to determine whether there were any differences in the mean gain scores among the three groups who received the short-course instruction. In this test the contrast between the mean gain scores of the Kalamazoo group and the Southfield group was examined. The mean gain scores of these two groups were selected for analysis because they represented the high and low scores of the three groups receiving instruction.

The .05 confidence interval obtained in the Scheffé analysis with an F-statistic of 2.78 and three and fifty-six degrees of freedom was $-16.59 \leq \hat{\psi} \leq 3.81$. Since one of the values of this contrast may be zero, it can be concluded that there was no significant difference at the .05 confidence level between the Southfield and Kalamazoo groups in their mean gain scores. It may also be inferred that there was no significant difference in the mean gain scores of the three groups receiving instruction since the mean gain score of the Ann Arbor group lies between the scores of the Kalamazoo and Southfield groups.

An analysis of the mean gain scores obtained by subtracting the pre-test scores from the post-test scores was made of the three groups receiving instruction in the short courses. These mean scores are given in Table 4.3. To determine whether the differences in the mean gain scores were significant, they were examined through the use of the analysis of variance. The critical value of the F-statistic in this test at the .05 confidence level with two and forty-two degrees of freedom was 3.22. The F-statistic computed from the analysis of variance was 1.10 with an associated confidence level of 0.34. This analysis showed no significant difference in the gain scores of the groups receiving instruction. The data are given in Table 4.4.

The four statistical analyses presented above, the two analysis of variance tests and the two Scheffé tests, showed that there was a significant difference at the .05 confidence level in the mean gain scores of the four groups who took the pre-tests and final tests; these analyses also showed that this significant difference was between the three groups who received instruction on the one hand and the control group who received no instruction. Further, there were no significant differences at the .05 confidence level in mean gain scores among the three short-course groups who received instruction. This was confirmed for the

TABLE 4.3.--Mean grade scores of three groups who took traffic engineering short-course pre-tests and post-tests

Group	Mean Test Scores		
	Pre-Test	Post-Test	Gain
Southfield	24.33	57.87	33.53
Ann Arbor	24.80	61.40	36.60
Kalamazoo	21.27	59.33	38.27

Key: The scores in this table are numerical based on a possible point score of 74.

Gain score represents the difference between the pre-test and the post-test score.

TABLE 4.4.--Analysis of variance of the gain scores of three groups who took traffic engineering short-course pre-tests and post-tests

Source of Mean Squares	Sum of Squares	Degrees of Freedom	Mean Square	Computed Value of F	Significance
Between Groups	172.94	2	86.47	1.10	.34
Within Groups	3316.32	42	78.96		
Total	3489.26	44			

Note: The critical value of F at the .05 confidence level is 3.22.

mean gain scores obtained by comparing the pre-test with both the post-test and final test scores. On the basis of these analyses of the mean gain scores of the four groups, the three groups who received instruction and the control group who did not receive instruction, the null hypothesis of no significant differences in learning among these groups was rejected.

Differences in Learning Resulting From Three Instructional Methods

The following is the null hypothesis which was tested for each of the three study groups who received instruction in one of the short courses:

Hypothesis 2:

There are no significant differences in learning among groups receiving three different methods of instruction in the traffic engineering short courses as measured by the differences in the pre-test, post-test and final test scores achieved by the students.

Three of the topics presented in the short courses were traffic volume data collection and analysis, intersection capacity analysis and school travel protection. At the conclusion of the lectures on each of these subjects, there was a problem session based on the material discussed. The problem sessions were conducted in three different ways:

A. The instructor worked demonstration problems and problems were also done by the students.

B. The instructor worked demonstration problems. No problems were done by the students.

C. The instructor worked no problems. The students did problems.

The methods were rotated among the three classes and three subject areas.

The differences in the three methods of instruction were analyzed by examining the test scores obtained by the students on the problems in each test on the three topics given above. Each problem in the tests was given a maximum score of ten points. Gain scores on these test problems were obtained by subtracting the pre-test scores from both the post-test and the final test scores. These gain scores are given in Tables 4.5 and 4.6

A 3 X 3 Latin square design was selected to analyze the gain scores obtained by the students on the test problems dealing with traffic volumes, intersection capacity and school travel protection. The Latin square design permits the experimenter to minimize the effects of the two nuisance variables, variation due to the three different topics and the three different groups of students included in the experiment.

TABLE 4.5.--Test problem gain scores of three groups who took traffic engineering short-course pre-tests and post-tests after receiving three different instructional methods

Course Topic	Course Location: Southfield b_1			Course Location: Ann Arbor b_2			Course Location: Kalamazoo b_3		
Traffic Volumes (a_1)	0	0	0	0	10	10	0	10	0
	0	0	0	10	10	10	10	10	10
	0	0	10	10	10	10	10	10	10
	0	0	10	10	10	10	10	10	10
	0	0	10c_1	0	10	10c_2	10	10	10c_3
Intersection Capacity (a_2)	10	5	5	4	4	3	0	5	8
	5	10	4	9	4	0	9	10	10
	10	5	10	6	5	6	4	8	10
	5	3	10	0	3	10	3	8	10
	3	5	10c_2	3	10	10c_3	0	10	10c_1
School Travel Protection (a_3)	6	6	8	6	10	6	0	6	4
	4	10	10	10	10	6	10	8	10
	10	0	10	4	0	10	10	10	6
	8	2	0	10	10	10	10	10	8
	4	10	10c_3	10	6	6c_1	10	10	10c_2

Key: Methods of instruction are as follows:

c_1 Lecture plus problems worked by instructor.

c_2 Lecture plus problems worked by instructor and students.

c_3 Lecture plus problems worked by students.

Cell numbers represent individual gain scores of students on test problems.

TABLE 4.6.--Test problem gain scores of three groups who took traffic engineering short-course pre-tests and final tests after receiving three different instructional methods

Course Topic	Course Location								
	Southfield			Ann Arbor			Kalamazoo		
	b_1			b_2			b_3		
	10	0	0	10	10	10	0	10	0
Traffic	10	0	0	0	10	0	10	10	10
Volumes	0	0	10	10	0	10	0	10	10
(a_1)	0	0	10	10	0	10	0	10	10
	0	0	10c_1	0	10	10c_2	0	0	10c_3
	3	4	8	3	6	3	0	2	0
Intersection	0	6	8	3	3	4	3	10	10
Capacity	8	0	10	6	3	8	0	9	10
(a_2)	0	0	10	6	10	10	0	2	10
	3	3	6c_2	3	3	10c_3	1	3	10c_1
School	0	0	0	4	10	0	0	4	0
Travel	0	10	2	8	6	0	10	10	10
Protection	10	0	6	2	0	10	2	10	10
(a_3)	10	0	10	2	0	10	0	10	10
	0	0	8c_3	8	2	2c_1	0	0	10c_2

Key: Methods of instruction are as follows:

c_1 Lecture plus problems worked by instructor.

c_2 Lecture plus problems worked by instructor and students.

c_3 Lecture plus problems worked by students.

Cell numbers represent individual gain scores of students on test problems.

The data on gain scores obtained by the students on the test problems given in Tables 4.5 and 4.6 were tested by the analysis of variance. Two analyses were made: The first of the gain scores obtained by subtracting pre-test from post-test scores and the second by subtracting pre-test from final test scores. The results of these analyses are given in Tables 4.7 and 4.8.

The analysis of variance performed on the gain scores obtained by subtracting pre-test from post-test scores gave a significant residual mean square at the .05 confidence level. The critical value of the F-statistic at the .05 confidence level with 2 and 126 degrees of freedom was approximately 3.07. The F-statistic computed for the residual mean square was 7.52. This indicated that there were interaction components present. To obtain a significant test of the instructional methods the assumption had to be made that there would be no significant differences between the three classes and between the three topics. There was a significant difference found among the three classes at the .05 confidence level. The critical value of the F-statistic at the .05 confidence level with 2 and 126 degrees of freedom was approximately 3.07. The F-statistic computed for the mean square between classes was 8.28. Thus, there was an interactive effect between the teaching

TABLE 4.7.--Analysis of variance of test problem gain scores obtained from traffic engineering short-course pre-tests and post-tests with three different instructional methods

Source of Mean Square	SS	df	MS	F	F^*	P
1. Between Topics (a)	35	2	17.5	1.47	3.07	NO
2. Between Classes (b)	197	2	98.5	8.28	3.07	<.001
3. Between Methods (c)	118	2	59.0	4.96	3.07	.009
4. Residual	179	2	89.5	7.52	3.07	<.001
5. Within Cell	1499	126	11.9			

Key: SS -- Sum of Squares

df -- degrees of freedom

MS -- Mean Square

F -- Computed Value of F

F^* -- Critical Value of F (.05)

P -- Significance

TABLE 4.8.--Analysis of variance of test problem gain scores obtained from traffic engineering short-course pre-tests and final tests with three different instructional methods

Source of Mean Square	SS	df	MS	F	F*	P
1. Between Topics (a)	13.4	2	6.7	0.34	3.07	NO
2. Between Classes (b)	74.4	2	37.2	1.90	3.07	NO
3. Between Methods (c)	56.4	2	28.2	1.45	3.07	NO
4. Residual	0.0	2	0.0	0.00	3.07	NO
5. Within Cell	2456.0	126	19.5			

Key: SS -- Sum of Squares

df -- degrees of freedom

MS -- Mean Square

F -- Computed Value of F

F* -- Critical Value of F (.05)

P -- Significance

method and the three classes, Southfield, Ann Arbor and Kalamazoo. As a result, the test of the teaching method was positively biased. Despite the fact that the computed value of the F-statistic for the differences in instructional methods was significant at the .05 confidence level, further analysis of the data was not carried out since it was impossible to determine whether the results obtained were due to the teaching method or to interactive effects. On this basis the null hypothesis that there was no difference in learning due to three different instructional methods cannot be accepted or rejected.

A second test was performed on the gain scores obtained by subtracting the pre-test scores from the final test scores on the three problems included in the tests for traffic volumes, intersection capacity and school travel protection. These gain scores which are given in Table 4.6 were tested by the analysis of variance. In this test the critical value of the F-statistic at the .05 confidence level with 2 and 126 degrees of freedom was approximately 3.07. The computed F-statistic for the difference between methods was 1.45. On the basis of this finding the null hypothesis that there was no difference in learning due to three different instructional methods was accepted.

Differences in Learning Compared to Education and Experience

The following is the null hypothesis which was tested for the forty-five students receiving instruction in the three traffic engineering short courses:

Hypothesis 3:

> There are no significant differences in learning among students attending the traffic engineering short courses with differing educational and experiential backgrounds as measured by the differences in the pre-test, post-test and final test scores achieved by the students.

Each of the forty-five students who attended one of the three short courses answered a questionnaire containing nineteen questions which related to his educational and experiential background. These nineteen questions follow with a statistical analysis of the relationships between the test scores of the students and their answers to the questions. The analyses were made by comparing mean gain scores obtained by subtracting pre-test from post-test and final test scores with the answers to the nineteen questions.

Question 1. What was the employing agency of the student?

(1) Police department
(2) Traffic engineering department
(3) City engineering department
(4) County road commission

The data for this question in relation to the post-test are presented in Table 4.09.

TABLE 4.9.--A comparison of the mean gain scores of students who were employed by various types of governmental agencies

Type of Agency	Number of Students	Mean Gain Score	Standard Deviation
Police Department	19	33.47	10.61
Traffic Engineering Department	7	33.00	5.26
City Engineering Department	13	41.38	7.43
County Road Commission	6	36.83	3.71

Note: Mean gain scores were derived by subtracting pre-test from post-test mean scores.

Anova Values: 3 and 41 degrees of freedom

Computed F : 2.64 Significance : .06

$F_{3,41}$ (.05): 2.84

The analysis of variance test of the mean gain scores for the four groups working for different agencies, obtained by subtracting the pre-test from the post-test scores, showed no significant difference among them at the .05 confidence level. Since the computed value of the F-statistic was less than the critical value of F, the null hypothesis was accepted on the basis of this comparison for this question (Table 4.09).

The data for question one (What was the employing agency of the student?) in relation to gain scores obtained by subtracting the pre-test from the final test scores are presented in Table 4.10. The analysis of variance test performed on these gain scores showed a significant difference among them at the .05 confidence level. The computed value of the F-statistic exceeded the critical value of F (Table 4.10). The null hypothesis was rejected on the basis of this comparison for this question. The mean gain scores were 27.37 for those persons working for a police department, 26.57 for those working for a traffic engineering department, 38.46 for those working for a city engineering department and 34.17 for those working for a county road commission.

Question 2. What was the position or title of the student?

(1) Police officer supervisor
(2) Police officer patrolman
(3) Engineer
(4) Technician

TABLE 4.10.--A comparison of the mean gain scores of students who were employed by various types of governmental agencies

Type of Agency	Number of Students	Mean Gain Score	Standard Deviation
Police Department	19	27.37	10.98
Traffic Engineering Department	7	26.57	8.85
City Engineering Department	13	38.46	10.00
County Road Commission	6	34.17	8.84

Note: Mean gain scores were derived by subtracting pretest from final test mean scores.

Anova Values: 3 and 41 degrees of freedom

Computed F : 3.77 Significance : .02

$F_{3,41}$ (.05): 2.84

The data for this question in relation to the post-test are presented in Table 4.11.

The analysis of variance of the gain scores of the four different job classification groups showed no significant differences at the .05 confidence level. The computed value of the F-statistic was less than the critical value of F (Table 4.11). The null hypothesis was accepted for this comparison for this question.

The data for the four groups listed in question two obtained by subtracting the pre-test from the final test scores are given in Table 4.12. The analysis of variance of the gain scores of the four groups showed no significant difference at the .05 confidence level. The computed value of the F-statistic was less than the critical value of F (Table 4.12) and the null hypothesis was accepted for this comparison for this question.

Question 3. How much of a student's total working hours were spent on traffic engineering?

(1) less than 10 per cent
(2) 10-35 per cent
(3) 36-65 per cent
(4) 66-90 per cent
(5) more than 90 per cent

The data for this question in relation to the post-test are presented in Table 4.13.

The analysis of variance of the gain scores of the persons answering this question showed no significant differences at the .05 confidence level. The

TABLE 4.11.--A comparison of the mean gain scores of students with their job classifications

Job Classification	Number of Students	Mean Gain Score	Standard Deviation
Police Supervisor	11	32.82	10.61
Police Patrolman	7	36.57	10.16
Engineer	8	39.75	6.30
Technician	19	36.37	8.29

Note: Mean gain scores were derived by subtracting pretest from post-test mean scores.

Anova Values: 3 and 41 degrees of freedom

Computed F : 0.96 Significance : .42

$F_{3,41}$ (.05): 2.84

TABLE 4.12.--A comparison of the mean gain scores of students with their job classifications

Job Classification	Number of Students	Mean Gain Score	Standard Deviation
Police Supervisor	11	27.55	12.11
Police Patrolman	7	27.71	10.67
Engineer	8	39.50	6.61
Technician	19	31.47	10.95

Note: Mean gain scores were derived by subtracting pre-test from final test mean scores.

Anova Values: 3 and 41 degrees of freedom

Computed F : 2.32 Significance : .09

$F_{3,41}$ (.05): 2.84

TABLE 4.13.--A comparison of the mean gain scores of students with the percentage of working time spent on traffic engineering

Time Spent on Traffic Engineering	Number of Students	Mean Gain Score	Standard Deviation
Less than 10%	28	38.11	9.73
10 - 35%	5	33.20	6.53
36 - 65%	2	33.50	2.12
66 - 90%	3	32.67	3.79
More than 90%	7	32.57	8.56

Note: Mean gain scores were derived by subtracting pre-test from post-test mean scores.

Anova Values: 4 and 40 degrees of freedom

Computed F : 0.91 Significance : .47

$F_{4,40}$ (.05): 2.61

computed value of the F-statistic was less than the critical value of F (Table 4.13) and the null hypothesis was accepted.

The data for question three in relation to the final test are presented in Table 4.14. The analysis of variance of the gain scores obtained by subtracting pretest from final test scores as they related to the answers to question three showed no significant differences among them at the .05 confidence level. Since the computed value of the F-statistic was less than the critical value of F (Table 4.14) the null hypothesis was accepted for this comparison for this question.

The series of questions four through seventeen were a related series which sought to obtain information on each student's occupational experience in traffic engineering. The data for these questions are given in Tables 4.15 and 4.16. The series of questions follow:

Question 4. Do you supervise the collection of traffic data?

Question 5. Do you personally collect traffic data?

Question 6. Are you sufficiently familiar with mechanical traffic counters to place them in position on the roadway and obtain accurate counts?

Question 7. Have you made turning movement counts?

Question 8. Have you collected speed data?

TABLE 4.14.--A comparison of the mean gain scores of students with the percentage of working time spent on traffic engineering

Time Spent On Traffic Engineering	Number of Students	Mean Gain Score	Standard Deviation
Less than 10%	28	33.04	11.77
10 - 35%	5	30.20	10.92
36 - 65%	2	30.50	4.95
66 - 90%	3	20.67	1.53
More than 90%	7	30.29	10.89

Note: Mean gain scores were derived by subtracting pretest from final test mean scores.

Anova Values: 4 and 40 degrees of freedom

Computed F : 0.88 Significance : .48

$F_{4,40}$ (.05): 2.61

TABLE 4.15.--A comparison of mean gain scores and analysis of variance values of students with the answers to questions 4-17 on experiential background

Question	Number of Students Answering Yes	Mean Gain Score	Number of Students Answering No	Mean Gain Score	Computed Value of F	Significance
4. Do you supervise the collection of traffic data?	22	38.27	23	34.09	2.57	.12
5. Do you personally collect traffic data?	24	38.33	21	33.62	3.30	.08
6. Are you sufficiently familiar with mechanical traffic counters to obtain accurate counts?	29	35.69	16	36.94	0.20	.66
7. Have you made turning movement counts?	30	35.10	15	38.20	1.22	.28
8. Have you collected speed data?	20	30.90	25	40.32	16.94	< .0005
9. Are you responsible for studies and recommendations regarding the use of stop signs?	28	33.71	17	40.12	6.10	.02

TABLE 4.15.--Continued

Questions	Number of Students Answering Yes	Mean Gain Score	Number of Students Answering No	Mean Gain Score	Computed Value of F	Significance
10. Are you responsible for studies and recommendations regarding the use of stop signs?	28	33.71	17	40.12	6.10	.02
11. Are you responsible for studies and recommendations regarding the use of traffic signals?	25	33.80	20	39.05	4.14	.05
12. Are you responsible for studies and recommendations regarding the use of speed regulations?	26	33.42	19	39.84	6.40	.02
13. Are you responsible for studies and recommendations regarding the use of parking regulations?	29	34.69	16	38.75	2.20	.15

TABLE 4.15.--Continued

Questions	Number of Students Answering Yes	Mean Gain Score	Number of Students Answering No	Mean Gain Score	Computed Value of F	Significance
14. Are you responsible for studies and recommendations regarding the use of turn prohibitions?	28	34.29	17	39.18	3.36	.07
15. Do you make studies regarding the widening of roadways?	25	35.16	20	37.35	0.67	.42
16. Do you make studies regarding the channelization of intersections and/or geometric design features of streets and highways?	23	37.22	22	35.00	0.69	.41
17. Do you make studies and recommendations regarding school crossing protection in your community?	25	31.88	20	41.45	17.70	$< .00005$

Note: Mean gain scores were derived by subtracting pre-test from post-test mean scores

1 and 43 degrees of freedom; Critical value of $F_{1,43}$ (.05) = 4.07

TABLE 4.16.--A comparison of mean gain scores and analysis of variance values of students with the answers to questions 4-17 on experiential background

Questions	Number of Students Answering Yes	Mean Gain Score	Number of Students Answering No	Mean Gain Score	Computed Value of F	Significance
4. Do you supervise the collection of traffic data?	22	34.18	23	28.65	2.92	.09
5. Do you personally collect traffic data?	24	32.75	21	29.76	0.81	.37
6. Are you sufficiently familiar with mechanical traffic counters to obtain accurate counts?	29	30.66	16	32.63	0.32	.57
7. Have you made turning movement counts?	30	29.83	15	34.40	1.73	.20
8. Have you collected speed data?	20	25.15	25	36.32	14.86	< .0005
9. Are you responsible for studies and recommendations regarding the use of yield signs?	28	29.36	17	34.65	2.49	.12

TABLE 4.16.--Continued

Questions	Number of Students Answering Yes	Mean Gain Score	Number of Students Answering No	Mean Gain Score	Computed Value of F	Significance
10. Are you responsible for studies and recommendations regarding the use of stop signs?	28	29.36	17	34.65	2.49	.12
11. Are you responsible for studies and recommendations regarding the use of traffic signals?	25	29.28	20	33.95	2.02	.16
12. Are you responsible for studies and recommendations regarding the use of speed regulations?	26	29.12	19	34.42	2.61	.11
13. Are you responsible for studies and recommendations regarding the use of parking regulations?	29	30.79	16	32.38	0.21	.65

TABLE 4.16.--Continued

Questions	Number of Students Answering Yes	Mean Gain Score	Number of Students Answering No	Mean Gain Score	Computed Value of F	Significance
14. Are you responsible for studies and recommendations regarding the use of turn prohibitions?	28	30.18	17	33.29	0.83	.37
15. Do you make studies regarding the widening of roadways?	25	30.96	20	31.85	0.07	.79
16. Do you make studies regarding the channelization of intersections and/or geometric design features of streets and highways?	23	31.87	22	30.82	0.10	.75
17. Do you make studies and recommendations regarding school crossing protection in your community?	25	27.56	20	36.10	7.59	.01

Note: Mean gain scores were derived by subtracting pre-test from final test mean scores

1 and 43 degrees of freedom; Critical value of $F_{1,43}$ (.05) = 4.07

Question 9. Are you responsible for studies and recommendations regarding the use of yield signs?

Question 10. Are you responsible for studies and recommendations regarding the use of stop signs?

Question 11. Are you responsible for studies and recommendations regarding the use of traffic signals?

Question 12. Are you responsible for studies and recommendations regarding the use of speed regulations?

Question 13. Are you responsible for studies and recommendations regarding the use of parking regulations?

Question 14. Are you responsible for studies and recommendations regarding the use of turn prohibitions?

Question 15. Do you make studies regarding the widening of roadways in your community or county?

Question 16. Do you make studies regarding the channelization of intersections and/or the correction of geometric design features of streets and highways?

Question 17. Are you responsible for studies and recommendations regarding the need for school crossing protection in your community?

The analysis of variance of the gain scores obtained by subtracting pre-test from post-test scores showed that there was a significant difference at the .05 confidence level in relation to the answers to questions eight (Have you collected speed data?), nine (Are you responsible for studies and recommendations regarding the use of yield signs?), ten (Are you responsible for studies and recommendations regarding the use of stop signs?), eleven (Are you responsible for studies and recommendations regarding the use of traffic signals?), twelve (Are you responsible for studies and recommendations regarding the use of speed regulations?) and seventeen (Do you make studies and recommendations regarding the need for school crossing protection in your community?). The critical value of the F-statistic at the .05 confidence level was less than the computed values of the F-statistic for these questions (Table 4.15). On the basis of these findings, the null hypothesis was rejected for questions eight, nine, ten, eleven, twelve and seventeen, based on the comparisons obtained from the post-test scores.

In each case given above the gain scores of students answering no to these questions were higher than those who gave a yes answer; that is, those who had not collected data or made studies related to speed regulations, yield signs, stop signs, traffic signals and school crossing protection had higher gain scores than those who had performed these tasks.

The analysis of variance of the gain scores obtained by subtracting pre-test from post-test scores showed that there was no significant difference at the .05 confidence level in relation to questions four through seven and questions thirteen through sixteen.

The critical value for the F-statistic exceeded the computed value of F (Table 4.15). On the basis of these results the null hypothesis was accepted for questions four through seven and thirteen through sixteen based on the comparisons obtained from the post-test scores.

The analysis of variance of the gain scores obtained by subtracting pre-test from final test scores showed that there was a significant difference at the .05 confidence level in relation to the answers to questions eight (Have you collected speed data?), and seventeen (Do you make studies and recommendations regarding the need for school crossing protection in your community?). The critical value of the F-statistic was less than the computed value for question eight and for for question seventeen (Table 4.16). On the basis of these results, the null hypothesis was rejected for questions eight and seventeen based on the comparisons obtained from the final test scores.

In both of the cases given above, the gain scores for those answering no to these questions was greater than the gain scores of those answering yes.

The analysis of variance of the gain scores obtained by subtracting pre-test from final test scores showed that there was no significant difference at the .05 confidence level in relation to questions four through seven and nine through sixteen. The critical value of the F-statistic exceeded the computed value of F for these questions (Table 4.16). On the basis of these results the null hypothesis was accepted for question four through seven and nine through sixteen based on the comparisons obtained from the final test scores.

Question 18. What was the educational level of the student?

(1) High school graduate
(2) Had attended college
(3) Had attended college and majored in engineering
(4) Had received a baccalaureate degree
(5) Had received a baccalaureate degree in engineering

The data for this question in relation to the post-test are presented in Table 4.17.

The mean gain scores for these groups obtained by subtracting the pre-test from the post-test scores varied from a high of 42.33 for those students who held a college degree to a low of 33.33 for those who had attended but not completed college. The analysis of variance performed on these gain scores showed no significant difference between them at the .05 confidence level. The critical value of the F-statistic exceeded the computed value of the F (Table 4.17). The null hypothesis was accepted on the basis of this comparison for this question.

TABLE 4.17.--A comparison of the mean gain scores of students with their educational levels

Educational Level	Number of Students	Mean Gain Score	Standard Deviation
High School Graduate	19	35.21	10.37
Had Attended College	9	33.33	10.16
Majored in Engineering	5	35.20	5.36
Received a Degree	3	42.33	3.51
Received an Engineering Degree	9	39.33	6.02

Note: Mean gain scores were derived by subtracting pre-test from post-test mean scores.

Anova Values: 4 and 40 degrees of freedom

Computed F : 0.94 Significance : .45

$F_{4,40}$ (.05): 2.61

The data for question eighteen (What was the educational level of the student?) in relation to the final test are presented in Table 4.18. The mean gain scores obtained by subtracting the pre-test from the final test score were 27.68 for high school graduates, 27.00 for those who had attended college without receiving a degree, 35.60 for those who had majored in engineering without receiving a degree, 41.67 for those who had earned a college degree and 37.67 for those who had earned an engineering degree.

The analysis of variance performed on these gain scores showed a significant difference at the .05 confidence level. The critical value of the F-statistic was less than the computed value (Table 4.18). The null hypothesis was rejected on the basis of this comparison for this question.

Question 19. Had the student attended any short courses in the past five years?

(1) Traffic engineering short course
(2) Police short course
(3) Other short course
(4) None

The data for this question in relation to the post-test are presented in Table 4.19.

The mean gain scores of the four groups giving different answers to this question varied from a high of 40.00 for those attending other short courses to a low of 30.25 for those who had attended traffic

TABLE 4.18.--A comparison of the mean gain scores of students with their educational levels

Educational Level	Number of Students	Mean Gain Score	Standard Deviation
High School Graduate	19	27.68	10.92
Had Attended College	9	27.00	12.94
Majored in Engineering	5	35.60	5.59
Received a Degree	3	41.67	4.73
Received an Engineering Degree	9	37.67	8.28

Note: Mean gain scores were derived by subtracting pretest from final test mean scores.

Anova Values: 4 and 40 degrees of freedom

Computed F : 2.84 Significance: .04

$F_{4,40}$ (.05): 2.61

TABLE 4.19.--A comparison of mean gain scores of students with their attendance at short courses in last five years

Type of Short Course	Number of Students	Mean Gain Score	Standard Deviation
Traffic Engineering	8	30.25	4.23
Police	6	39.17	3.76
Other	9	40.00	5.34
None	22	35.86	11.12

Note: Mean gain scores were derived by subtracting pre-test from post-test mean scores.

Anova Values: 3 and 41 degrees of freedom

Computed F : 2.12 Significance : .11

$F_{3,41}$ (.05): 2.84

engineering short courses. The analysis of variance showed no significant difference at the .05 confidence level in these scores. The critical value of the F-statistic exceeded the computed value of F (Table 4.19). On the basis of these results, the null hypothesis was not rejected for this comparison for this question.

The data for question nineteen (Had the student attended any short courses in the past five years?) in relation to the final test are presented in Table 4.20.

The mean gain scores for the four groups listed in question nineteen obtained by subtracting the pre-test from the final test scores were 21.50 for those who attended a traffic engineering short course, 33.50 for those who attended a police short course, 38.89 for those who attended some other kind of short course and 31.27 for those who had attended no short courses in the past five years. The analysis of variance of these scores showed a significant difference at the .05 confidence level. The computed value of the F-statistic exceeded the critical value of F (Table 4.20). The null hypothesis was rejected on the basis of this comparison for this question.

A Comparison of Student Scores With Those Established by a Panel of Experts as Passing Scores

A fourth test of the effectiveness of traffic engineering short-course instruction was made by

TABLE 4.20.--A comparison of mean gain scores of students with their attendance at short courses in last five years

Type of Short Course	Number of Students	Mean Gain Score	Standard Deviation
Traffic Engineering	8	21.50	4.11
Police	6	33.50	4.76
Other	9	38.89	6.17
None	22	31.27	13.00

Note: Mean gain scores were derived by subtracting pre-test from final test mean scores.

Anova Values: 3 and 41 degrees of freedom

Computed F : 4.40 Significance : .01

$F_{3,41}$ (.05): 2.84

comparing student scores with those established by a panel of experienced traffic engineers as a minimum passing grade. The grades established by the panel expressed in percentages were 71.4 per cent for the test on traffic volumes, 67.9 per cent for the tests on intersection capacity and for school travel protection, 72.1 per cent for intersection traffic control and 70.7 per cent for speed regulation. The weighted mean grade for passing the entire course was 70 per cent.

The mean passing grades recommended by the panel of traffic engineers were compared to the grades obtained by the students in the three classes on the pre-test, the post-test and the final test. The number of students passing each test in each subject area and the final test is given in Table 4.21.

No student in the three classes passed the pre-test, although a few passed the pre-test for specific subject areas.

There were thirty-nine of a total of forty-five students who passed the post-test; twelve in the Southfield class, fourteen in the Ann Arbor class, and thirteen in the Kalamazoo class.

There were twenty-nine of a total of forty-five students who passed the final test; eight in the Southfield class, twelve in Ann Arbor and nine in Kalamazoo.

TABLE 4.21.--Number of students obtaining passing grades

Topic	Southfield			Ann Arbor			Kalamazoo		
	Pre-Test	Post-Test	Final Test	Pre-Test	Post-Test	Final Test	Pre-Test	Post-Test	Final Test
Volumes	2	3	5	2	13	10	2	12	9
Capacity	0	11	9	0	11	11	0	10	8
Schools	0	14	8	0	14	10	0	14	11
Intersections	2	15	11	2	14	15	0	13	12
Speed	6	*	14	7	*	15	5	*	14
Total	0	12	8	0	14	12	0	13	9

*Post-test and final test coincided.

Whether a student passed the course depended on which test grades were examined. The post-tests were given individually for each subject area immediately at the conclusion of the lecture period. The final test was given at the end of the fifth session which was four weeks after the first session.

It appeared reasonable to the panel of expert traffic engineers that retention of the material learned was important. With this in mind, the final test appeared to be appropriate for evaluating whether a student had passed the course.

Summary

The preceding chapter contained the results of the data obtained to test the three hypotheses included in this study, and the data obtained to determine whether students had achieved a passing grade.

Chapter V will contain the summary, findings, conclusions, recommendations and a discussion.

CHAPTER V

SUMMARY, FINDINGS AND RECOMMENDATIONS

The preceding chapter contained the findings based on the data obtained in this study of traffic engineering short courses. Analyses of data were presented of the following:

(1) The differences in learning among three groups who received traffic engineering short-course instruction and one group who received no instruction;

(2) The differences in learning which resulted from three different instructional methods;

(3) The differences in learning which resulted from differences in education or work experience;

(4) The number of students in the short courses who obtained a passing grade as determined by a panel of traffic engineers.

This chapter contains the summary, findings, conclusions, recommendations, and recommendations for further research and a discussion.

Summary

Statement of the Problem

The purpose of this study was to test the effectiveness of traffic engineering short-course instruction based on a learning system which included specific learning objectives.

Methodology

The effectiveness of traffic engineering short-course classes was studied by analyzing the test results of forty-five students from three short courses and fifteen persons who took tests without receiving instruction.

A traffic engineering short-course design with topics having specific learning objectives, teaching techniques and evaluation methods was used with three classes which met in Southfield, Ann Arbor and Kalamazoo. The classes met one day a week for five successive weeks. A pre-test covering five subject areas taught in the course was administered to all students at the first class session. A post-test was given at the end of each morning covering the topic of that session. A final test covering all five morning session topics was given at the end of the course. The pre-test, post-test and final test were identical except for numerical changes in problems.

In the first three morning sessions, a different method of instruction was used in the three classes for the three topics covered in these sessions. In the first three morning sessions, three different instructional methods were used as follows:

(1) A lecture session plus a problem session in which the instructor worked demonstration problems and the students in the class worked problems;

(2) A lecture session plus a problem session in which the instructor worked demonstration problems, but the students did not work problems;

(3) A lecture session plus a problem session in which the instructor did not work problems, but the students did work problems.

The method of instruction was rotated to give each class the same treatment.

Each student in the three classes completed a questionnaire on his educational and work experience background.

The analysis of variance was used to measure gain scores obtained from comparing pre-test to post-test and pre-test to final test results.

Findings

Significant differences were found among the four groups, three short-course classes and one control group at the < .0001 confidence level in test gain score means. The three short-course classes showed a mean gain of 31.35 points from a pre-test mean score of 23.47 to a final test score of 54.82. The control group showed a mean gain of 0.07 points from a pre-test score of 23.00 points to a final test score of 23.07 points.

Further analysis of mean test scores of the three classes receiving instruction found no significant differences at the .05 confidence level in these test scores.

The null hypothesis of no significant differences in learning among groups receiving instruction and those receiving no instruction was rejected (Hypothesis 1).

Significant differences which were found among the three instructional methods in mean test gain scores obtained by comparing pre-test and post-test scores cannot be interpreted due to interaction of independent variables. Significant differences at the 0.25 level were found when the gain scores obtained by comparing pre-test and final test scores were used.

The null hypothesis of no significant differences in learning among groups receiving three different instructional methods can neither be rejected or accepted since the results from the two tests were inconclusive

(Hypothesis 2). Despite the fact that the null hypothesis can neither be rejected nor accepted, it is interesting to note that the instructional method in which both the instructor and students worked problems resulted in a total gain score on the pre-test--post-test comparison in the three classes of 352 points, while the method in which only the instructor worked problems resulted in a total gain score of 241 points and the method in which only students worked problems resulted in a total gain score of 305 points. Similar results were obtained by comparing gain scores obtained from the pre-test--final test comparison. The method in which both instructor and student worked problems resulted in a gain score of 255 points, when only the instructor worked problems, 184 points and when only the students worked problems, 227 points.

Of the forty-five students whose grades were analyzed in this study, thirty-nine achieved a passing grade based on post-test results and twenty-nine based on final test results. Passing grades were established by a panel of seven traffic engineers who direct traffic engineering departments in Michigan. Since the final test was given at the end of the course while the post-test was given immediately after each lecture session, the final test appeared to be more useful in establishing whether a student passed the course. Using the final test as a basis, twenty-nine out of forty-five students, or 64.4 per cent, passed the course.

Significant differences among groups with differing education and work experience backgrounds could be found in only a limited number of cases. When gain scores resulting from comparing pre-test and post-test results were used, significant differences at the .05 confidence level were found among groups responding to these questions:

A. Was the student responsible for studies and recommendations regarding the use of yield signs? There was a significant difference at the .02 confidence level. Those answering yes had a mean gain score of 33.71; those answering no, 40.12.

B. Was the student responsible for studies and recommendations regarding the use of stop signs? There was a significant difference at the .02 confidence level. Those answering yes had a mean gain score of 33.71; those answering no, 40.12.

C. Was the student responsible for studies and recommendations regarding the use of traffic signals? There was a significant difference at the .05 confidence level. Those answering yes had a mean gain score of 33.80; those answering no, 39.05.

D. Was the student responsible for studies and recommendations regarding the use of speed regulations?

There was a significant difference at the .02 confidence level. Those answering yes had a mean gain score of 33.42; those answering no, 49.84.

When gain scores resulting from comparing pre-test and final test results were used, significant differences were found among the groups responding to the following questions:

1. What was the employing agency of the student?

   (a) Police department
   (b) Traffic engineering department
   (c) City engineering department
   (d) County road commission

There was a significant difference in answers at the .02 confidence level. The mean gain scores of these groups were as follows: those employed by a police department, 27.37; those employed by a traffic engineering department, 26.57; those employed by a city engineering department, 38.46; and those employed by a county road commission, 34.17.

2. What was the educational level of the student?

   (a) High school graduate
   (b) Had attended college
   (c) Had attended college (engineering major)
   (d) Had a college degree
   (e) Had an engineering degree

There was a significant difference in answers at the .04 confidence level. The mean gain scores of these groups were as follows: those who had graduated from high school, 27.68; those who had attended college without receiving a degree, 27.00; those who had majored in engineering in college without receiving a degree, 35.60; those who had received a college degree, 41.67; and those who had received an engineering degree, 37.67.

3. What short courses had the student attended in the past five years?

   (a) Traffic engineering
   (b) Police
   (c) Other
   (d) None

There was a significant difference in answers at the .01 confidence level. The mean gain scores of these groups were as follows: those who had attended a traffic engineering short course, 21.50; those who had attended some other type of traffic-oriented short course, 33.50; those who had attended other types of short courses, 38.89; and those who had not attended any short courses, 31.27.

Significant differences among groups responding to two questions were found when gain scores from both pre-test and post-test and from pre-test and final test comparisons were used:

1. Have you collected speed data?

There was a significant difference in answers using both test gain scores at the .0005 level. Those students who gave a yes answer had a mean gain score of 30.90 from the pre-test, post-test comparison and 25.15 from the pre-test, final test comparison while those answering no had scores of 40.32 and 36.32 respectively.

2. Do you make studies and recommendations regarding the need for school-crossing protection in your community? Answer yes or no.

There was a significant difference in answers at the .0005 confidence level for the gain scores obtained from the pre-test, post-test comparison and a difference at the .01 confidence level for the gain scores obtained from the pre-test, final test comparison. Those students who gave a yes answer had a mean gain score of 31.88 on the first test and 27.56 on the second test. Those students who answered no had a mean gain score of 41.45 on the first test and 36.10 on the second test.

Significant differences at the .05 confidence level were not found in analyzing the remaining ten questions used to determine a student's educational and work experience background.

On the basis of the analysis of the data presented, it was not possible to accept or reject the null hypothesis of no significant differences among groups with differing educational and experiential backgrounds (Hypothesis 3).

Conclusions

This study was designed to test the effectiveness of traffic engineering short courses. The method selected for testing whether the courses were effective was to measure what learning took place by means of a pre-test given at the beginning of the course, post-tests given immediately after a topic in the course had been presented and a final test given at the end of the course. The following conclusions were reached on the basis of the analyses of the grade scores:

1. The mean grade scores achieved by each of the three classes on the pre-tests, post-tests and final tests were given in Tables 4.1 and 4.3. The maximum number of points on the tests was 74. The mean scores of the three classes combined were 23.47 (31.7%) on the pre-test, 59.53 (80.4%) on the post-test and 54.82 (74.08%) on the final test. It was concluded that learning did take place as measured by these scores.

2. The study of the effectiveness of traffic engineering short courses showed that the learning that took place was substantial when compared to the grades established by a panel of experienced traffic engineers as a passing grade. The passing grade established by this panel was

51.8 points or 70 per cent. The mean grade scores of each class on the final test equalled or exceeded this grade of 70 per cent.

On an individual basis twenty-nine students out of a total of forty-five equalled or exceeded the grade of 70 per cent established as the passing grade for the course.

3. The short courses could not be considered to be a complete success as shown by this study. While twenty-nine persons achieved a passing grade, sixteen did not. Since all of these persons were doing some traffic engineering work in their communities, all should have the knowledge and skills to perform these tasks acceptably.

4. The reasons why some persons had better grades than others was not satisfactorily determined by this study. The evidence obtained indicated that past experience in traffic engineering matters was of little value insofar as achieving high grades on tests was concerned. In every case where significant results were obtained on differences between test gain scores related to work experience, those who had not had this experience did better than those who had.

5. There was some evidence that the educational level of the students was important when related to their grades. Those who had received some type of college degree did significantly better on the final test than those who had not finished or attended college.

6. The study of traffic engineering short courses did not reveal much useful information on the effectiveness of different types of educational methods. No significant information was obtained on which of the three methods related to problem sessions was the most effective. While it was true that the highest grade scores were obtained overall by the three classes from the method in which both the instructor and the students worked problems, this was not true in each individual session.

Recommendations

During the presentation of the short courses, it became apparent that two major improvements should be made in these courses. A number of the students, particularly those with nonengineering backgrounds, experienced difficulty with the mathematics involved in the various topics presented. A beginning session, which might be optional for students, should be offered for the purpose of presenting a short refresher in basic mathematics.

During the presentation of topics involving obtaining answers to problems, more time should be devoted to demonstration problems by the instructor and additional problems should be given the students to solve. This might involve the assigning of problems to be worked between the weekly sessions.

Further research should be done on the effectiveness of traffic engineering short courses. Such research should be directed at the following:

(1) In-depth investigations of what traffic engineering tasks students actually perform in their daily work;

(2) Post-course investigations of what uses are made by the students of material presented in the short courses;

(3) Presenting short courses using specific learning design procedures with different instructors presenting various topics.

Discussion

Very few investigations have been made of the effectiveness of traffic engineering short courses. In most of the courses presented in the past, little attention had been given to course objectives or the means by which these objectives could be achieved. Thus, despite an apparent great need for instruction in traffic engineering for persons performing this work in the smaller cities and counties, it was impossible to measure the value of these courses to participants.

The presentation of short courses in which objectives were stated and tests were administered appeared to be helpful in improving the courses. This was so because the objectives and the tests were related. The student was informed of what was expected of him during the course. Some of the students commented on this stating that it was helpful in maintaining their attention and in studying their course notes.

The process of having stated objectives and of giving tests was helpful to the instructor in these short courses. Outlines were developed which related to the course objectives. By this means the instructor was able to direct the discussions and problem sessions to the objectives of each topic offered.

An expansion of traffic engineering short-course instruction was believed to be of great importance if traffic engineering practices in Michigan were to be improved. Most of the students who attended the three short courses were poorly informed on traffic engineering methods. In the thirty hour sessions the students attended, only a part of what must be known for effective traffic engineering practice was presented. Additional courses are needed and must be presented to additional groups throughout the state.

It may also be desirable to establish standards for persons doing traffic engineering work in communities. Some of the larger communities have such standards requiring that the traffic engineer be a registered professional engineer and/or a member of the Institute of Traffic Engineers. Civil service tests have been established in some communities, counties and at the state level for various levels of traffic engineering work.

If standards for traffic engineering work were established, the need for short courses would expand considerably. Under these circumstances it might also be desirable to establish entry behavior levels for students in these courses. If students who attended short courses were required to meet some minimum level of entering behavior, the quality of instruction could be improved.

The assigning of homework would be valuable in traffic engineering short courses which meet one day a week for a number of weeks. This would give the student greater practice than can be obtained during the classday. Students should also be directed to apply principles and methods discussed in each class session to typical problems in their communities and to report on these the following week. Each session might begin with a review of the homework and the material discussed in the previous week's session.

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APPENDICES

APPENDIX A

TOPICAL OUTLINES OF FIVE SUBJECT AREAS WHICH WERE PRESENTED IN THE TRAFFIC ENGINEERING SHORT COURSES

APPENDIX A

Topical Outlines of Five Subject Areas Which Were Presented in the Traffic Engineering Short Courses

I. Traffic Volume Data Collection and Analysis:

A. Purpose of traffic volume counting.

B. Types of traffic counts.

C. Time and location of counts.

D. Adjusting traffic volume data to a common base.

E. Constructing a traffic volume flow map.

II. Intersection Capacity Analysis:

A. The nature of highway capacity analyses.

B. Uses of capacity studies.

C. Type of capacity studies.

D. Computation of capacities at intersections.

III. School Children Travel Protection:

A. The basic problem in providing protection.

B. Planning for safety.

C. School traffic committees.

D. Procedure for determining necessity for school crossing protection.

E. Selecting the appropriate type of school crossing protection.

IV. Intersection Traffic Controls:

A. Basic problems of safety at intersections.

B. Selecting proper traffic control devices for intersections.

C. Data needs for determining whether traffic control devices are needed at intersections.

D. Analysis of data.

E. Factors affecting traffic at major intersections.

F. Accident patterns at intersections.

V. Traffic Speed Regulation:

A. Public attitude toward speed.

B. Engineering rationale for speed zoning.

C. Relationship of accidents to speed.

D. Spot speed studies.

E. Analysis of speed data.

F. Establishing speed regulations.

APPENDIX B

TEST QUESTIONS AND PROBLEMS FOR FIVE SUBJECT AREAS PRESENTED IN THE TRAFFIC ENGINEERING SHORT COURSES

NAME ____________________________

APPENDIX B

Traffic Volumes

Test Questions

1. Traffic counts may be useful for: (Select the five correct answers)

    a. Determining speed limits.
    b. Estimating the need for highway improvements.
    c. Determining adequate highway design.
    d. Determining the proper size of traffic signs.
    e. Measuring the adequacy of existing highways.
    f. Evaluating accident data.
    g. Estimating the 85th percentile speed of vehicles at a point on the roadway.
    h. Determining the need for traffic signals.
    i. Estimating the need for off-street parking.
    j. Controlling truck traffic on arterial routes.

2. The greatest value may usually be obtained from a traffic count when it is compared to:

    a. Accident data.
    b. Prevailing roadway speed.
    c. The capacity of the roadway.
    d. Other traffic volumes.
    e. The design features of the roadway.

3. The three types of traffic counts are:

    a. Simultaneous, machine, manual.
    b. Continuous, machine, turning movement.
    c. Machine, turning movement, classification.
    d. Manual, electronic, mechanical.

4. A volume count made during the following time period is used for making intersection capacity analyses:

    a. 6 A.M. to 6 P.M.
    b. The peak hour.
    c. Eight highest volume hours.
    d. 4 P.M. to 6 P.M.
    e. 7 A.M. to 9 P.M.

5. For accident purposes the most useful time to obtain traffic volume counts is when the ________________ occurred.

6. In making studies to determine the need for traffic signals, the best time to collect volume data is from:

   a. 6 A.M. to 10 P.M.
   b. 10 A.M. to 2 P.M.
   c. 6 A.M. to 6 P.M.
   d. 4 P.M. to 6 P.M.
   e. 7 A.M. to 9 P.M.

7. Which of the following factors are involved in adjusting a traffic count to a common base such as the ADT (average daily traffic)?

   a. Day of the week.
   b. Time of day.
   c. Season of the year.
   d. a, b and c.
   e. a and c.

8. Peak-hour volume is defined as the highest volume recorded:

   a. In one hour of any 24 hour day.
   b. The highest hourly volume on a normal weekday.
   c. The average of the highest volume in the morning and evening peak-hour combined.
   d. The highest hourly volume recorded in an entire year.
   e. None of the above.

9. A 24 hour count is 12,000 vehicles. The 3 to 4 P.M. count is 500 vehicles. The hourly factor for expanding the hourly count to 24 hours for the period 3 to 4 P.M. is:

   a. 15
   b. 18
   c. 20
   d. 24
   e. 30

10. The PHV (peak-hour volume) at a given location is 800 vehicles.
    The hourly factor is 10.
    The weekly factor is .80.
    The monthly factor is 1.1.

    Find the ADT (average daily traffic)

    ________________ answer

NAME ____________________

Intersection Capacity

Test Questions

1. To make a capacity analysis of an intersection in the downtown area of a community in a metropolitan area (350,000 population) on two-way streets with parking, I would use:

   a. Figure B-2.
   b. Figure B-3.
   c. Figure B-4.
   d. Figure B-5.
   e. Figure B-6.

2. The adjustment factor for a metropolitan area population of 350,000 and peak-hour factor of 0.85 combined using Figure B-6 is:

   a. 1.00.
   b. 0.86.
   c. 1.03.
   d. 1.23.
   e. 1.14.

3. The area factor for a central business district is:

   a. 0.90.
   b. 0.95.
   c. 1.00.
   d. 1.10.
   e. 1.20.

4. The truck factor (f_T) for fifteen per cent (15%) trucks is:

   a. 1.05.
   b. 1.00.
   c. 0.95.
   d. 0.90.
   e. 0.85.

5. On a two-way street with no parking and an approach width greater than 35 feet, a left turn adjustment factor of .950 indicates that of the total approach traffic, left turns are:

   a. 5%.
   b. 10%.
   c. 12%.
   d. 15%.
   e. 20%.

6. On a one-way street, the left turn adjustment factor is always the same as the right turn factor (assuming the same percentage of turns in each case).

   a. True.
   b. False.

7. Given the following factors, determine the appropriate intermediate factor:

f_{PPH}	1.00
f_A	1.25
f_B	1.00
f_T	0.90
f_R	1.00
f_L	0.80

ANSWER

   a. 0.85.
   b. 0.90.
   c. 0.95.
   d. 1.00.
   e. 1.05.

8. The total cycle length of a traffic signal is 60 seconds. The green time on the approach under study is 24 seconds. G/C will be:

   a. 0.40.
   b. 0.45.
   c. 0.50.
   d. 0.55.
   e. 0.60.

9. On a two-way street the approach width used to measure capacity is always half the width of the approach street pavement.

   a. True.
   b. False.

10. In urban conditions the level of service and load factor used for design purposes is:

   a. A - 0.0.
   b. B - 0.1.
   c. C - 0.3.
   d. D - 0.7.
   e. E - 1.0.

11. Use Figure B-3 in the outline for this problem: Given an approach width of 35 feet, a load factor of 0.7, the approach volume per hour of green is approximately:

   a. 1,800 vehicles an hour.
   b. 2,300 vehicles an hour.
   c. 2,800 vehicles an hour.
   d. 3,100 vehicles an hour.
   e. 3,600 vehicles an hour.

12. Given a service volume of 3,000 vehicles an hour and a composite factor (f_c) of .6, the actual service volume of an intersection approach is:

   a. 1,400 vehicles an hour.
   b. 1,500 vehicles an hour.
   c. 1,800 vehicles an hour.
   d. 2,000 vehicles an hour.
   e. 2,400 vehicles an hour.

13. One of the following does <u>not</u> affect intersection capacity calculations:

   a. Curb parking on the intersection approach.
   b. Striping the approach lanes.
   c. Changing a street to one-way operation.
   d. Prohibiting turns.
   e. Adjusting the amount of green time.

14. Given the following information for an intersection approach, determine the capacity of the approach: (two-way street, no parking, level of service C).

a.	Metropolitan area of 250,000		
b.	Average peak-hour factor.	f_{PPH}	______
c.	Central business district.	f_A	______
d.	No bus operation.	f_B	______
e.	Trucks 10%.	f_T	______
f.	Right turns 15%.	f_R	______
g.	Left turns 10%.	f_L	______
h.	G/C 40%.	f_i	______
i.	Approach width -- 30 feet.		

______ Answer

NAME ____________________________

School Travel Protection

Test Questions

1. The least safe method of protecting children crossing traveled roadways is the:

    a. Pedestrian overpass.
    b. School children patrols.
    c. Police officers.
    d. Traffic signals.
    e. Stop signs.

2. The minimum allowable speed limit in a school zone in Michigan is:

    a. 15 miles per hour.
    b. 20 miles per hour.
    c. 25 miles per hour.
    d. 30 miles per hour.
    e. 35 miles per hour.

3. Stop signs and yield signs should not be used at school crossings unless their use is warranted by:

    a. Excessive vehicular speeds.
    b. The total traffic situation.
    c. The absence of crossing guards.
    d. Curb parking on the approaches.
    e. None of the above.

4. A basic principle to be followed in studying and planning safe travel to school for students is:

    a. The public usually knows what is the best type of protection.
    b. Children should be taught to be responsible pedestrians at the earliest possible age.
    c. The maximum use of traffic control devices provides the most protection.
    d. Uniformity is of little importance in treating school crossings.
    e. None of the above.

5. In studying the necessity for crossing protection at a school crosswalk, the analysis assumes that in crossing the street students will walk in rows of:

   a. Two.
   b. Three.
   c. Four.
   d. Five.
   e. Six.

6. Refer to Figure C-1 in the outline. If the group size is 36 to 40, N equals:

   a. 5.
   b. 6.
   c. 7.
   d. 8.
   e. 9.

7. Refer to Figure C-1 in the outline. In determining the 85th percentile group size, the total number of groups is multiplied by:

   a. .10.
   b. .15.
   c. .20.
   d. .25.
   e. .30.

8. Refer to Figure C-2 in the outline. On a roadway 40 feet wide and with N (the number of rows) being 6, the adequate gap time -- G is:

   a. 18 seconds.
   b. 20 seconds.
   c. 24 seconds.
   d. 28 seconds.
   e. 30 seconds.

9. In determining the percentage of delay time (D) this formula is used: $D = \frac{(T - t)}{T} 100$

   Where T = total survey time
   t = total of all gaps equal or greater than G

   If T = 60 minutes (3600 seconds) and t = 30 minutes (1800 seconds), D will equal:

   a. 40%.
   b. 50%.
   c. 60%.
   d. 65%.
   e. 70%.

10. On a roadway 60 feet wide the per cent of pedestrian delay time - D is 60 seconds. To justify the need for traffic control at a school crossing under these conditions the point "P" must be to the right of N equal to:

    a. 1.
    b. 2.
    c. 4.
    d. 6.
    e. 8.

11. During the period 8 to 9 A.M., students were counted at a school crossing. The group sizes were as follows:

36-40	5
31-33	10
26-30	25
21-25	10

The pavement width is 40 feet. In measuring the gaps, the following data was obtained:

Total time of measurement -- one hour or 3,600 seconds.
Total time of all gaps greater or equal to G (Adequate gap time) -- 30 minutes or 1,800 seconds.

Find:

Answers:

a. The 85th percentile group size (N). ________
b. The adequate gap time (G). ________
c. The percent of delay time (D). ________

Does the crossing justify school crossing protection?

a. Yes.
b. No.

NAME ____________________________

Intersection Traffic Controls

Test Questions

1. At the intersection of two high volume major streets the most usual type of traffic controls are:

   a. Traffic signals.
   b. 4-way stop signs.
   c. 2-way stop signs.
   d. Yield signs.
   e. None of the above.

2. In the absence of an accident record at a minor intersection, yield or stop signs are not needed if the safe approach speed exceeds:

   a. 10 miles an hour.
   b. 15 miles an hour.
   c. 20 miles an hour.
   d. 30 miles an hour.
   e. 40 miles an hour.

3. At a minor intersection, yield or stop signs may be justified if the right angle collisions in an average year are:

   a. 1 or more.
   b. 2 or more.
   c. 3 or more.
   d. 4 or more.
   e. 5 or more.

4. A stop sign is used at a minor intersection which justifies traffic controls in place of a yield sign when the safe approach speed is less than:

   a. 30 miles an hour.
   b. 20 miles an hour.
   c. 15 miles an hour.
   d. 10 miles an hour.
   e. 5 miles an hour.

5. The intersection pattern which encourages through traffic is known as the:

   a. Diagonal pattern.
   b. Irregular pattern.
   c. Discontinuous pattern.
   d. Grid pattern.
   e. Circumferential pattern.

6. Ordinarily, stop signs are placed on the street with the lower volume. When they are placed on the street with the higher volume, this is done to:

   a. Reduce vehicle speeds.
   b. Help prevent developing the busier street as a through street.
   c. Control trucks on the street.
   d. Promote higher volumes of traffic.
   e. None of the above.

7. In studying an intersection where there are a number of right angle collisions involving vehicles on two approaches, the first thing to do is:

   a. Install a stop sign.
   b. Determine whether the vision obstruction can be removed.
   c. Reduce the speed limit.
   d. Install a yield sign.
   e. None of the above.

8. The major reason for using traffic control devices (stop or yield signs) at minor street intersections is to:

   a. Reduce the traffic volume.
   b. Determine who has the right-of-way.
   c. Control vehicular speeds.
   d. Prevent accidents.
   e. Promote orderly traffic flow.

NAME ____________________________

Speed Regulation

Test Questions

1. Motorists determine the speed they travel by:

    a. Watching the speed limit signs.
    b. Traffic and roadway conditions.
    c. The volume of traffic.
    d. Considering the weather conditions.
    e. None of the above.

2. Speed limits are set for:

    a. The worst weather conditions.
    b. Peak-hour traffic conditions.
    c. Fair weather, off-peak volumes.
    d. Unusually favorable conditions.
    e. None of the above.

3. Speed limits help reduce the difference in speeds when they are based on (select the wrong answer):

    a. Studies of prevailing speeds.
    b. Weather conditions.
    c. Character of the roadway.
    d. The development alongside the roadway.
    e. The accident history of the road.

4. The chances of involvement in a traffic accident are greater at speeds which are:

    a. Much higher than the average speed.
    b. The same as the speed limit.
    c. Much lower than the average speed.
    d. Approximately the same as the average speed.
    e. None of the above.

5. The chances of having a personal injury as a result of a traffic accident increase as:

   a. The speed decreases.
   b. Are not affected by speed.
   c. The speed approximates the speed of other vehicles.
   d. The speed increases.
   e. None of the above.

6. The required number of randomly selected vehicles to obtain a valid speed sample in an urban area is:

   a. 50.
   b. 75.
   c. 100.
   d. 200.
   e. 300.

7. The average speed of the vehicles obtained in a sample is obtained by adding all of the speeds and:

   a. Multiplying by the number of speeds.
   b. Dividing by the number of speeds.
   c. Subtracting the number of speeds.
   d. Adding the number of speeds.
   e. None of the above.

8. The pace is defined as the largest number of speeds in a sample in a range of:

   a. 5 miles an hour.
   b. 8 miles an hour.
   c. 10 miles an hour.
   d. 15 miles an hour.
   e. 20 miles an hour.

9. The 85th percentile speed is the speed which is exceeded by:

   a. 5 per cent of the vehicles.
   b. 10 per cent of the vehicles.
   c. 15 per cent of the vehicles.
   d. 20 per cent of the vehicles.
   e. 25 per cent of the vehicles.

10. In the chart given below the 85th percentile speed is:

a. 60 - 65.
b. 50 - 54.
c. 25 - 29.
d. 40 - 44.
e. 45 - 49.

Speed Range	Number Recorded at This Range
60 - 65	3
55 - 59	7
50 - 54	10
45 - 49	25
40 - 44	25
35 - 39	10
30 - 34	10
25 - 29	5
20 - 24	5

APPENDIX C

LETTER TO PANEL OF TRAFFIC ENGINEERS WHO DETERMINED PASSING GRADES FOR TESTS PRESENTED IN THE TRAFFIC ENGINEERING SHORT COURSES

APPENDIX C

August 21, 1972

Dear :

During the spring of 1972 we gave a series of traffic engineering short courses to approximately 70 persons. At the conclusion of each unit of instruction, tests were given to the students to determine what they had learned. I am asking your assistance in evaluating the test grades. A copy of the tests and the course outlines are enclosed.

Please put yourself in the position of a prospective employer of these students who would be doing the kind of work as indicated by these tests. Further, assume that your decision to hire or not to hire will be based on the test scores the students made on this series of five tests. I will appreciate your telling me what grade the student should make on each test for you to hire him. In doing this, please consider that the person has just learned how to do the things on which he was tested. Presumably, he would improve with practice in his job. Therefore, the grade should indicate the lowest level of performance acceptable to you.

Thank you very much for your help.

Very truly yours,

Adrian H. Koert