AN ANALYSIS OF PHYSICS INSTRUCTIONAL PATTERNS IN ENGINEERING TECHNOLOGY PROGRAMS

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PREFACE

This study is concerned with an analysis of the physics instruction presently offered to engineering technology students and the emerging patterns of physics instruction for these students. Methods of physics instruction were studied using an extensive literature survey, personal correspondence with those using innovative methods in this field, and a survey questionnaire. The questionnaire was sent to physics instructors and technical school administrators at institutions with at least one professionally accredited engineering technology program. From the questionnaire the details of current physics instruction for engineering technology students were determined and the opinions of physics instructors and administrators were obtained about the type of physics instruction which they believed should be offered in the future. The salient features of the professionally accredited programs were identified. The results from the survey are reviewed and current trends are described. Also, suggestions are made concerning the modification of the physics curriculum for engineering technology students.

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The author also wishes to express his appreciation and thanks to the many professional educators who participated in the survey and made valuable suggestions and comments. A special note of thanks is given to Herman W. Pollack, Orange County Community College, Middleton, New York; Arnold A. Strassenburg, American Institute of Physics; Norman C. Harris, The University of Michigan; and Alexander Avtgis of the Wentworth Institute for their assistance in the preparation of the survey questionnaire.

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CHAPTER I

INTRODUCTION

Preliminary Remarks

The history of engineering technology education began about 1829 with the development of "mechanics institutes" in eastern and midwestern industrial centers. The early schools strove to meet the needs of an industrial society; needs which neither the high school nor the college were meeting. The two-year technical institute in America dates from 1892, when Pratt Institute adopted the concept after making a study of technical education in Western Europe (1).

Under the pressure of an expanding free public school system a second wave of technical schools founded late in the 19th century flourished for a few years only to disappear or evolve into classical engineering schools. While the four-year engineering institute has a history extending over a century and a half, the two-year associate degree technology program began about 1900. Its growth has paralleled the growth of the community college which increased in number from 8 in 1900 to over 1000 schools in 1970.

Beginning in the late 1950's, numerous four-year engineering technology programs were developed to provide technically trained graduates for support of the expanding technology of the country. As the interdependence between science and industry has grown, the demand for persons who can apply the findings of science to the improvement of industrial practices has increased greatly. Nearly a hundred four-year technology programs are now in existence as compared to only three or four in 1955.

The modern engineering technician occupies a position between the engineer and the skilled worker. His job is to translate the ideas of the engineer into working plans to be followed by the shopman in producing a product or carrying out a testing procedure (2).

The engineering-technology curriculum has historically been built on a foundation of engineering sciences; mathematics, chemistry, and physics. Such coursework normally constitutes about ten per cent of the two-year curriculum and nearly twenty five per cent of the baccalaureate degree program. Traditionally this background science has been taught by the faculty and staff of the institute using textual materials expressly selected for the technology student. Recently, however, with the advent of the four-year program and pressure for accreditation of programs by national groups such as the Engineering Council for Professional Development, the move has been toward increased utilization of regular university physics courses to provide instruction in the basic engineering sciences.

Statement of the Problem

There has been a rapid expansion of both two-year and four-year engineering technology curricula with little opportunity to do careful curriculum development work in the area of basic science for engineering technology students. An increasing pressure from accreditation authority is pushing large numbers of technology students into traditional university science courses; courses which do not usually take into account the specific needs, interests, and prior educational experience of those students.

Many educators believe that technical students require a different instructional program from that traditionally available to university students. As a result, a few innovative projects in physics for engineering technology students have been undertaken in recent years. However, information about such projects has not been widely disseminated and the work is virtually unknown to the majority of physics faculty responsible for teaching engineering technology students. There exists a serious lack of communication between the physics faculty and the technology faculty.

This study was undertaken (a) to determine the content and structure of physics instruction for technical students in diverse institutions with accredited engineering technology programs, (b) to ascertain the views of physics instructors and technical school administrators as to the characteristics of a "best" physics program for technical students and (c) to identify emerging patterns of physics instruction, that is, how the physics program for engineering technology students will probably change in the near future and the reasons for those changes. Guidelines for modifying physics instruction will be suggested. The salient features of these accredited programs will be identified and the rationales behind the types of physics instruction offered at the surveyed institutions will be examined.

Definitions

The terms engineering technology, engineering technician, and engineering technology curriculum are understood to be as defined under the heading "Definitions" in the Thirty-first Annual Report of the Engineering Council for Professional Development (3).

Engineering technology is that part of the engineering field which requires application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational spectrum between the craftsman and the engineer at the end of the spectrum closest to the engineer.

An engineering technician is one whose education and experience qualify him to work in those areas of engineering which require the application of established scientific and eingineering knowledge and methods, combined with the technical skills, in the support of engineering or scientific activities toward the accomplishment of engineering objectives.

An engineering technology curriculum is a planned sequence of college-level courses, usually leading to an associate degree, designed to prepare students to work in the field of engineering technology.

The term engineering technology student is understood to mean a student enrolled in a program of engineering technology instruction. Included among the various types of engineering technology programs are electrical, mechanical, civil, chemical, nuclear, environmental, aeronautical, design, surveying, construction, computer, industrial, air conditioning, electronic, and architectural programs.

Limitations of the Study

This study is limited to undergraduate physics instruction for engineering technology students. Innovative and experimental programs in physics for engineering technology students discussed in this study are limited to those found in the recent professional literature and those described in direct correspondence with persons involved in the development of these programs.

Only institutions with a professionally accredited engineering technology program are included in the survey of physics instruction for engineering technology students. Each institution surveyed had at least one engineering technology program accredited by the Engineering Council for Professional Development (ECPD). It is assumed that the physics instruction offered in the professionally accredited engineering technology programs is representative of the more "successful" physics programs offered to engineering technology students offered at various institutions around the country.

One instructor of physics at each institution surveyed was asked to complete a questionnaire although more than one instructor may have been involved in physics instruction at that institution. It is assumed by the author that each physics instructor responding to the questionnaire survey presented a representative and honest description of the physics instruction at that institution and the rationale behind it.

Representative administrators from the surveyed institutions were also requested to complete that portion of the questionnaire dealing with their opinions of the ideal physics instruction for engineering technology students and the rationale underlying that type of instruction. It is an assumption of the author that these administrators gave a representative and honest opinion concerning their ideas of the most appropriate type of physics instruction for engineering technology students.

The survey was limited to data collected during the Fall of 1972.

The amount of data and detail concerning physics instruction and the rationale behind that instruction was necessarily limited in order to assure a reasonable response to the survey questionnaire. This study is also based on the assumption that the faculty and administrators at institutions with an accredited engineering technology program are either active in the development of innovative physics programs or are aware of such work at other institutions.

Significance of the Study

This study will aid those doing curriculum development work in the area of basic science for technical students. Although this study is concerned only with physics instruction, the results can be extended to the areas of mathematics and chemistry as well. This study attempts to call attention to the special needs, interests, and educational experiences of engineering technology students and aid in the construction of educational programs in physics for such students. It details some of the elements that make up the "more successful" physics programs at institutions with accredited engineering technology programs. This study also attempts to collect pertinent information into an account which will aid educators in physics and in technical education to develop the most rational physics programs for engineering technology students and technology students in general.

Summary

With increasing numbers of students entering engineering technology programs it is imperative that careful attention be paid to the basic science component of their curriculum. The physics instruction offered to engineering technology students was investigated through various means. A questionnaire was constructed and sent to representatives of all academic institutions with accredited programs in engineering technology. Through the questionnaire results and a study of the professional literature it is hoped to determine (a) the details of current physics instruction at institutions having professionally accredited engineering technology programs, (b) the educational rationale underlying the current physics instruction, (c) the emerging patterns of physics instruction for engineering technology students, (d) the opinion of physics instructors and technical school administrators concerning the type of physics instruction which should be offered to engineering technology students in the future, and (e) the existence and salient features of any innovative physics programs appropriate for engineering technology students.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

There seems to be no journal for technical institute faculties in which curriculum studies are regularly published. A detailed survey of physics journals such as _Physics Today_, _American Journal of Physics_, _The Physics Teacher_, and others, reveals only about 6 or 7 articles published within the last decade concerning physics instruction for technical students. A careful reading of program announcements for all national meetings of the American Association of Physics Teachers over the last decade reveals only one or two papers reporting efforts to define and describe appropriate physics programs for technical students. There seems to have been very little activity in the area in the past several years despite tremendous activity in technical education itself. Thus, a real need exists for some form of regular public communication between physics and technical institute staffs in order to foster the development of appropriate physics programs designed especially to meet the needs and interests of technology students.

Status of Physics in the Engineering Technology Curriculum

According to Norman C. Harris (4), technicians who work in supporting roles to engineers and scientists, those engaged in industrial design, production, and testing operations, need a significant background in physics and mathematics in addition to specialized technical knowledge and skills. Ideally, the engineering technicians should have both breadth and depth in the basic science and mathematics disciplines.

Harris maintains that physics as a discipline may serve as a common intellectual meeting ground of engineers and technicians. The practical applications of concern to both take their substance from physical principles and laws. The engineer is usually much more sophisticated in mathematics than the technician, and his knowledge of engineering theory is much greater. However, in the area of basic physics, engineers and technicians can work together to bring common understanding to problems of research, design, and testing. Only if technicians receive the right kind and level of physics instruction can this meeting come about.

A number of reasons why technical programs should include a full year of applied physics at the college level are given by Harris. These reasons are: (a) As science and engineering move toward greater sophistication in theoretical disciplines, technicians who work in supporting roles must have a real understanding of physical principles and of physics laboratory techniques. (b) As technical programs become more popular, more students without a high school physics background are enrolling in junior colleges and technical institute programs. Any physics deficiency must be remedied at the outset of their technical education. (c) In response to recent pressure, many high school physics courses have been "upgraded" in theoretical content to the point where very little practical or technical content remains. Excellent as such courses may be for future physicists and mathematicians, they do not provide basic instruction in applied mechanics, heat, and electricity which technical students need, nor do they emphasize applications to industrial problems. (d) High school physics laboratory work is entirely inadequate as a background for technical education. The usual one-hour laboratory period does not allow sufficient time for thought and for careful, deliberate investigation. The future technician must not only understand physical laws but he must also have an opportunity to use precision equipment, to get acquainted with laboratory procedures, and to make detailed investigations in which he develops facility with process as well as his understanding of precept.

Harris further states that "neither the 'general college physics' course, with its emphasis on historical and philosophical concept oriented to liberal arts students, nor the 'engineering physics' course with its calculus and college algebra prerequisite is suitable for technicians."

Frank L. Juszli (5) believes that the basic sciences - mathematics, physics, and early courses in electricity and chemistry - serve three important roles in engineering technology programs. The first role is to provide a background of fundamental information concerning concepts, laws, principles, and terminology. The second role of the basic science is to provide quantitative considerations. Physics, chemistry, and electricity courses tend to formulate principles and to manipulate quantities in such a manner as to be measureable in the laboratory. The third role of basic sciences is to provide services to the bread-and-butter concerns of the technicians. These include: (a) Service to technical specialty courses. Certain topics are emphasized in basic science with later specific applications in mind. (b) Service to the emphasis on engineering applications which is a major objective of engineering technology programs. This involves teaching a responsible approach to equipment and experimental investigations, methods of measurement, analysis of problems, and evaluation of results. This service is probably best achieved in introductory physics courses and electricity courses. (c) Service to communications. Teaching students how to report detailed work in an informative manner is a vital function of responsible engineering programs.

A report of the American Association for the Advancement of Science (6) offers a statement concerning the role of physics in these curricula: "The technician must have sufficient knowledge of the basic principles and phenomena of the science underlying his specialty to be an effective, comprehending, and perceptive worker with his or her professional counterpart and to be able to master the inevitable (and often rapid) changes brought about by technological developments."

The AAAS report further recommended that the physics courses for technical students "...should not be the 'traditional' college physics, chemistry, and mathematics, oriented toward theory with limited emphasis on applications, but that they should be inclined toward the applied" (6).

Schaefer and McCord (7) also believe that physics is important to the engineering technician and to the industrial technician. They characterize the engineering technician as being field oriented and the industrial technician as being more job oriented. The engineering technician and even the industrial technician will find that his job makes frequent demands on his ability to perform mathematical computations, and his understanding of the basic principles of physics and how to apply them to design and testing operations.

The importance of physics to the engineering technology curriculum may be inferred from its place in the curriculum. Many believe that physics should be required in the freshman year of the technical program since physical principles form the foundation upon which much of the content of technical specialty courses rests.

The trend seems to be for the engineering technology student to spend about one-fifth of his time in physical science study, the major portion of which is in physics (8). The precise level of rigor of the technical physics course is a matter of much discussion and some controversy among junior college and technical institute educators. Some feel that the physics course for technicians should be essentially the same as that required of freshman engineering students. At the other extreme, some educators minimize the importance of physical science and recommend merely that some selected content from physics at a "practical-physics" level be taught perhaps as part of one of the technical specialty courses or as "related science" in a shop course.

Each institution is perhaps the best judge of its own program, but judgments should be based on careful and scholarly curriculum evaluation with long-term occupational trends in mind. It is usually agreed, however, that the basic sciences are at the very heart of engineering technology programs. Their role is vital in providing opportunities to mold the student's thinking, shape his practical experience, and point him toward the goals of the entire curriculum. It appears that physics will remain an integral part of the engineering technology curriculum for many years to come.

Physics Programs for Engineering Technology Students

If one is to adapt physics instruction to the special needs of students in the engineering technology curricula, one must first examine these students in terms of their prior experiences, educational backgrounds and scholastic aptitudes.

Jesse J. Defore describes some of the characteristics of engineering technology students (9,10). The engineering technology student is usually a male between 19 and 21 years old and comes from a metropolitan area. His father is most likely employed in some occupation related to technical fields. Secondary education of a successful engineering technology student includes a relatively high concentration of mathematics and science courses. He is usually from the second quarter in his high school class. His test scores usually lie above the median for quantitative ability in college students, although test scores on tests for verbal ability may not. He is strongly occupation-oriented and usually shows a preference for practical matters rather than those that are theoretical. He has considerable manual dexterity which he probably developed early in life. He is usually motivated toward obtaining employment and therefore he often desires to concentrate his studies in subject areas that he believes will be relevant to his goals.

It is generally agreed that physics should be an integral part of any engineering technology curriculum and it appears important that this instruction be tailored to the special needs and interests of engineering technology students. However, there are relatively few innovative physics programs designed especially for engineering technology students. The following programs are the major innovations in physics instruction for technology students which have been published in the major physics, engineering, or technology journals within the last decade.

Tech Physics Project

The Tech Physics Project represents one of the most important and extensive programs under production for teaching physics to engineering technology students in the module concept.

It was argued at a conference called by the American Association for the Advancement of Science in July, 1968, that the physics courses taught to future technicians at community colleges and technical institutes usually fail to motivate students, probably because they do not relate the important principles of physics to practical problems relevant to technology. Through a series of conferences with technical institute teachers the general conclusion was established that existing materials for teaching physics to technicians were inadequate. The materials do not adequately link physical principles to the kind of systems and devices with which the technician works when on the job (11).

The following year, the Commission on College Physics sponsored a National Conference on Technical Physics in the Two-Year Colleges. The Commission on College Physics convened a group of physicists and technologists at Florissant Valley Community College on May 15-17, 1969, for the purpose of discussing the teaching of physics to prospective technicians. The conferees agreed that an alternative was needed to the standard deductive-style, textbook-oriented program, but they felt that no single course would be likely to satisfy the wide variability of technical programs and student backgrounds. New material should cater to the technical student's initial interest in things rather than ideas.

These conclusions were in complete harmony with the recommendations contained in the report of a national conference convened by the Commission on College Physics (12).

At the conference, held on the campus of the Florissant Valley Community College in St. Louis, Missouri, a recommendation was made that new teaching materials in modular form be produced. To stimulate student interest, each module was to focus attention on a particular technical device. Although the main focus of each module was to be on understanding how the physical system works, the intention was that a selected series of modules should introduce students to the major ideas and principles of physics which help one to understand the operation of the devices. It was felt that through experimentation, study of written and visual materials, and problem solving, the student would learn the principles of physics in the context of the instruments of technology.

In summary, modules should capitalize on the student's interest in doing things that are related to the technology he plans to enter. Textual material should complement experiments, rather than the reverse. While most modules were to focus on some aspect of technology, the overall objective of any module would be to uncover the physics involved and not to develop the technology of the device.

What should be the primary goal of physics instruction in a technology curriculum? Some advocate dealing primarily with the theoretical aspects of basic physics and leaving applications to technology courses and on-the-job training. At the other extreme are those who favor limiting the physics course to practical applications of physics principles. Some feel that physicists are ineffective in this task. The Tech Physics Project in advocating the production of modules takes the intermediate position embodied in the following points: (a) the physics course should lead the student to understand basic principles of physics; (b) the physics teacher is best able to do this; (c) motivation is an all important factor in this learning process, and (d) technology students are more likely to be motivated by inductive discovery through personal investigation of a technological system than by a process of deductive reasoning which stems from abstract generalizations based on the experience of others.

The titles of some modules under production and the names and addresses of project directors at each of the four module production centers are listed in Table I (13).

Each of the modules is designed to require about two or three weeks of time. Thus, about 12 to 15 modules could be covered in the conventional, one-year physics course.

Each Tech Physics Project module contains the following components (12):

1. a statement of the prerequisites;
2. a set of behavioral objectives toward which the student will work;
3. an entry test;
4. an instructional program consisting of
    a. a physical system to be available in the laboratory around which the module is built, and
    b. a description of how the student will interact with the system in order to meet the behavioral objectives; (this will include narrative, questions, problems, learning aids, and activities involving experimentation. There will also be an emphasis on industrial applications of the principles involved.)
5. an exit test; and

TABLE I

TECH PHYSICS PROJECT MODULES

A. **Florissant Valley Community College**
St. Louis, Missouri
Director: Bill Aldridge

1. Binoculars
2. The Incandescent Bulb
3. The pH Meter
4. An Automobile Ignition System and Spark Plugs
5. The Analytical Balance
6. The Laser
7. The Guitar
8. The Fluorescent Lamp
9. The Thermostat Control
10. The Lantern Projector
11. The Magnetic Tape Recorder
12. The Aspirator
13. The Carburetor
14. The Diffusion Pump

B. State University of New York at Binghamton
Binghamton, New York
Co-directors: Carl Stannard and Bruce Marsh

1. The Electric-eye Control
2. The Solenoid
3. Electro-mechanical Switches and Relays
4. Automobile Collisions
5. The Cathode Ray Tube
6. The Stroboscope
7. The Toaster
8. The Strain Gauge
9. Galvanometers, Ammeters, and Voltmeters
10. The Electric Motor
11. The Alternator-Generator
12. Floats and Loads
13. The Mechanical Vacuum Pump

TABLE I (Continued)

C. Technical Education Research Center
Cambridge, Massachusetts
Co-directors: Nathaniel Frank and Ernest Klema

1. The Gyroscope
2. Passive and Active Amplifiers
3. The Hydraulic Amplifier
4. Noise in Electronic Devices (Diodes, Resistors, Transistors)
5. The Recording Potentiometer
6. The Transistor Heat Sink
7. The Thermoelectric Cooling Device
8. The Water-cooled Heat Exchanger
9. Resonance Devices (Pendulum, Mass on a Spring, LC Circuit)
10. The Spectrophotometer
11. The Interferometer
12. Solid State Detectors
13. Spectral Sources
14. The Compressor Refrigerator

D. Oak Ridge Associated Universities
Oak Ridge, Tennessee
Director: Lawrence Akers

1. The Gamma Ray Spectrometer
2. The X-ray Tube
3. The Geiger-Mueller Counter
4. The Ion Chamber
5. The Cloud Chamber
6. Gauges (Depth Gauge, Beta Thickness Gauge, Metal Wall Thickness Gauge, Liquid Level Gauge)
7. The Sub-surface Soil Moisture Gauge
8. The Treatment of Data
9. The Van de Graaff Generator

6. a resource document for the instructor, elaborating on the system, the physics, multi-media aids, and industrial applications.

The behavioral objectives could be in a form like that suggested by Mager (14). The definition of a behavioral objective according to Mager is:

1. A statement of instructional objective is a collection of words or symbols describing one of your educational intents.

2. An objective will communicate your intent to the degree you have described what the learner will be DOING when demonstrating his achievement and how you will know when he is doing it.

3. To describe terminal behavior (what the learner will be DOING):

   a. Identify and name the over-all behavior set.

   b. Define the important conditions under which the behavior is to occur (givens, restrictions, or both).

   c. Define the criterion of acceptable performance.

The materials are being produced in modular form to increase the flexibility available to designers of technical physics courses. Modules having variety in topics, styles, and levels are to be produced. Variety in the choice of topic and level of treatment among the modules will make it possible for an instructor to assemble a course appropriate to the interests and abilities of his students, technical programs offered at his institution, and the needs of his community and industry (15).

The American Institute of Physics (AIP) is the coordinator for the materials development project aimed at providing a better physics course for prospective technicians who study at community colleges, technical institutes, and universities which offer four-year technology programs. Additional information on the Tech Physics Project can be obtained from A. A. Strassenburg, AIP, SUNY-Stony Brook, Stony Brook, New York.

The Technical Education Research Centers (TERC) operate the year round and work on several different projects simultaneously of which the

Tech Physics Project is only one. Modules of a different type than the Tech Physics modules are being prepared and tested at the Southwest Center of TERC and Texas State Technical Institute in Waco, Texas. Some of these modules include the Basic Machine Series, Work Series, and Energy Series. Each module consists of objectives, pre-test, post-test, and learning frames with problems and quizzes. These modules would probably not be suitable for engineering technology students since they are not of the "hands-on" type of instruction.

Principal Problem Approach

Wentworth Institute developed the Principal Problem Approach through a four-year program in curriculum development in the area of engineering technology. This program has resulted in the development of courses based on a group of problems in which classroom and laboratory work are brought together (16).

The major parts of the principal problems approach are:

1. Preliminary discussion - pertinent information, so that the student knows exactly how to proceed with the design problem;

2. References - references to relevant information in texts, manuals, and journals which will aid the student in his design work;

3. Laboratory procedure - the necessary guidance for maximum benefit, defining the direction toward the successful completion of the problem while eliciting from the student the application of knowledge previously gained; and

4. Concluding discussion - clarification and summary of vital points that need to be emphasized.

While the student is involved with a principal problem, his classwork, laboratory work, and homework assignments all focus on the solution to this problem.

The laboratory problems are carefully selected to possess the following characteristics:

1. They clearly set the goal for the student. This goal is to be constantly in sight, providing the setting for laboratory, classroom, and homework activities which will lead to a successful solution.

2. They elicit from the student an understanding of fundamental engineering principles. The student is made aware that he must apply his knowledge to the problem, thus pressing him beyond the stage of mere recall.

3. They follow a planned sequence, progressing from known principles into more complex situations.

Each laboratory course can be divided into one or more blocks of related problems, each dealing with a principal problem and a desired end result. Each block may consist of a number of parts or phases representing successive steps toward the final result. Students should usually be placed together in small groups (two or three students per group) in the performance of a laboratory problem in order to facilitate discussions of interpretations and applications. Using the principal problems approach the laboratory and the classroom are no longer separate but form a unified system of learning.

Six laboratory manuals using the principal problems approach have been prepared and published by Prentice-Hall, Inc. of New York City.

B.C.I.T. Physics Laboratory Projects

The British Columbia Institute of Technology has instituted a laboratory program for presenting physics to students in various technologies (17). The period from September to the end of February is used for traditional physics laboratory experiments while the last three months of the year are used for specialized laboratory projects. These projects consist of 6 to 9 hours of laboratory work spread over two or three weeks. Four or five projects can be completed by each student during the last three months of physics laboratory.

The laboratory is designed with the following objectives:

1. to give the students a detailed introduction to report writing, laboratory procedures, and basic measuring techniques;

2. to give students some background in certain physics topics; and

3. to introduce the students to certain topics of special importance to their own technology, using laboratory projects.

Although these objectives are for technical students in general, this type of laboratory experience can be adapted for specific use by each of the various engineering technologies.

Conceptually, only one lecture course is given and the laboratory part of the physics course is tailored to the various technologies. This approach can be very effective in providing for special topics without sacrificing the over-all benefit derived from a general first year physics laboratory course.

Summary

The major development in physics instruction for engineering technology students is the Tech Physics Project using a modular form of instruction. The emphasis is on the use of a "hands-on" approach. The instruction is centered around some aspect of technology. The objective of a module is not to develop the technology of a device, however, but to uncover the physics involved. The Principal Problem Approach and the B.C.I.T. Physics Laboratory Projects are basically designed for technology students in general, but each can be adapted for engineering technology students in particular. The Principal Problem Approach focuses all classwork, laboratory work, and homework on a carefully selected principal problem. The B.C.I.T. Physics Laboratory Projects offer 6 months of traditional physics laboratory experiments but also offer 3 months devoted to specialized laboratory projects. The professional literature with which both technicians and physics educators are familiar provides little information of other developments in the area of physics instruction for engineering technology students.

CHAPTER III

RESEARCH DESIGN

Basic Plan of Study

In order to assist in the determination of the most appropriate manner of handling the sudden influx of engineering technology students into the existing university physics courses at Oklahoma State University, this study was undertaken to assemble knowledge about existing programs of physics instruction for engineering technology students and newly developing programs for these students.

A search of the professional literature was undertaken to discover major developments in teaching physics to engineering technology students and furnish the names of persons directly involved in the development of physics instruction programs and materials. Correspondence with these persons included a request for details of their programs and the reasons for pursuing these developments with regard to the specific interests and abilities of engineering technology students. They were also asked to provide any information of which they were aware concerning other significant developments in the area of physics instruction for engineering technology students.

A questionnaire was developed in order to survey a sample of institutions with engineering technology programs. Topics included in the questionnaire were details of current physics instruction, the rationale behind that instruction, an inquiry into the type of physics instruction which should be offered, the rationale behind that form of instruction, and a request for information concerning newly developing physics programs and the direction of physics instruction for engineering technology students in the future. The most important features of the "more successful" programs were identified and the rationale behind them was investigated. Questionnaires were sent to representative institutions with two-year and four-year engineering technology programs. Physics instructors and technical school administrators were surveyed in order to determine their views concerning the ideal physics instruction for engineering technology students.

This study is intended to be in part a resource book for both physics instructors and technical school personnel who are interested in physics instruction for technical students, and specifically, engineering technology students.

Methodology

An extensive search of the professional literature was conducted in order to obtain information concerning characteristics of students in technical curriculums and physics instruction for engineering technology students. Those journals included in the survey of the literature are listed in Table II. The literature survey extended from 1960 to the present.

A questionnaire was constructed in order to determine the details of current physics instruction at other institutions, the rationale behind that instruction, the views of physics instructors and technical school administrators concerning an ideal physics instructional program, and the existence or development of new and innovative physics instruc-

TABLE II

PROFESSIONAL LITERATURE SURVEYED

Applied Physics Letters
American Journal of Physics
Educational Newsletter
Engineering Education
Industrial Arts and Vocational Education
Journal of Applied Physics
Journal of Chem. Education
Journal of Engineering Education
Physics Bulletin
Physics Education
Physics Today
School Science and Math
Science
Science Education
Science Education News
Scientific American
Technical Education News
Technology Review
The Physics Teacher

tional programs for engineering technology students. A rough copy of the questionnaire was sent to selected leaders in the physics and engineering technology fields. Among those who critically analyzed the questionnaire and made valuable suggestions are; Dr. Arnold A. Strassenburg, Director, MANPOWER AND TRAINING, American Institute of Physics, New York City, New York; Professor Herman W. Pollack, Physical Sciences Division, Orange County Community College, Middleton, New York; Dr. Norman C. Harris, Professor of Technical Education, The University of Michigan, Ann Arbor, Michigan; and Dr. Alexander Avtgis, Wentworth Institute, Boston, Massachusetts.

After revising the questionnaire several times, it was finally prepared in the form shown in Appendix A.

The questionnaire was constructed such that there were five distinct parts. The first part of the questionnaire was for the purpose of determining the details of current physics instruction for engineering technology students. Part two of the questionnaire was for the purpose of determining why the current type of physics instruction is used as opposed to some other form of instruction. The third part of the questionnaire attempted to determine what each educator thought should be the type of physics instruction appropriate for engineering technology students. Part four of the questionnaire inquired into the rationale behind the type of physics instruction which each educator believed should be offered. Finally, part five of the questionnaire allowed each educator to discuss his ideas about the technical student, changes needed in physics instruction, and his knowledge of any innovative programs of physics instruction for engineering technology students.

Questionnaires were sent to all institutions with at least one professionally accredited engineering technology program (18). The list of institutions having such accredited technology programs is given in Appendix B. The institutions having a professionally accredited engineering technology program include eight 2-year, university-affiliated institutions, eighteen 2-year, independent institutions, eight 4-year, university-affiliated institutions, and five 4-year, independent institutions.

A questionnaire was sent to one physics instructor at each institution. A questionnaire was also sent to twenty selected technical school administrators representative of the various types of institutions. The questionnaires were sent out during September of 1972. During November of 1972 a second copy of the questionnaire was sent to each of the educators who had not responded to the first.

Summary

Three basic methods were utilized in order to determine the status of physics instruction for engineering technology students. These methods included a search of the professional literature, direct correspondence with knowledgeable educators, and a survey questionnaire. The purpose of the questionnaire was to determine details of current physics instruction and elicit the opinions of knowledgeable educators about the most appropriate type of physics instruction for engineering technology students.

CHAPTER IV

RESULTS

Literature Survey

Only one major development in the area of physics instruction for engineering technology students was discovered from the survey of the professional literature. That major program development is the Tech Physics Project using a modular format and the "hands-on" approach. The Principal Problem Approach and the B.C.I.T. Physics Laboratory Projects are two other developments in physics instruction for technical students but no other development in physics instruction for engineering technology students has received as much attention as the Tech Physics Project.

Questionnaire Response

The questionnaire concerning physics instruction at the 52 institutions having a professionally accredited engineering technology program was completed and returned by physics instructors from eight 2-year, university-affiliated institutions, eight 4-year, university-affiliated institutions, eighteen 2-year, independent institutions, and five 4-year, independent institutions. The physics instructors surveyed returned 39 questionnaires out of the possible 52 giving a 75% return. The twenty technical school administrators representative of all the types of institutions returned 13 of the questionnaires for a 65% return. Thus, the return of questionnaires by both the physics instructors and technical school administrators was approximately 72%. The results of the questionnaires returned by the physics instructors are shown in Appendix C. The questionnaires returned by the technical school administrators are summarized in Appendix D.

Status of Current Physics Instruction

The first part of the questionnaire concerned the status of current physics instruction. With regard to the student population, the average size of the physics classes at the surveyed institutions is usually between 20 and 30 students. The number of physics students per class at the surveyed institutions is shown in Figure 1. While most physics classes have between 20 and 30 students, seven of the institutions reported having physics classes with more than forty students. More than three-fourths of the institutions have physics classes consisting of 81% to 100% engineering technology students. Most of the institutions with at least one professionally accredited engineering technology program offer physics instruction specifically for engineering technology students.

The per cent of institutions surveyed having particular engineering technology students in the physics instruction is shown in Figure 2. Within the physics classes the engineering technologies in decreasing order of representation are mechanical, electrical, electronic, civil, chemical, construction, architecture and design, nuclear, and environmental technology.

The number of semester hours of physics instruction required for most engineering technology programs varies from three to more than ten, but is usually seven or eight semester credit hours. The number of

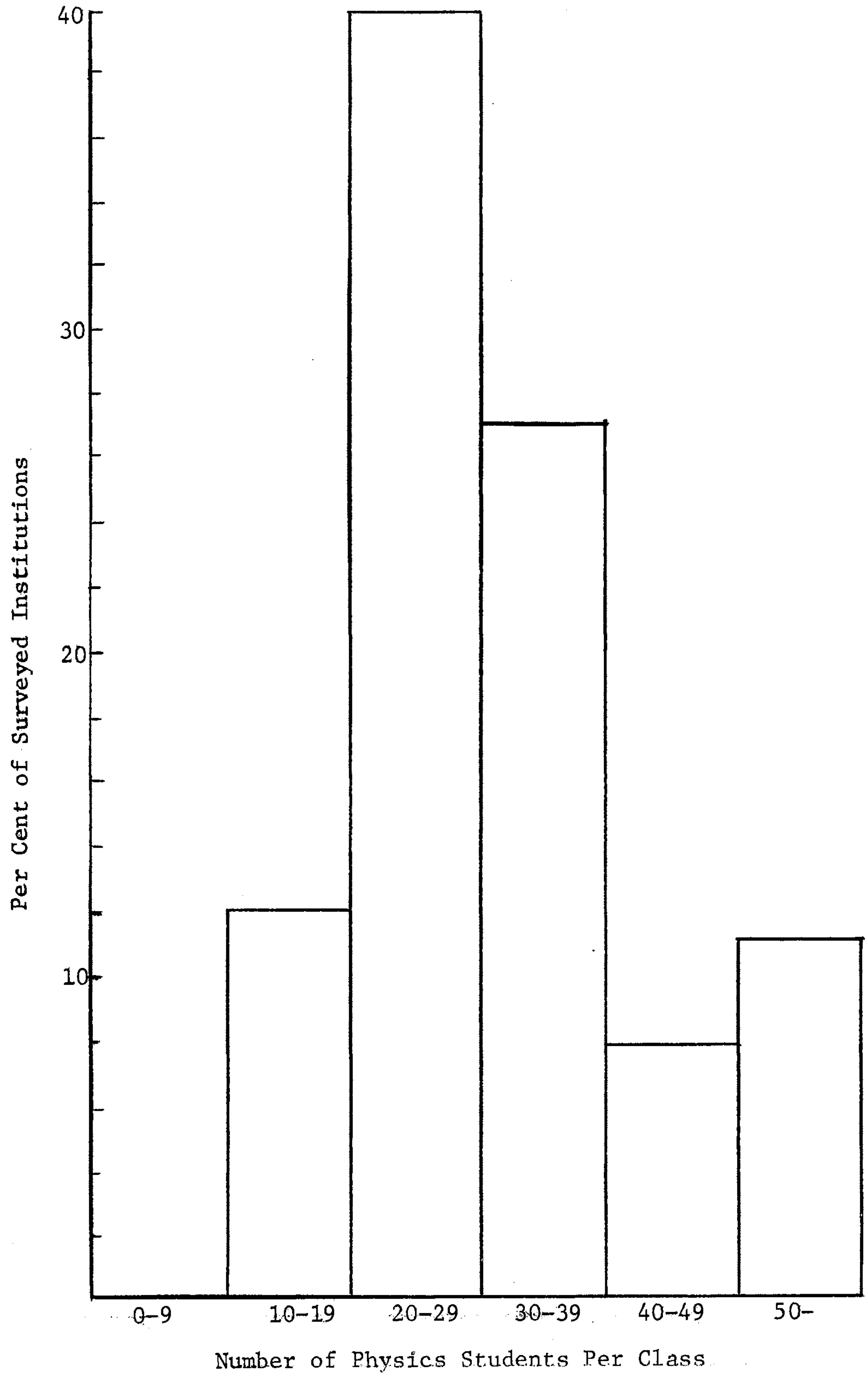

Figure 1. Per Cent of Surveyed Institutions Reporting Particular Physics Class Sizes

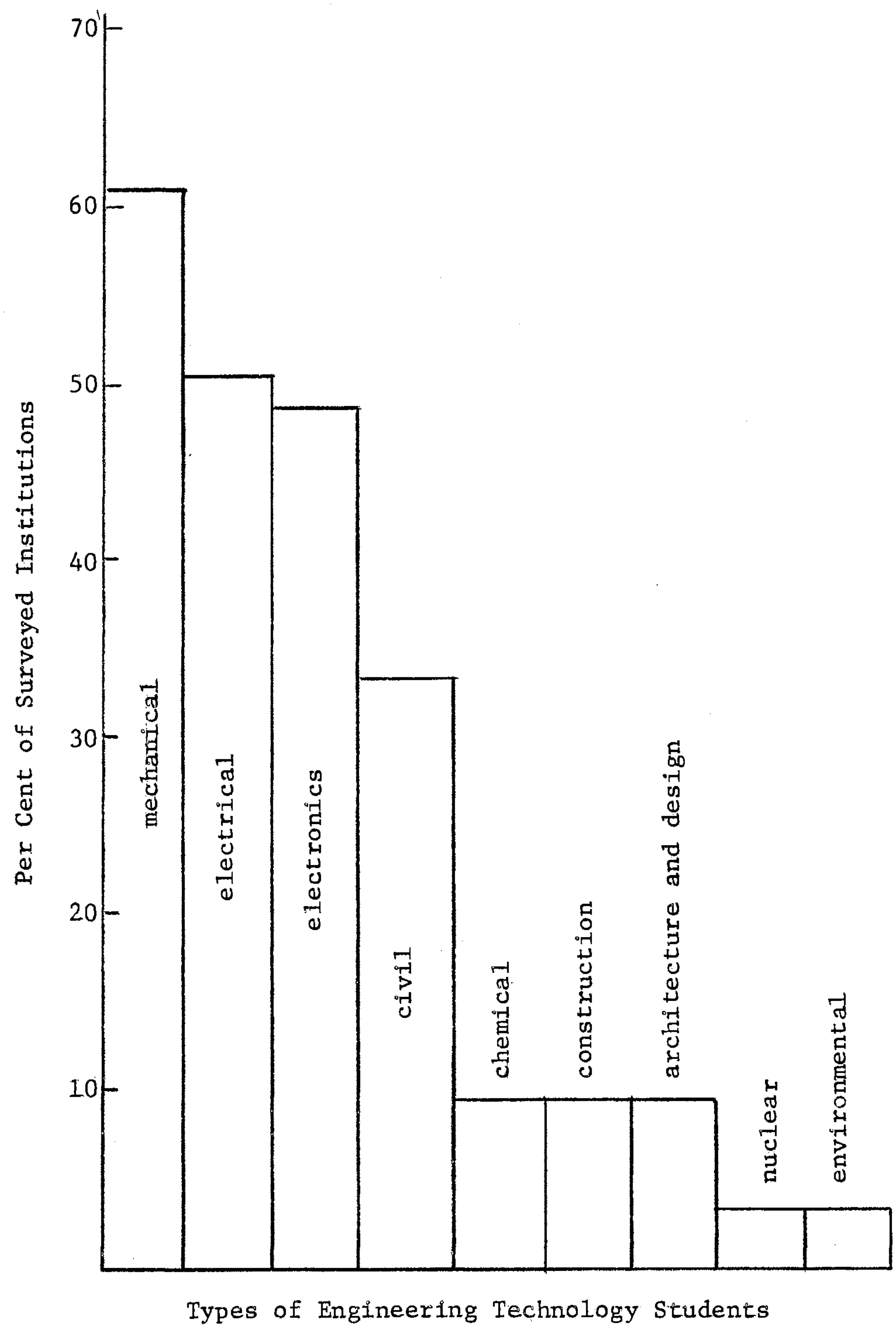

Figure 2. Per Cent of Surveyed Institutions Having Particular Engineering Technology Students in Physics Instruction

semester hours of physics instruction required at the surveyed institutions for most engineering technologies is shown in Figure 3. All engineering technology programs require at least 3 or 4 hours of physics instruction and 5% of the programs require more than ten semester hours.

By far the predominant teaching approach used in physics classroom instruction is the lecture method supplemented by problem-solving. About 85% of the physics instructors surveyed listed the lecture as the main teaching method they employed in the classroom. Most of the physics instructors appear to believe that the lecture is the most appropriate teaching approach for the number of engineering technology students involved in the study of physics. The large number of students in some physics classes may necessitate the lecture method, but many physics instructors having classes with less than 30 students also use the lecture method of teaching. Only one physics instructor used individually paced instruction as the primary means of teaching physics.

Only about a third of the physics programs make any special provisions for differential learning rates among students. Also, only about a third of the physics instructors make use of behavioral objectives in their physics instruction. While 42% of the physics instructors in the associate degree programs use behavioral objectives, only 18% of the physics instructors in the 4-year programs use them.

The evaluation techniques used in the physics classroom are, in decreasing order of use, written examinations, written reports, extra-class problem sets, and oral examinations. Written exams are used about three times more often than written reports or problem sets. Only two physics instructors among those surveyed use oral exams as part of the evaluation of physics students. About half of the physics instructors

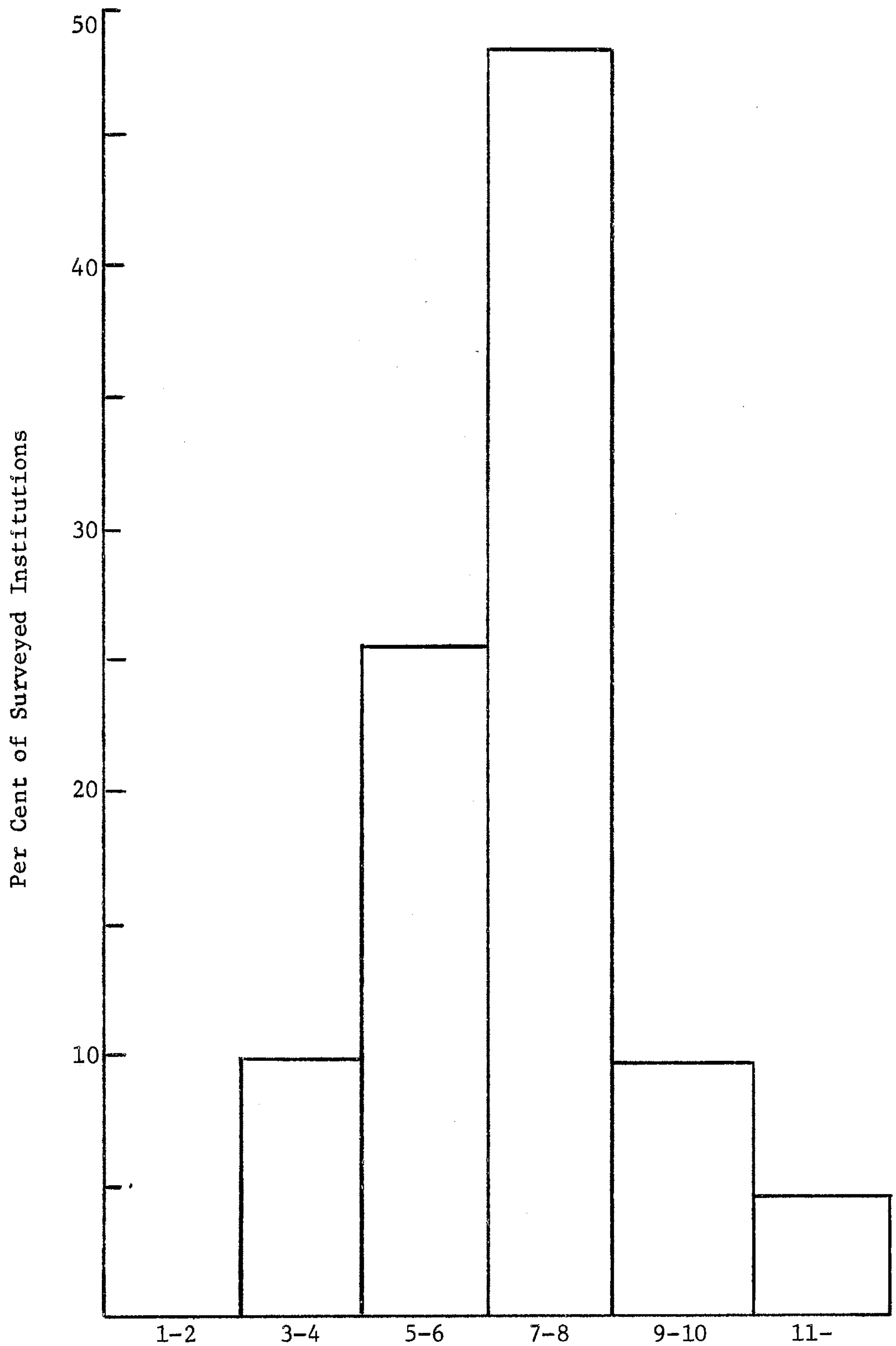

Figure 3. Number of Semester Hours of Physics Instruction Required for Most Engineering Technology Programs

design exams to stress theory and applications equally. The remaining physics instructors design exams to stress applications as opposed to theory. Only one instructor favored stressing theory as opposed to applications on examinations.

Approximately three-fourths of the physics programs have a discussion or problem session associated with the physics instruction. All institutions have some form of laboratory experience associated with the physics instruction. However, at one institution the physics laboratory is an elective course.

While the length of the physics classroom period is almost always 50 minutes, the length of the laboratory period is either two or three hours. Twenty one of the institutions surveyed have a two hour lab while seventeen of the institutions have a three hour lab. The laboratory material and the lecture material are reported as closely coordinated in all physics programs except one.

Three fourths of the physics instructors use prescribed experiments from a traditional physics lab manual. About one fourth of the instructors use prescribed experiments from their own lab manual while only two instructors use independent experiments or projects. Thirty seven of the thirty nine instructors surveyed require written reports for evaluation of the laboratory experience while nine instructors use written exams and two instructors use oral examinations. Oral reports and term projects are not used by any of the instructors as part of the evaluation technique in the physics labs. Those instructors who make use of written exams in the laboratory usually utilize exams which stress theory and applications equally.

The distribution of total physics instructional time for certain areas of physics is shown in Figure 4. There is an emphasis on mechanics and electricity in the physics courses in accordance with the predominant representation of mechanical engineering technology students and electrical engineering technology students.

The most commonly used textbooks for physics instruction for engineering technology students are those written by Smith & Cooper, Joseph, and Beiser (see Table III). There is no predominately used text for physics instruction. Each of these texts is used as much as either of the other two. A list of the physics textbooks used for physics instruction in engineering technology programs is given in Table III.

Engineering technology students usually begin physics instruction during the first semester or quarter of study. About 62% of the students begin physics instruction during the first semester or quarter, 23% begin in the second semester or quarter, 13% begin in the third semester or quarter, and 2% begin during the fourth semester or quarter. No students begin physics instruction later than the fourth semester or quarter.

Only about one fourth of the surveyed institutions require high school physics as a prerequisite for beginning physics instruction in engineering technology programs. More associate degree programs require high school physics as a prerequisite than do the 4-year engineering technology programs. One year of high school algebra is a prerequisite at 46% of the surveyed institutions while 31% list two years of high school algebra as a prerequisite. High school trigonometry is listed by 41% of the institutions as a prerequisite for physics instruction. Among other prerequisites are geometry, physical science, and technical mathematics. About 20% of the institutions list college algebra as a coreq-

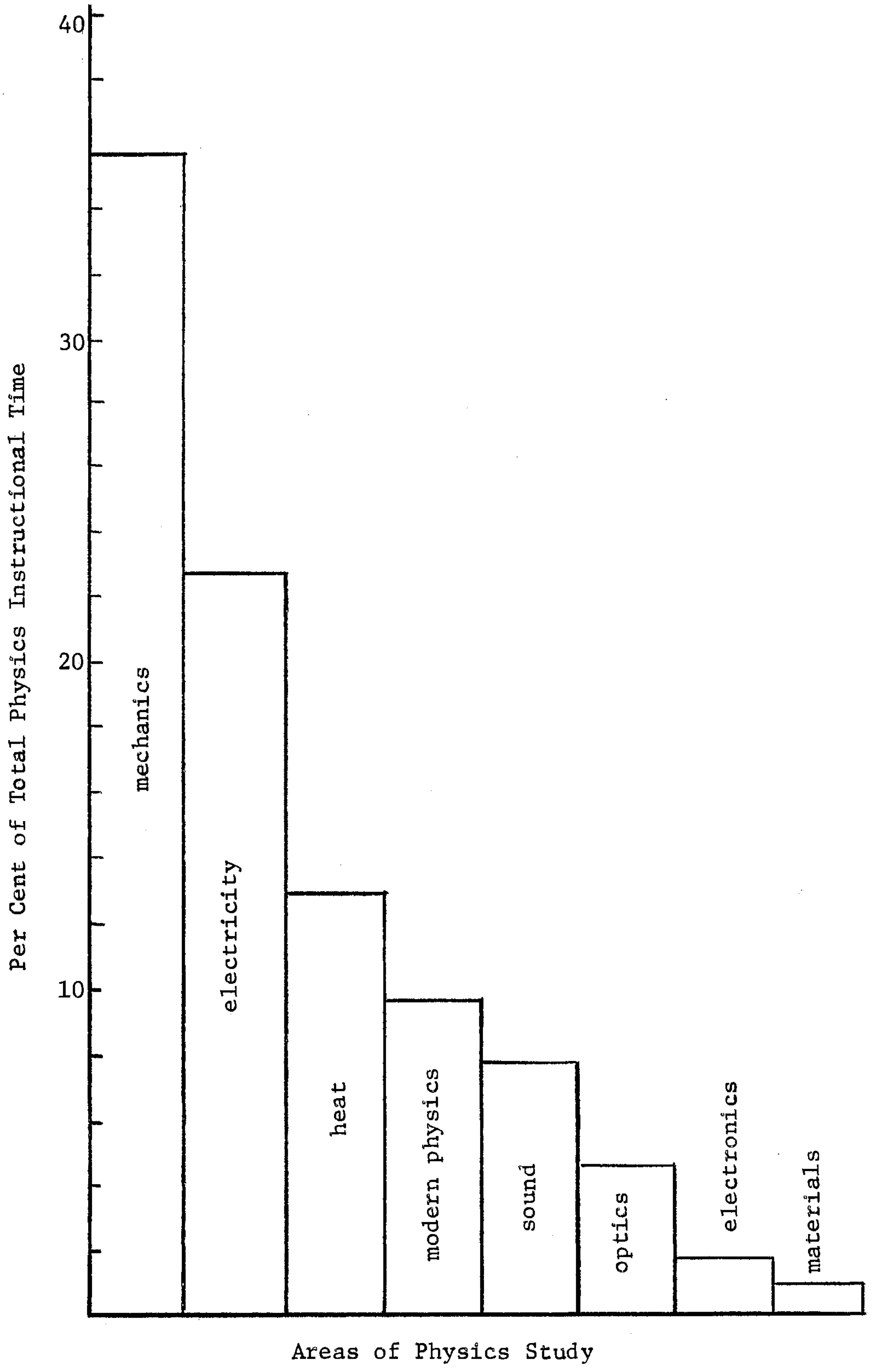

Figure 4. Present Appropriation of Total Physics Instructional Time

TABLE III

TEXTBOOKS USED FOR PHYSICS INSTRUCTION
IN ENGINEERING TECHNOLOGY PROGRAMS

Beiser, Arthur Basic Concepts of Physics, 1972 (Addison Wesley)
Beiser, Arthur Modern Technical Physics, 1966 (Addison Wesley)
Blackwood, Oswald H., Kelley, William C. and Bell, Raymond M., General Physics, 1973 (John Wiley and Sons, Inc.)
Bueche, Frederick Introduction to Physics for Scientists and Engineers 1969 (McGraw-Hill).
Harris, Norman C. and Hemmerling, Edwin, M. Introductory Applied Physics, 1963 (McGraw-Hill)
Joseph, Alexander, et. al. Physics for Engineering Technology, 1966 (John Wiley and Sons, Inc.)
Miller, Franklin, Jr. College Physics, 1967 (Harcourt Brace Jovanovich, Inc.)
Morgan, Joseph Introduction to University Physics, 1969 (Allyn and Bacon)
Richards, James A., Sears, Francis W., Wehr, and Zemansky, Mark W. Modern College Physics, 1962 (Addison Wesley)
Sears, Francis W. and Zemansky, Mark W. College Physics, 1960 (Addison Wesley)
Sears, Francis W. and Zemansky, Mark W. University Physics, 1970 (Addison Wesley)
Semat, Henry Fundamentals of Physics, 1966 (Holt, Rinehart and Winston)
Shortley, George and Williams, Dudley Elements of Physics, 1971 (Prentice-Hall)
Smith, Alpheus W. and Cooper, John N. Elements of Physics, 1964 (McGraw-Hill)
Weber, Robert L., Manning, Kenneth V. and White, Marsh W. College Physics, 1965 (McGraw-Hill.

uisite and 15% of the institutions list college level trigonometry as a corequisite.

At 74% of the institutions surveyed the physics instruction is the responsibility of members of the physics department. While about 85% of the physics instructors of engineering technology students are members of a physics department at 4-year institutions, only 70% are members of a physics department at 2-year institutions. At 18% of the institutions the physics instructors are members of technical institute departments. The remaining physics instructors are members of a science department or engineering department.

Two-thirds of the physics instructors consider physics instruction for engineering technology students to be preparation for specialized training while one third believe it to be a part of general education. Ten per cent of the physics programs emphasize the acquisition of detailed knowledge while 15% emphasize the development of general concepts. The remaining programs emphasize both acquisition of detailed knowledge and development of general concepts equally.

About 38% of the physics instructors state that the total physics instruction for engineering technology students at their institution is oriented toward practical applications. The remaining 62% state that both theoretical concepts and practical applications are emphasized with about 55% of the time devoted to theoretical concepts and 45% of the time devoted to practical applications. The independent institutions place emphasis on practical applications of theoretical concepts while the university-affiliated institutions emphasize theoretical concepts in their physics instruction.

Instructors' Opinion of Most Appropriate Physics Instruction

The physics instructors responding to the survey described the type of physics instruction they though would best meet the needs and interests of engineering technology students. The physics instructors list problem-solving methods as the most suitable teaching approach for teaching physics to engineering technology students. Twenty-two of the physics instructors list problem-solving as the most appropriate teaching method while 13 list individually paced instruction and 12 list the lecture method. Although problem-solving methods are most favored by physics instructors at 2-year institutions, individually paced instruction is favored by instructors at 4-year institutions. One physics instructor thought that the major teaching method for engineering technology students should be animated "Disney-type" movies about topics in physics. Although 85% of the physics instructors presently use the lecture as the major teaching approach, only 31% believe it to be the most appropriate teaching method for teaching physics to engineering technology students. While 13 instructors believe individually paced instruction is the best teaching strategy for engineering technology students, only one instructor is presently using this method.

The physics instructors surveyed think that the total physics instructional time should ideally be appropriated as shown in Figure 5. Comparison with Figure 4 reveals that the instructors feel less instructional time should be devoted to mechanics than presently is the case and more time should be devoted to the study of heat, light, and sound.

A majority of the physics instructors who responded to the questionnaire do not think behavioral objectives should be used extensively in

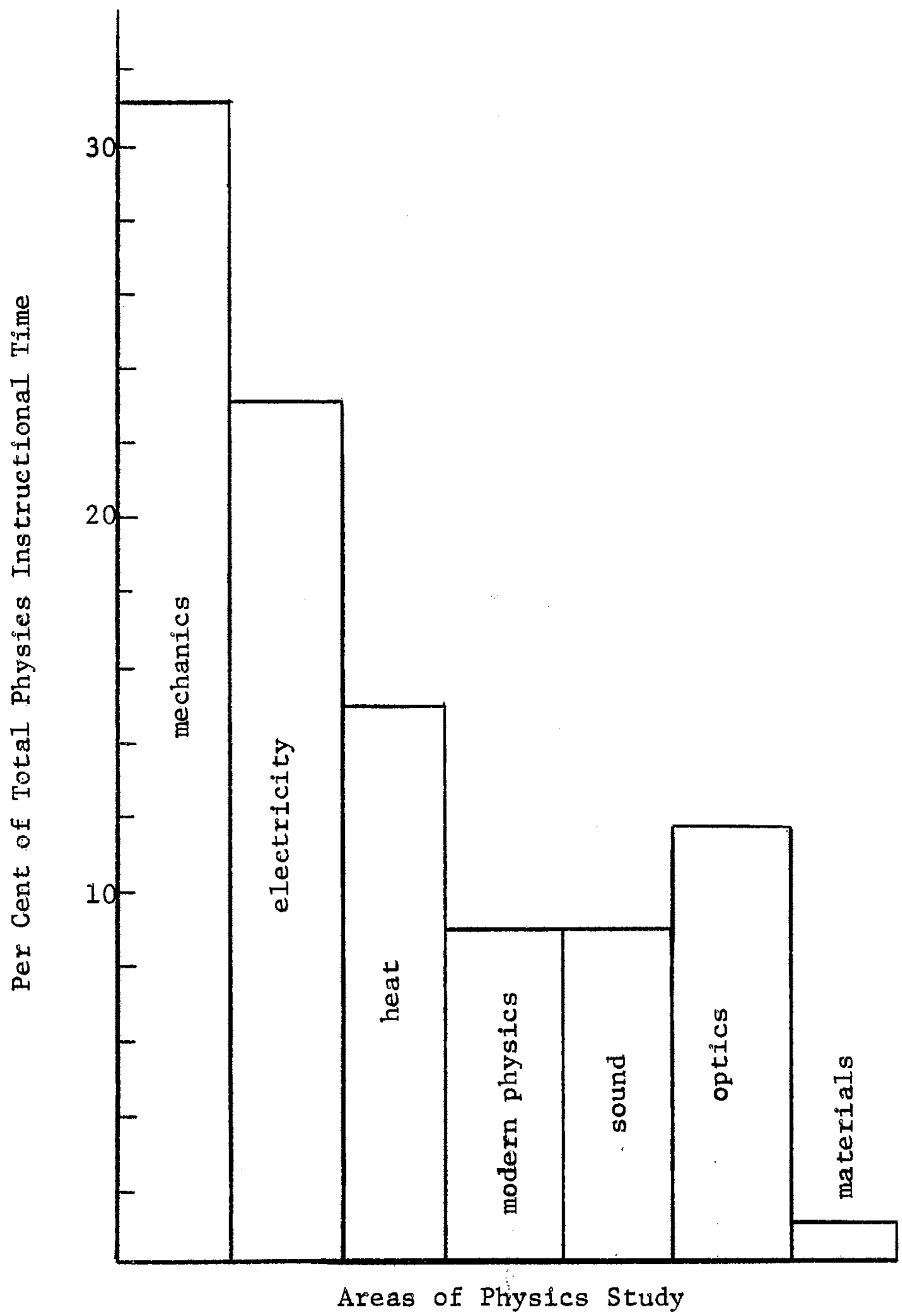

Figure 5. Physics Instructors' Opinion of Ideal Appropriation of Total Physics Instructional Time

physics instruction. Some of the instructors had no knowledge of behavioral objectives. Only a third of the physics instructors actually use behavioral objectives in their physics instruction. The instructors of physics at the university-affiliated institutions do not favor the use of behavioral objectives while the instructors at the independent institutions believe behavioral objectives should be used extensively.

Approximately 90% of the physics instructors indicated that special provisions should be made for differential learning rates among students although only one third now make any special provisions. Individually paced instruction is the major alternative which can make provisions for differential learning rates.

Twelve of the thirty nine physics instructors responding to the questionnaire indicated that a change in the length of the class period would be necessary in order to provide the type of physics instruction which they considered most appropriate for engineering technology students.

A large majority of the physics instructors believe a laboratory experience oriented toward applications should be associated with the physics instruction as is now the case. A large majority also think that a formal written report should be required in the laboratory experience and the classroom material and laboratory material should be closely coordinated. There were five instructors, however, who did not believe a formal written report should be necessary in the laboratory.

Eighteen of thirty nine instructors think that physics should be considered as part of general education and also as preparation for specialized training. But, thirteen instructors indicated that physics should be considered primarily as preparation for specialized training while seven instructors believe that physics should be considered primarily as part of general education. While 38% of the physics instructors at 4-year institutions believe that physics should be considered part of general education, only 8% of the instructors at 2-year institutions agree. While 23% of the instructors at independent institutions believe physics instruction should be considered part of general education, 59% of the instructors at university-affiliated institution believe this to be the case. The instructor at a 2-year, independent institution is most likely to hold the opinion that physics instruction for engineering technology students should be preparation for specialized training.

About 60% of the physics instructors believe that both theoretical concepts and practical applications should be part of physics instruction for engineering technology students. They believe the balance between them should be approximately 46% theoretical concepts and 54% practical applications. This is just the opposite balance that the instructors stated was the basis of current physics instruction. About 35% of the instructors believe physics instruction should be primarily oriented toward practical applications and 5% of the instructors believe theoretical concepts should be of primary concern.

Three fourths of the physics instructors believe that both detailed knowledge and general concepts should be the basis for physics instruction. They suggest a balance of 53% detailed knowledge and 47% general concepts. However, about 20% of the instructors think the instruction should be based on general concepts and only one instructor thought detailed knowledge should be the primary emphasis of the physics course. The physics instructors believe more physics instruction should be based on general concepts and less on detailed knowledge than is now the case.

Most of the physics instructors are of the opinion that the majority of engineering technology students cannot adequately extrapolate from general concepts to specific applications. However, about half of the instructors believe that these students can adequately form general concepts from specific applications. Although 64% of the instructors at 2-year institutions believe the majority of engineering technology students can adequately extrapolate from general concepts to specific applications only 28% of the instructors at 4-year institutions agree. Also, while 73% of the instructors from 2-year institutions believe the majority of engineering technology students can adequately form general concepts from specific applications, only 42% of the instructors from 4-year institutions agree. The instructors at 4-year institutions are more skeptical of the cognitive ability of engineering technology students than the instructors at the 2-year institutions.

Three fourths of the physics instructors surveyed believe that the engineering technology student should be offered a different type of physics program than that which is offered in the traditional liberal arts program or university program. However, the remaining one fourth of the instructors find no need to offer engineering technology students a unique physics program tailored to their own needs and interests.

Very few of the physics instructors reported any major changes in physics instruction for engineering technology students over the last five years. Those changes that were listed included changing texts, more hours of instruction, more modern physics material, and more emphasis on applications.

Only one third of the surveyed institutions are planning any significant changes in physics instruction in the near future. Those changes that are being planned include video tape problem solutions, addition of more applied laboratory activity, addition of modern physics, and the use of self-pacing physics modules. Only one institution was planning to use self-pacing physics modules in the near future although this is the major new development in physics instruction for engineering technology students.

Twenty nine of the thirty nine physics instructors stated that adequate physics resources were already available to meet the needs and interests of engineering technology students. Even if the physics instructors were given adequate time and other resources to develop any type of physics program they wanted, most of the instructors implied that they were satisfied with their present program of physics instruction.

Administrator's Opinion of Most Appropriate Physics Instruction

The technical school administrators believe that the distribution of the total physics instructional time should be as shown in Figure 6. The administrators generally agree with the physics instructors concerning the percentage of instructional time appropriated to various areas of physics study. The largest difference of opinion concerns modern physics. The physics instructors believe 9% of the instructional time should be devoted to modern physics while the administrators believe only 5% of the time should be devoted to this topic.

The administrators surveyed held a different opinion than the physics instructors regarding the use of behavioral objectives. While only 16 of 35 instructors believe that behavioral objectives should be

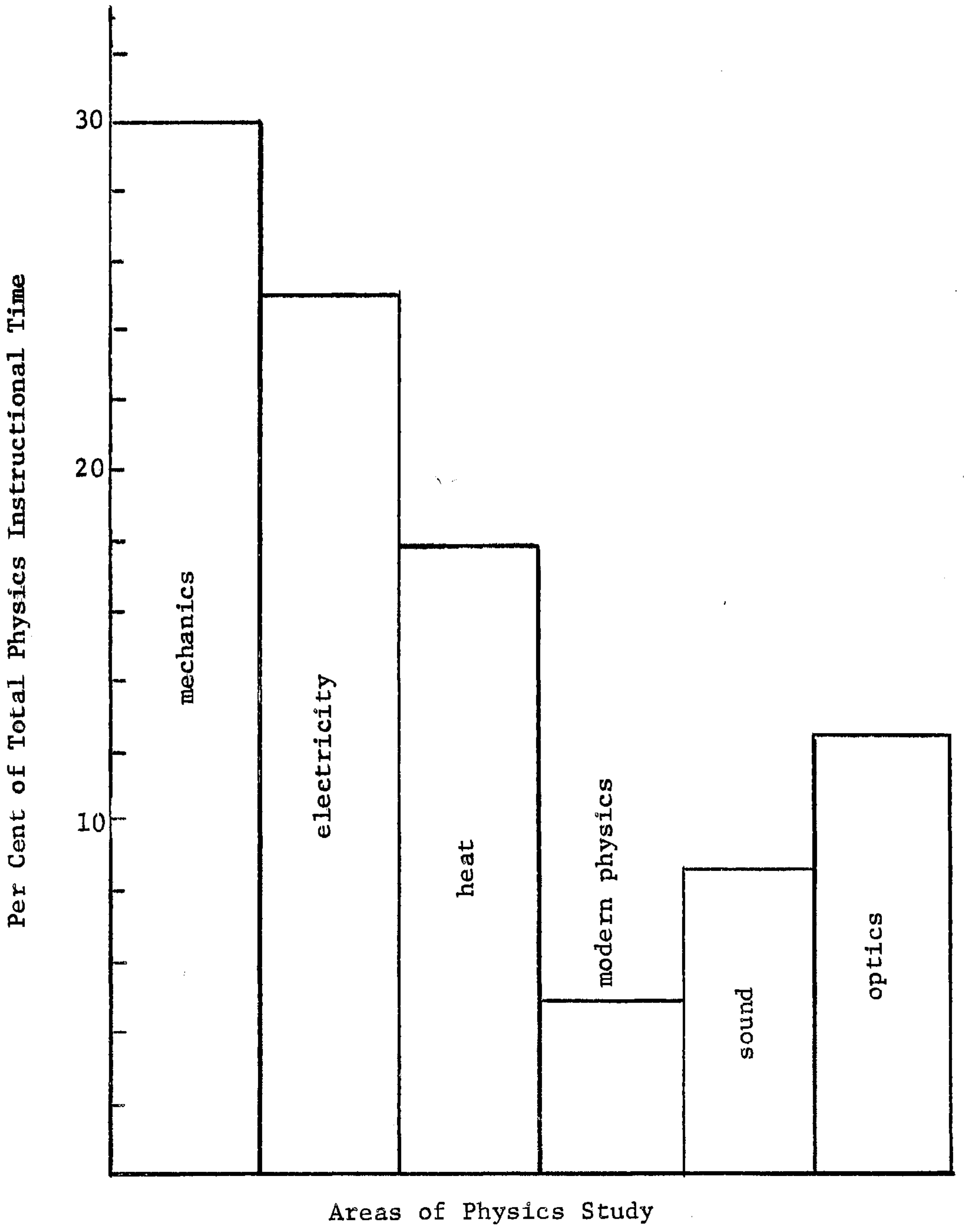

Figure 6. Technical School Administrators' Opinion of Ideal Appropriation of Total Physics Instructional Time

used extensively in physics instruction, 11 out of 12 administrators believe they should be used.

Two thirds of the administrators do not think a change in the length of the class period would be necessary to provide an appropriate form of physics instruction to engineering technology students while half of the instructors did think there should be a change in the length of the class period.

While most of the physics instructors believe that the majority of engineering technology students cannot adequately extrapolate from general concepts to specific applications, 60% of the administrators believe these students can extrapolate adequately. Both the administrators and the instructors are evenly divided over whether the majority of engineering technology students can adequately form general concepts from specific applications.

About 65% of the administrators and 80% of the physics instructors believe that adequate physics resources to meet the needs and interests of engineering technology students now exist. Neither the administrators nor the physics instructors believe there is a need to develop innovative physics programs for the engineering technology students.

The administrators of the technical programs would change the physics instruction by having more physics instruction, hire "effective" instructors, use self-pacing physics instruction, open labs, industrial applications labs, and a unified physics approach.

There is general agreement among the administrators and physics instructors concerning the appropriate type of teaching approach in the classroom. Both consider problem-solving methods most important with the lecture and individually paced instruction having less but equal importance. There is also close agreement about making provisions for differential learning rates among students and having an associated laboratory experience with the classroom instruction.

General agreement also exists between the administrators and instructors regarding the rationale behind the type of physics instruction offered to engineering technology students. Each believes physics should be considered both as part of general education and as preparation for specialized training but with the emphasis on specialized training. Both groups also believe the physics instruction should be concerned with theoretical concepts but emphasize more practical applications of those theoretical concepts. Finally, both groups believe that the physics instruction should be based on the acquisition of detailed knowledge and also the development of general concepts but with the emphasis on detailed knowledge.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Due to the rapid expansion of engineering technology programs in the last decade there has been little opportunity for educators to study the type of physics instruction available for these types of students. This study was undertaken to study the physics programs presently available for the engineering technology student and the types of innovative physics programs now being considered for future use. A search of the professional literature, direct correspondence with leaders in the field, and a survey questionnaire were the principal means of gathering information concerning physics instruction for engineering technology students.

The results of the search of the professional literature could be indicative of an attitude of unconcern among many educators regarding the teaching of physics to engineering technology students and technology students in general. Except for the national Tech Physics Project of developing a modular form of instruction, there are really no other developments of significant stature going on or being published in the professional literature.

The survey questionnaire which was sent to physics instructors and technical school administrators at 52 institutions having at least one professionally accredited engineering technology program clarified the type of physics instruction presently offered and the type of physics instruction which the instructors and administrators thought should be offered in the near future. A large majority of the surveyed institutions have physics classes which are predominantly engineering technology students and which are specifically intended for engineering technology students as opposed to other technology students or liberal arts students. The use of the lecture method of instruction and written examinations stressing applications seems to be the most common approach at the present time for teaching physics to engineering technology students. A laboratory experience is almost mandatory for engineering technology students in physics and there is general agreement that the "hands-on" approach is the best teaching approach for technology students.

When the physics instructors were asked what they believe to be the most appropriate method for teaching physics to engineering technology students, most of them chose to teach through a problem-solving approach rather than the lecture. Individually paced instruction was also considered to be an appropriate way of teaching physics even though only one instructor of all those surveyed was using this method at the time. There was no definite agreement concerning the role of physics instruction in the total education of engineering technology students. Some educators believe physics should be considered as preparation for specialized training and some believe physics should be considered as part of general education. The instructors also are moving toward the teaching of general concepts in physics and away from the teaching of detailed knowledge.

Most of the physics instructors believe that the engineering technology student should be offered a different type of physics program from that which is usually offered in the liberal arts program. Only a few of the institutions reported any major changes in the type of physics instruction offered to engineering technology students over the last five years, and only a third of the institutions are considering any significant changes in their physics instruction in the future. Only one institution is planning to use the self-pacing modules in the near future even though this is the most important development in physics instruction specifically developed for engineering technology students. In final consideration, there appeared to be little interest in developing or using innovative teaching methods for physics instruction in engineering technology programs. Most of the physics instructors are satisfied with their present program.

The administrators of technical education agree with the physics instructors concerning the type of physics instruction they considered most appropriate for engineering technology students. The administrators also believe that there now exists adequate physics instructional resources to meet the needs and interests of the engineering technology student. As with the physics instructors, there seems to be little interest among technical school administrators in developing or utilizing innovative approaches for teaching physics to engineering technology students.

Conclusions

Since a large percentage of the survey questionnaires were returned by the physics instructors and technical school administrators, the information from the questionnaire should give a representative description of current physics instruction for engineering technology students at various institutions. Also, the opinions of the instructors and administrators should give a representative idea of how physics instruction for these students will change in the future.

Physics remains a foundation course for engineering technology students as evidenced by the fact that most engineering technology students are required to take it during their first semester or quarter and almost no students begin physics instruction later than the third semester or quarter. The level of the introductory physics course is quite elementary since only one fourth of the surveyed institutions required high school physics as a prerequisite. The importance of physics instruction is also indicated by the large number of semester credit hours of instruction required in most engineering technology programs.

There is presently widespread use of the lecture method of instruction which may be due to class size, inadequate resources, or tradition. The laboratory experience is important in physics instruction as evidenced by the fact that it is required for almost all engineering technologies. However, the fact that even one institution has no required laboratory experience associated with the physics instruction is somewhat surprising since it is invariably agreed that the "hands-on approach" is the most appropriate way to teach technical students.

There appears to be little opportunity for the engineering technology student to do independent experiments or projects since a large majority of the physics programs utilize prescribed experiments from a manual. It may be well, however, to offer the engineering technology student some opportunities to do original work also. The engineering technician can make valuable suggestions to the engineer relating to the practical aspects of the engineer's work. The engineering technician should be more than a robot trained to perform definite functions. He should also be an individual with the ability to do some independent thinking.

The appropriation of total physics instructional time is such that mechanics and electricity receive the most emphasis which is appropriate since mechanics and electricity are the foundations of most engineering technology fields.

The general lack of provisions for differential learning rates among students indicates that a majority of the physics programs are not totally responsive to the needs and interests of the individual students. Thus, there are still areas for improvement in the physics program since educators generally agree that making provisions for differential learning rates should be one of the basic goals of every educational program.

Behavioral objectives are not used to any great extent in the current physics instructional programs due to the lack of knowledge of behavioral objectives, insufficient time or inclination to develop behavioral objectives, or the belief that instruction should not be limited or evaluated through the use of behavioral objectives. The most probable reason behavioral objectives are not used to any great extent is the large amount of time required to convert a traditional course to a course utilizing behavioral objectives. There still remain, however, many instructors who do not favor the use of behavioral objectives for other reasons. They argue that behavioral objectives are too limiting to the students and instructors since they leave no room for creative thinking on the part of the student and do not allow the instructor to deviate from the physics program.

Many of the present physics programs utilize traditional college or university physics texts. The use of physics texts written especially for technical students in general or engineering technology students in particular may be comparatively small due to the desire of the physics instructors for their programs to be considered equal in quality to that of the regular college or university. It may also be that the instructors do not believe textbooks different from the regular physics textbooks are necessary to teach physics to engineering technology students. Possibly, they may be waiting for a better physics text especially designed for technical students, that is, they may prefer the regular texts to the technical physics texts now available. Certainly, more physics texts designed especially for technology students should be organized and written in order to provide physics instructors with viable alternatives to the standard physics texts.

The written examination is the most widely used evaluation technique in the classroom since it provides a permanent, objective basis for evaluation. The current evaluation techniques emphasize applications more than theory and therefore it can be inferred that the physics programs are more oriented toward applications than theory since the evaluation should reflect the content of the coursework. Written reports are an appropriate evaluation technique in the laboratory since the ability to write a formal report is often required of engineering technology students going into employment in industry.

Quality physics programs for engineering technology students, as those in professionally accredited instititutions are assumed to be, should preferably be taught by physicists rather than technology personnel since three fourths of the physics instructors surveyed were members of a physics department. It seems only natural that physics instruction could best be taught by a member of a physics department, that is, an instructor whose primary interest and area of specialization is physics.

Presently, there is no definite agreement concerning the role of physics instruction in the education of engineering technology students, that is, whether physics for engineering technology students should be considered as part of general education or preparation for specialized training. The rationale or intent behind the instruction may have a definite effect on the total education of the student. Each institution should clearly define the intent and purpose of the physics courses for engineering technology students as well as for other students.

Important to the type of physics instruction offered to engineering technology students is the opinion of the physics instructors and technical school administrators concerning the cognitive abilities of these students. A majority of the physics instructors surveyed do not believe that these students can adequately extrapolate from general concepts to specific applications. However, a majority of the technical school administrators do believe that these students can adequately extrapolate from general concepts to specific applications. Both the physics instructors and the technical school administrators are evenly divided over whether the engineering technology students can adequately form general concepts from specific applications. Thus, since the physics instructors are closer to the actual educational process of these students and are more aware of student abilities in physics, the physics instruction should probably be designed such that the students work from specific applications to the formation of general concepts.

The physics instructors would change the instruction in the future by moving from the present widespread use of the lecture method to the use of problem-solving methods or individually paced instruction. This desire for a change in the method of instruction indicates a desire for a type of instruction which stresses actual application more and makes provisions for differential learning rates among students.

Half of the surveyed physics instructors believe that the length of the physics classroom period should be changed in order to offer a more appropriate form of physics instruction to engineering technology students. Perhaps the physics instructors are more aware of the problems and options available in teaching physics than the administrators and therefore recognize the limitations in attempting to develop or utilize new formats of physics instruction without changing the time limitations also. However, some of the physics instructors need to become more aware of the developments not only in physics, but also in education. Several of the physics instructors had never heard of behavioral objectives although the use of behavioral objectives began over a decade ago. Since the use and acceptance of behavioral objectives in education has become so widespread, it would be in the best interest of the students for the physics instructors to be aware of the contributions such developments in education can make to more effective teaching.

A more significant apparent contradiction is evident in the results of the questionnaire. Most physics instructors believe some change in the length of the classroom period would be necessary to offer the most appropriate physics instruction to engineering technology students and most of the instructors would change the method of instruction from the lecture method to problem-solving methods or individually paced instruction, yet most instructors profess satisfaction with their present instruction. When the instructors were asked what type of physics program they would like to see offered to engineering technology students if adequate time and resources were made available, most stated they were satisfied with their present program of instruction. Thus, either the physics instructors are by nature defending their teaching abilities and their physics programs or they do not believe it is worth the time and effort to develop or utilize a unique type of physics instruction specifically designed for engineering technology students.

The only difference of opinion between the physics instructors and technical school administrators concerning the most appropriate form of physics instruction is that the administrators do not believe the length of the classroom period would have to be changed in order to offer the most appropriate type of physics instruction. This difference of opinion may be due to the fact that the administrators are basically concerned about the difficulty of scheduling around varying lengths of class periods while the physics instructors are more concerned only with the actual content of a new type of physics program.

Both the physics instructors and the technical school administrators believe that the rationale behind the most appropriate type of physics instruction should be that (a) physics should be considered more as preparation for specialized training than general education, (b) the instruction should be more oriented toward practical applications than theoretical concepts, and (c) the instruction should be based equally on the acquisition of detailed knowledge and general concepts. At least there presently exists some concensus of opinion concerning the rationale behind the type of physics instruction that should be offered to engineering technology students in the future.

Some of the salient features of the "more successful" physics programs include the following: a laboratory closely coordinated with the classroom work, a problems or discussion session, utilization of the "hands-on" approach, the requirement of formal written reports in the laboratory, some provision for differential learning rates, use of a textbook nationally recognized for its content and approach, highly qualified and "effective" instructors who are members of a physics department, and various methods of evaluation to prevent students from being discriminated against for an inherent disability to perform on certain types of tests.

Although the development of modules for physics instruction seems to be the most important development for the teaching of physics to engineering technology students, there is little actual evidence to indicate that it will become a major method of physics instruction in the near future. The lack of any other innovative physics programs of equal significance reported in the professional literature or determined through correspondence indicates a general agreement that the modular form is the most appropriate form of instruction or that there is little interest in finding any better physics instructional program than that now being used. Most educators appear to be satisfied with the present type of physics instruction offered to engineering technology students. If other major developments are actually taking place, then there is a severe lack of public communication regarding these new developments. Thus, it appears that if any changes in physics instruction for engineering technology students do occur in the next five to ten years, they will almost assuredly be changes to the form of instruction as outlined in the Tech Physics Project.

There is a general movement toward more use of the "hands-on" approach and thus there should be a corresponding movement toward more self-learning and discovery learning. The student will become more responsible for his own education in the future. If the physics instructors carry out their expressed intentions there will be special provisions made for differential learning rates among students which implies that individually paced instruction which could be in modular form may be an important development in the field of physics education for engineering technology students.

If the present trend requiring accountability from the educational institutions continues, the physics instruction for engineering technology students will almost certainly move toward the extensive use of behavioral objectives. Since the Tech Physics Project is based upon the use of behavioral objectives it may well become the most predominant method for teaching physics to engineering technology students whether the instructors believe it is the most appropriate or not. Also, since the Tech Physics Project is being developed with the assistance of the Technical Education Research Centers and under the direction of the American Institute of Physics, there may be indirect pressure on some institutions to implement this type of physics instruction.

Recently the pressure for accreditation has been bringing engineering technology students into regular physics courses due to a presumably inadequate physics program offered to these students in the regular technical programs. With the development of more and better physics resources for technology students the trend should be reversed and the engineering technology students presently in liberal arts physics programs should move back into a high quality type of physics instruction specifically designed for those with a leaning toward the use of the "hands-on" approach.

The transition into a new method of physics instruction for engineering technology students will probably be slow because the present physics instructors of engineering technology students believe that they are now offering adequate physics instruction to these students. The question, however, should not be what is an adequate program of physics instruction but what is the best program of physics instruction. Again, there may be changes in the type of physics instruction offered to engineering technology students, but the changes will probably be slow in coming due to an apparent lack of interest in developing and trying more appropriate forms of physics instruction to meet the needs and interests of these special students.

Recommendations for Further Study

The rationale behind the type of physics instruction could be studied in more detail in order to attempt to understand why most physics instructors appear to be satisfied with the present methods of teaching physics and why there seems to be so little interest in developing physics instructional programs more appropriate to engineering technology students.

A survey of engineering technology students in various types of physics instructional programs would provide some input into the study of the type of physics instruction best received by these students. A related survey of the physics instructors at these institutions would provide a means of comparing the views of the instructors with those of the students.

The scope of this study could be widened to include physics instruction for other technology students besides the engineering technology students. Any physics instructional program developed for technical students in general could readily be adapted to meet the needs and interests of engineering technology students in particular. Suggestions could be made to adapt existing physics instruction for technical students to physics instruction for engineering technology programs. This study could also be widened in scope to include institutions without an accredited engineering technology program in a survey questionnaire. It might be determined if the physics instructors and technical school administrators in such schools are also as reluctant to change their physics programs as the educators at institutions with an accredited engineering technology program.

A detailed study of various physics textbooks especially written for engineering technology students, technical students in general, and liberal arts students could be undertaken in order to determine the differences and similarities between them. This critical comparison of the available textbooks could assist those institutions in the selection of an appropriate form of textbook and could aid also in the development of a physics curriculum appropriate to each student's needs and interests.

The physics instruction for engineering technology students on a regional level could be investigated since the engineering technology program may vary with regional population, educational philosophy, financial resources, surrounding industry, and other factors. Various physics instructional programs could be tried at different institutions within the region and compared through a regional conference and detailed evaluation forms to be completed by both the professional educators and the students in the physics program.

Since almost half of the physics instructors surveyed in this study believe the 50 minute classroom period should be changed in order to provide more appropriate physics instruction to engineering technology students, further study should be undertaken to determine how these instructors would change the classroom period and what they would do with the change in time. This study would attempt to determine the specific reasons why many physics instructors think the length of the classroom period should be changed.

A SELECTED BIBLIOGRAPHY

(1) Beatty, H. Russell "The Development of Technical Education." Engineering Education, Vol. 58 (May, 1968), p. 1063.

(2) The Junior College and Education in the Sciences. Report of the National Science Foundation to the Subcommittee on Science and Research and Development of the Committee on Science and Astronautics, U. S. House of Representatives, 90th Congress, First Session (1967), p. 101.

(3) "ECPD Adopts Recommendations of ASEE Report for Accreditation of Engineering Technology Programs." Technical Education News, Vol. 23 (February 1964), pp. 3-4.

(4) Harris, Norman C. "Physics for Technicians - More Important Than Ever." Technical Education News, Vol. 24 (September 1964), pp. 5-6.

(5) Juszli, Frank L. "Roles of Basic Sciences in Engineering Technology Programs." Technical Education News, Vol. 26 (September, 1966), p. 9.

(6) "Technical Education: A Growing Challenge in American Education." American Association for the Advancement of Science, Miscellaneous Publication Number 68-14 (July, 1968); pp. 8-11.

(7) Shaefer, Carl J., and Robert E. McCord "Needed: A Definition of the Technician." Technical Education News, Vol. 22 (June, 1963), p. 23.

(8) Defore, Jesse J. "Survey of Credit Hours in the Physical Sciences." Technical Education News, Vol. 23 (December, 1963), p. 4.

(9) Defore, Jesse J. "Profile of an Engineering Technology Student." Engineering Education, Vol. 57 (November, 1966), pp. 227-228.

(10) Defore, Jesse J. "Characteristics of Engineering Technology Students." Engineering Education, Vol. 61 (April, 1971), pp. 844-846.

(11) Strassenburg, Arnold A. "Experiences of University Physicists Working With Their Two-Year College Neighbors." American Journal of Physics, Vol. 39 (April, 1971), pp. 363-370.

(12) Aldridge, Bill "Physics in Two-Year Technical Curricula." The

Physics Teacher, Vol. 8 (1970), p. 302.

(13) Alexander, D. Murray "A Project to Develop Modules of Physics Instruction for Future Technicians." (Unpublished Paper Presented at the Annual Meeting of the American Association of Physics Teachers, San Francisco, California, February 3, 1972).

(14) Mager, Robert F. Preparing Instructional Objectives. Palo Alto, California: Fearon Publishing Company (1962).

(15) Strassenburg, Arnold A. "Progress Report on the Tech Physics Project." Personal Communication from the Office of Education and Manpower, American Institute of Physics, New York, March, 1972.

(16) Avtgis, Alexander W. "A New Approach to Engineering Technology Laboratory Instruction." Engineering Education (May, 1970), pp. 881-882.

(17) Parker, R. H. and A. B. L. Whittles "Instruction of Special Physics Topics (Geophysics) Through the Use of Physics Laboratory Projects." American Journal of Physics, Vol. 38 (January, 1970), pp. 65-67.

(18) Accredited Institutions of Higher Education. American Council on Education, One Dupont Circle, Washington, D.C. (1971).

APPENDIXES

APPENDIX A

SAMPLE SURVEY QUESTIONNAIRE

SURVEY OF PHYSICS INSTRUCTION
IN ENGINEERING TECHNOLOGY PROGRAMS

I. PLEASE DESCRIBE YOUR INSTITUTION AND ENGINEERING TECHNOLOGY PROGRAM(S) BY CHECKING THE APPROPRIATE RESPONSES.

1. Which engineering technology degrees are offered by your institution?

   ________ associate degree
   ________ bachelor degree
   ________ other (please specify) ______________________________

2. What is the affiliation of your institution?

   ________ university affiliated
   ________ independent
   ________ other (please specify) ______________________________

3. What is the major source of institutional support?

   ________ public
   ________ private

II. PLEASE DESCRIBE <u>YOUR CURRENT PHYSICS PROGRAM(S)</u> FOR ENGINEERING TECHNOLOGY STUDENTS BY CHECKING THE APPROPRIATE RESPONSES.

4. How many semester credit hours of physics instruction are required in most engineering technology programs? (Consider quarter-credits as 2/3 of a semester-credit.)

   ________ one or two
   ________ three or four
   ________ five or six
   ________ seven or eight
   ________ nine or ten
   ________ more than ten

5. In which semester (or quarter) does the student usually begin physics instruction?

   ________ first
   ________ second
   ________ third
   ________ fourth
   ________ fifth
   ________ sixth
   ________ later
   ________ semester
   ________ quarter

6. What prerequisites are required of a student for beginning physics instruction?

   _______ first year high school algebra
   _______ second year high school algebra
   _______ high school trigonometry
   _______ high school physics
   _______ other (please specify) _______________
   _______ other (please specify) _______________

7. What is the average size of the physics class(es)?

   _______ under 10
   _______ 10 to 20
   _______ 21 to 30
   _______ 31 to 40
   _______ 41 to 50
   _______ more than 50

8. What percentage of a typical physics class are engineering technology majors?

   _______ 0 to 20%
   _______ 21 to 40%
   _______ 41 to 60%
   _______ 61 to 80%
   _______ 81 to 100%

9. What approximate percentage of the physics class is represented by each of the following groups?

   _______ % mechanical technology students
   _______ % chemical technology students
   _______ % electrical technology students
   _______ % electronic technology students
   _______ % other (please specify) _______________
   _______ % other (please specify) _______________
   _______ % other (please specify) _______________

10. How many (approximate) engineering technology students are enrolled in physics instruction each semester (or quarter)?
    _______________/_______________

11. What is the length of the classroom period in minutes? _______

12. What is the predominant teaching approach used in physics classroom instruction?

    _______ lecture
    _______ programmed instruction
    _______ project method
    _______ individually paced instruction
    _______ problem-solving methods
    _______ other (please describe briefly) _______________
    ____

13. What fraction of physics instructional time over the total number of physics courses taken by engineering technology students is devoted to each of the following areas of study?

_______ % mechanics
_______ % heat
_______ % sound
_______ % electricity
_______ % modern physics
_______ % other (please specify) ____________________
_______ % other (please specify) ____________________

14. Are special provisions made for differential learning rates among students?

_______ yes
_______ no   If yes, please describe briefly. __________
____

15. Are behavioral objectives used in the physics instruction?

_______ yes
_______ no

16. What textbook(s) are currently used in physics instruction in classes containing engineering technology students?

____

____

17. What principal evaluation techniques are used in the classroom to measure student progress in physics?

_______ written examination   _______ written reports
_______ oral examinations   _______ oral reports
_______ extra-class problem sets   _______ term projects
_______ exams stressing applications as opposed to theory
_______ exams stressing theory as opposed to applications
_______ exams stressing theory and applications equally.

18. Is a discussion or problems session associated with the physics instruction?

_______ yes
_______ no

19. Is a laboratory experience associated with the physics instruction?

_______ yes
_______ no

20. What is the length of the laboratory period? _____ hours.

21. Are the lab material and lecture material closely coordinated?

_______ yes
_______ no

22. Which of the following best describe the laboratory program?

_______ prescribed experiments using traditional manual
_______ prescribed long-term projects
_______ independent projects
_______ other (please describe briefly) ____________________
____

23. What principal evaluation techniques are used in the laboratory?

_______ written examinations
_______ oral examinations
_______ written reports
_______ exams stressing applications as opposed to theory
_______ exams stressing theory as opposed to applications
_______ exams stressing theory and applications equally.
_______ oral reports
_______ term projects

24. Is the physics instructor a member of a physics department, a technical institute department, or some other department?

_______ physics department
_______ technical institute department
_______ other department (please specify) ________________

25. Has accreditaiton influenced the type of physics instruction provided for the engineering technology students?

_______ yes
_______ no

III. PLEASE INDICATE <u>THE RATIONALE BEHIND THE TYPE OF PHYSICS INSTRUCTION NOW OFFERED</u> TO ENGINEERING TECHNOLOGY STUDENTS AT YOUR INSTITUTION BY CHECKING THE APPROPRIATE RESPONSES.

26. Is physics instruction considered to be part of general education or preparation for specialized training?

_______ general education
_______ preparation for specialized training

27. Does the physics instruction emphasize acquisition of detailed knowledge, development of general concepts, or both equally?

_______ detailed knowledge
_______ general concepts
_______ both equally

28. Is the total physics instruction for engineering technology students oriented toward theoretical concepts or practical application of those concepts?

_______ theoretical concepts
_______ practical applications
_______ both (What balance between the two?) _______________
____

IV. PLEASE DESCRIBE THE TYPE OF PHYSICS PROGRAM WHICH YOU CONSIDER WOULD BEST MEET THE NEEDS AND INTERESTS OF ENGINEERING TECHNOLOGY STUDENTS IF TIME AND OTHER RESOURCES WERE AVAILABLE.

29. What should be the predominant teaching approach for engineering technology students enrolled in physics?

_______ lecture
_______ project method
_______ problem-solving methods
_______ programmed instruction
_______ individually paced instruction
_______ other (please describe briefly) _______________
____

30. What per cent of the total physics instructional time should be devoted to each of the following areas?

_______ % mechanics
_______ % heat
_______ % light
_______ % sound
_______ % electricity
_______ % other (please specify) _______________
_______ % other (please specify) _______________

31. Should behavioral objectives be used extensively?

_______ yes
_______ no

32. Should special provisions be made for differential learning rates among students?

_______ yes
_______ no

33. Would a change in the length of the class period be necessary to provide the type of instruction which you consider most appropriate for engineering technology students?

_______ yes
_______ no

34. Should a laboratory experience oriented toward applications be associated with physics instruction for engineering technology students?

_______ yes
_______ no

35. Should a formal written report be required in the laboratory experience?

_______ yes
_______ no

36. Should the lecture material and laboratory material be closely coordinated?

_______ yes
_______ no

V. PLEASE INDICATE WHAT YOU BELIEVE SHOULD BE THE PHILOSOPHY BEHIND THE TYPE OF INSTRUCTION OFFERED TO ENGINEERING TECHNOLOGY STUDENTS BY CHECKING THE APPROPRIATE RESPONSES.

37. Should physics be considered as part of general education, as preparation for specialized training, or both?

_______ general education
_______ preparation for specialized training
_______ both (please comment) ____________________________
____

38. Should physics instruction for engineering technology students be oriented toward theoretical concepts or practical applications of those concepts?

_______ theoretical concepts
_______ practical applications
_______ both (What balance between the two?) _______________
____

39. Should physics instruction for engineering technology students be based on the acquisition of detailed knowledge, the development of general concepts, or both?

_______ detailed knowledge _______ general concepts
_______ both (What balance between the two?) _______________
____

PLEASE RESPOND BRIEFLY TO THE FOLLOWING QUESTIONS:

1. Can the majority of engineering technology students adequately extrapolate from general concepts to specific applications?

_______ yes
_______ no

Comments:

2. Can the majority of engineering technology students adequately form general concepts from specific applications?

_______ yes
_______ no

Comments:

3. Do you consider the engineering technology student to be sufficiently different in terms of background, intelligence, and interests to necessitate a different type of physics program from that which is traditionally offered in liberal arts programs?

_______ yes
_______ no

Comments:

4. What major changes, if any, have taken place in the physics instruction offered engineering technology students in the last five years?

5. Are any significant changes in the physics instruction for engineering technology students being considered for the near future?

_______ yes
_______ no If yes, describe briefly. ____________________

____

____

6. Are adequate physics resources now available to meet the needs and interests of engineering technology students?

_______ yes
_______ no

Comments:

7. If adequate time and other resources were available, what type of physics program would you like to see offered for engineering technology students? Please give reference to on-going programs if appropriate.

____
Name of Respondent

____
Title

____
Institution

APPENDIX B

INSTITUTIONS WITH PROFESSIONALLY ACCREDITED

ENGINEERING TECHNOLOGY PROGRAMS

Phoenix College
Phoenix, Arizona

City College of San Francisco
50 Phelan Avenue
San Francisco, California

Grossmont College
8800 Grossmont College Drive
El Cajon, California

Hartford State Technical College
Hartford, Connecticut

Norwalk State Technical College
Norwalk, Connecticut

Thames Valley State Technical College
Norwich, Connecticut

Waterbury State Technical College
Waterbury, Connecticut

Embry-Riddle Aeronautical Institute
Daytona Beach, Florida

St. Petersburg Junior College
St. Petersburg, Florida

Southern Technical Institute
Marietta, Georgia

Ricks College
Rexburg, Idaho

Purdue University
Lafayette, Indiana

Iowa State University
The Technical Institute
Ames, Iowa

Franklin Institute of Boston
Boston, Massachusetts

Lowell Technological Institute
Lowell, Massachusetts

Wentworth Institute
Boston, Massachusetts

Lake Superior State College
Sault Sainte Marie, Michigan

Michigan Technological University
Houghton, Michigan

Nevada Technical Institute
Stead Campus
Reno, Nevada

New Hampshire Technical Institute
Concord, New Hampshire

Eastern New Mexico University
Portales, New Mexico

New Mexico State University
Las Cruces, New Mexico

Academy of Aeronautics
La Guardia Airport
Flushing, New York

Alfred University
Alfred, New York

Broome Community College
Binghamton, New York

Bronx Community College
120 E. 148th Street
Bronx, New York

Queensborough Community College
Springfield Blvd. & 56th Avenue
Bayside, New York

Hudson Valley Community College
Troy, New York

Mohawk Valley Community College
Utica, New York

SUNY, Ag. & Tech. College at Alfred
Alfred, New York

SUNY, Ag. & Tech. College at Canton
Canton, New York

SUNY, Ag. & Tech. College at Farmingdale
Farmingdale, New York

Fayetteville Technical Institute
Fayetteville, North Carolina

Gaston College
Dallas, North Carolina

Sinclair Community College
Dayton, Ohio

University of Akron
302 E. Buchtel Avenue
Akron, Ohio

University of Dayton
300 College Park Avenue
Dayton, Ohio

Oklahoma State Technical Institute
Stillwater, Oklahoma

Blue Mountain Community College
Pendleton, Oregon

Oregon Technical Institute
Klamath Falls, Oregon

Penn State University
Wilkes-Barre Campus
Wilkes-Barre, Pennsylvania

Spring Garden College
Philadelphia, Pennsylvania

Temple University
Broad Street & Columbia Avenue
Philadelphia, Pennsylvania

Midlands Technical Education Center
Columbia, South Carolina

Chattanooga State Technical Institute
4501 Amnicola Highway
Chattanooga, Tennessee

Del Mar College
Corpus Christi, Texas

University of Texas
Technical Institute Division
Arlington, Texas

Bringham Young University
The Technical Institute
Provo, Utah

Weber State College
Ogden, Utah

Vermont Technical College
Randolph Center, Vermont

Old Dominion University
Norfolk, Virginia

Milwaukee School of Engineering
Milwaukee, Wisconsin

Capitol Institute of Technology
3200 Sixth Street, N.W.
Washington, D.C.

Erie County Technical Institute
Main Street & Youngs Road
Buffalo, New York

APPENDIX C

SURVEY QUESTIONNAIRE RESULTS

FROM PHYSICS INSTRUCTORS

SURVEY OF PHYSICS INSTRUCTION IN ENGINEERING TECHNOLOGY PROGRAMS

I. PLEASE DESCRIBE YOUR INSTITUTION AND ENGINEERING TECHNOLOGY PROGRAM(S) BY CHECKING THE APPROPRIATE RESPONSES.

1. Which engineering technology degrees are offered by your institution?

   _______ associate degree
   _______ bachelor degree
   _______ other (please specify) ______________________________

2. What is the affiliation of your institution?

   _______ university affiliated
   _______ independent
   _______ other (please specify) ______________________________

3. What is the major source of institutional support?

   _______ public
   _______ private

II. PLEASE DESCRIBE <u>YOUR CURRENT PHYSICS PROGRAM(S)</u> FOR ENGINEERING TECHNOLOGY STUDENTS BY CHECKING THE APPROPRIATE RESPONSES.

4. How many semester credit hours of physics instruction are required in most engineering technology programs? (Consider quarter-credits as 2/3 of a semester-credit.)

   _______ one or two
   ___4___ three or four
   ___10___ five or six
   ___19___ seven or eight
   ___4___ nine or ten
   ___2___ more than ten

5. In which semester (or quarter) does the student usually begin physics instruction?

   ___24___ first
   ___9___ second
   ___5___ third
   ___1___ fourth
   _______ fifth
   _______ sixth
   _______ later
   _______ semester
   _______ quarter

6. What prerequisites are required of a student for beginning physics instruction?

- *18* first year high school algebra
- *12* second year high school algebra
- *16* high school trigonometry
- *10* high school physics
- *8* other (please specify) *College Algebra*
- *6* other (please specify) *College Trigonometry*
- *5* other (please specify) *Geometry*
- *1* other (please specify) *Physical Science*
- *1* other (please specify) *Technical Math*

7. What is the average size of the physics class(es)?

- ____ under 10
- *5* 10 to 20
- *15* 21 to 30
- *10* 31 to 40
- *3* 41 to 50
- *4* more than 50

8. What percentage of a typical physics class are engineering technology majors?

- *2* 0 to 20%
- *3* 21 to 40%
- *2* 41 to 60%
- *2* 61 to 80%
- *28* 81 to 100%

9. What approximate percentage of the physics class is represented by each of the following groups?

(No. of Tech Programs Listed)

- *1* % environment
- *24* % mechanical technology students
- *4* % chemical technology students
- *20* % electrical technology students
- *19* % electronic technology students
- *13* % other (please specify) *Civil*
- *4* % other (please specify) *Construction*
- *4* % other (please specify) *Arch & Design*
- *1* % other (please specify) *Nuclear*

10. How many (approximate) engineering technology students are enrolled in physics instruction each semester (or quarter)? ____/____

11. What is the length of the classroom period in minutes? *50*

12. What is the predominant teaching approach used in physics classroom instruction?

- *33* lecture
- ____ programmed instruction
- ____ project method
- *1* individually paced instruction
- *18* problem-solving methods
- *2* other (please describe briefly) *Demonstrations*

13. What fraction of physics instructional time over the total number of physics courses taken by engineering technology students is devoted to each of the following areas of study?

36 % mechanics
13 % heat
8 % sound
25 % electricity
10 % modern physics
5 % other (please specify) *Optics*
2 % other (please specify) *Electronics*
1 % other (please specify) *Materials*

14. Are special provisions made for differential learning rates among students?

13 yes
24 no If yes, please describe briefly. ____________

15. Are behavioral objectives used in the physics instruction?

13 yes
24 no

16. What textbook(s) are currently used in physics instruction in classes containing engineering technology students?

Joseph (7), Smith & Cooper (7), Beiser (6), Harris & Hemmerling (3), Miller (2)

17. What principal evaluation techniques are used in the classroom to measure student progress in physics?

35 written examination
3 oral examinations
12 extra-class problem sets
13 exams stressing applications as opposed to theory
1 exams stressing theory as opposed to applications
17 exams stressing theory and applications equally.
13 written reports
1 oral reports
____ term projects

18. Is a discussion or problems session associated with the physics instruction?

29 yes
8 no

19. Is a laboratory experience associated with the physics instruction?

37 yes
1 no

20. What is the length of the laboratory period? *17 - 3 hr.; 21 - 2 hr.* hours.

21. Are the lab material and lecture material closely coordinated?

    37 yes
    1 no

22. Which of the following best describe the laboratory program?

    28 prescribed experiments using traditional manual
    ____ prescribed long-term projects
    1 independent projects
    8 other (please describe briefly) *Prescribed experiments using own material.*
    1 other (please describe briefly) *Independent experiments.*

23. What principal evaluation techniques are used in the laboratory?

    9 written examinations
    2 oral examinations
    37 written reports
    1 exams stressing applications as opposed to theory
    1 exams stressing theory as opposed to applications
    4 exams stressing theory and applications equally.
    ____ oral reports
    ____ term projects

24. Is the physics instructor a member of a physics department, a technical institute department, or some other department?

    29 physics department
    7 technical institute department
    3 other department (please specify) *Science*
    2 other department (please specify) *Engineering*

25. Has accreditation influenced the type of physics instruction provided for the engineering technology students?

    19 yes
    19 no

III. PLEASE INDICATE THE RATIONALE BEHIND THE TYPE OF PHYSICS INSTRUCTION NOW OFFERED TO ENGINEERING TECHNOLOGY STUDENTS AT YOUR INSTITUTION BY CHECKING THE APPROPRIATE RESPONSES.

26. Is physics instruction considered to be part of general education or preparation for specialized training?

    16 general education
    27 preparation for specialized training

27. Does the physics instruction emphasize acquisition of detailed knowledge, development of general concepts, or both equally?

4 detailed knowledge
6 general concepts
29 both equally

28. Is the total physics instruction for engineering technology students oriented toward theoretical concepts or practical application of those concepts?

____ theoretical concepts
15 practical applications
24 both (What balance between the two?) *55% theoretical concepts - 45% applications*

IV. PLEASE DESCRIBE THE TYPE OF PHYSICS PROGRAM WHICH YOU CONSIDER WOULD BEST MEET THE NEEDS AND INTERESTS OF ENGINEERING TECHNOLOGY STUDENTS IF TIME AND OTHER RESOURCES WERE AVAILABLE.

29. What should be the predominant teaching approach for engineering technology students enrolled in physics?

12 lecture
4 project method
22 problem-solving methods
1 programmed instruction
13 individually paced instruction
1 other (please describe briefly) *Animated movies*
1 other (please describe briefly) *Laboratory*

30. What per cent of the total physics instructional time should be devoted to each of the following areas?

31 % mechanics
15 % heat
12 % light
9 % sound
23 % electricity
9 % other (please specify) *Modern Physics*
1 % other (please specify) *Materials*

31. Should behavioral objectives be used extensively?

16 yes
19 no

32. Should special provisions be made for differential learning rates among students?

33 yes
4 no

33. Would a change in the length of the class period be necessary to provide the type of instruction which you consider most appropriate for engineering technology students?

 12 yes
 12 no

34. Should a laboratory experience oriented toward applications be associated with physics instruction for engineering technology students?

 33 yes
 5 no

35. Should a formal written report be required in the laboratory experience?

 29 yes
 5 no
 3 a few

36. Should the lecture material and laboratory material be closely coordinated?

 35 yes
 3 no

V. PLEASE INDICATE WHAT YOU BELIEVE SHOULD BE THE PHILOSOPHY BEHIND THE TYPE OF INSTRUCTION OFFERED TO ENGINEERING TECHNOLOGY STUDENTS BY CHECKING THE APPROPRIATE RESPONSES.

37. Should physics be considered as part of general education, as preparation for specialized training, or both?

 7 general education
 13 preparation for specialized training
 18 both (please comment) ______

38. Should physics instruction for engineering technology students be oriented toward theoretical concepts or practical applications of those concepts?

 2 theoretical concepts
 13 practical applications
 23 both (What balance between the two?) *46% theoretical concepts - 54% applications*

39. Should physics instruction for engineering technology students be based on the acquisition of detailed knowledge, the development of general concepts, or both?

 1 detailed knowledge
 8 general concepts
 29 both (What balance between the two?) *53% knowledge - 47% concepts.*

PLEASE RESPOND BRIEFLY TO THE FOLLOWING QUESTIONS:

1. Can the majority of engineering technology students adequately extrapolate from general concepts to specific applications?

 14 yes
 22 no

Comments:

2. Can the majority of engineering technology students adequately form general concepts from specific applications?

 18 yes
 17 no

Comments:

3. Do you consider the engineering technology student to be sufficiently different in terms of background, intelligence, and interests to necessitate a different type of physics program from that which is traditionally offered in liberal arts programs?

 29 yes
 8 no

Comments:

4. What major changes, if any, have taken place in the physics instruction offered engineering technology students in the last five years?

lab was added
more physics instruction
more emphasis on applications
more modern physics
tracking
self paced instruction

5. Are any significant changes in the physics instruction for engineering technology students being considered for the near future?

   12 yes
   24 no   If yes, describe briefly. *Applied labs, videotape problem solutions, introduction of modern physics, modules*

6. Are adequate physics resources now available to meet the needs and interests of engineering technology students?

   29 yes
   7 no

   Comments:

7. If adequate time and other resources were available, what type of physics program would you like to see offered for engineering technology students? Please give reference to on-going programs if appropriate.

use of behavioral objectives
team teaching
animated movies
modern physics for all technology students
modules
tracking
on-line computer experience
more emphasis on multi-media

Name of Respondent

Title

Institution

APPENDIX D

SURVEY QUESTIONNAIRE RESULTS FROM

TECHNICAL SCHOOL ADMINISTRATORS

IV. PLEASE DESCRIBE THE TYPE OF PHYSICS PROGRAM WHICH YOU CONSIDER WOULD BEST MEET THE NEEDS AND INTERESTS OF ENGINEERING TECHNOLOGY STUDENTS IF TIME AND OTHER RESOURCES WERE AVAILABLE.

29. What should be the predominant teaching approach for engineering technology students enrolled in physics?

4 lecture
1 project method
7 problem-solving methods
____ programmed instruction
3 individually paced instruction
____ other (please describe briefly) ____________

30. What per cent of the total physics instructional time should be devoted to each of the following areas?

30 % mechanics
18 % heat
13 % light
9 % sound
25 % electricity
5 % other (please specify) *Modern Physics*
____ % other (please specify) ____________

31. Should behavioral objectives be used extensively?

11 yes
1 no

32. Should special provisions be made for differential learning rates among students?

11 yes
2 no

33. Would a change in the length of the class period be necessary to provide the type of instruction which you consider most appropriate for engineering technology students?

4 yes
9 no

34. Should a laboratory experience oriented toward applications be associated with physics instruction for engineering technology students?

11 yes
1 no

35. Should a formal written report be required in the laboratory experience?

___*9*___ yes
___*2*___ no
___*1*___ a few

36. Should the lecture material and laboratory material be closely coordinated?

___*13*___ yes
______ no

V. PLEASE INDICATE WHAT YOU BELIEVE SHOULD BE THE PHILOSOPHY BEHIND THE TYPE OF INSTRUCTION OFFERED TO ENGINEERING TECHNOLOGY STUDENTS BY CHECKING THE APPROPRIATE RESPONSES.

37. Should physics be considered as part of general education, as preparation for specialized training, or both?

___*1*___ general education
___*3*___ preparation for specialized training
___*9*___ both (please comment) ______________________________

____

38. Should physics instruction for engineering technology students be oriented toward theoretical concepts or practical applications of those concepts?

______ theoretical concepts
___*5*___ practical applications
___*8*___ both (What balance between the two?) *45% theoretical concepts - 55% applications*

39. Should physics instruction for engineering technology students be based on the acquisition of detailed knowledge, the development of general concepts, or both?

______ detailed knowledge
___*4*___ general concepts
___*9*___ both (What balance between the two?) *60% detailed knowledge - 40% general concepts.*

PLEASE RESPOND BRIEFLY TO THE FOLLOWING QUESTIONS:

1. Can the majority of engineering technology students adequately extrapolate from general concepts to specific applications?

   6 yes
   4 no

   Comments:

2. Can the majority of engineering technology students adequately form general concepts from specific applications?

   5 yes
   5 no

   Comments:

3. Do you consider the engineering technology student to be sufficiently different in terms of background, intelligence, and interests to necessitate a different type of physics program from that which is traditionally offered in liberal arts programs?

   7 yes
   3 no

   Comments:

4. What major changes, if any, have taken place in the physics instruction offered engineering technology students in the last five years?

   calculus-oriented theory
   trend toward general concepts
   more application
   become more theoretical

5. Are any significant changes in the physics instruction for engineering technology students being considered for the near future?

   __*6*__ yes
   __*6*__ no   If yes, describe briefly. *Modules, more use of media, individually paced instruction, behavioral objectives*

6. Are adequate physics resources now available to meet the needs and interests of engineering technology students?

   __*7*__ yes
   __*4*__ no

   Comments:

7. If adequate time and other resources were available, what type of physics program would you like to see offered for engineering technology students? Please give reference to on-going programs if appropriate.

   industrial application lab
   more physics instruction
   "effective" instructors
   self-pacing
   open labs
   unified physics approach
   more application

Name of Respondent

Title

Institution

VITA

RALPH EDWIN HILBELINK

Candidate for the Degree of

Doctor of Education

Thesis: AN ANALYSIS OF PHYSICS INSTRUCTIONAL PATTERNS IN ENGINEERING TECHNOLOGY PROGRAMS

Major Field: Higher Education

Biographical:

Personal Data: Born in Cedar Grove, Wisconsin, May 28, 1943.

Education: Graduated from Cedar Grove High School, Cedar Grove, Wisconsin, in 1961; received Bachelor of Arts degree with a major in physics from Central College, Pella, Iowa, in 1965; received Master of Science degree in physics from Sam Houston State University, Huntsville, Texas, in 1967; enrolled in doctoral program at Oklahoma State University, 1968-74; attended the University of Wisconsin in Madison, Wisconsin, in 1972; completed the requirements for the Doctor of Education degree at Oklahoma State University in May, 1974.

Professional Experience: Graduate teaching assistant, Physics Department, Sam Houston State University, 1965-67; mathematics instructor, Wild Rose High School, Wild Rose, Wisconsin, 1967-68; graduate teaching assistant, Physics Department, Oklahoma State University, 1968-71; physics and mathematics instructor, Oak Park - River Forest High School, Oak Park, Illinois, 1973-74.

Professional Organizations: National Physics Honorary Society, American Institute of Physics, American Association of Physics Teachers, National Council of Teachers of Mathematics, School Science and Mathematics Association.