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ABSTRACT

The encompassing objective of this project was to assist two-year colleges in establishing electromechanical technican (EMT) training programs by developing the necessary planning and instructional materials and by providing direct program planning assistance. The research effort of the project was to develop and test an integrated systems of instruction built around discrete technical concepts that are basic to more than one technology and have multiple applications. The system requires that each concept be presented in a logical sequence with concurrent applications in Electricity, Mechanics, Physics, Mathematics, and Technical Communications. Student achievement was measured and recorded at all stages of the program. Instructional materials were student tested, revised, and retested. Case studies were made to identify the administrative problems encountered in introducing the system in new as well as in existing two-year schools. The project was completed in August 1973. At that time, EMT project materials were being used in 30 states, and planning assistance had been provided to 375 schools. At least 70 of these schools established new electromechanical technology programs using the EMT materials. Post-project dissemination of the planning and instructional materials developed is being effected. (Author/DB)

FINAL REPORT

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DEVELOPMENT AND EVALUATION OF EDUCATIONAL PROGRAMS IN ELECTROMECHANICAL TECHNOLOGY

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November 30, 1973

The research reported herein was performed pursuant to a grant with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education

FOREWORD

Educational change seldom occurs without careful study and experimentation, an evolutionary process that can lag far behind the changes in occupational needs brought about by new technology. Research and development in technical education is effectively reducing this lag by focusing on emerging occupations. Electromechanical technology is one of the burgeoning new occupational fields in which new combinations of skill and knowledge cannot be met by traditional education services.

The Electromechanical Technology program developed and tested by the Technical Education Research Centers (TERC) is revolutionary in many respects. It incorporates, in a carefully integrated sequence of courses, many of the best instructional techniques developed over the years by technical education specialists. This brief report summarizes the purpose, procedures, and results of five years of intensive research and development effort that has produced a new system of instruction for the unique requirements of this emerging technology.

The organization and structure of the EMT curriculum developed by TERC differs significantly from the familiar single-specialty technical programs commonly offered in two-year institutions. This kind of technology cannot be adequately presented by a mere rearrangement of existing courses. A totally integrated system of instruction has been developed and tested extensively in two-year institutions, with excellent results.

School administrators interested in expanding technical education services should examine this new system carefully. More than forty publications supporting the system are available, including extensive planning guides.

M. W. Roney
Principal Investigator

ACKNOWLEDGEMENTS

The Electromechanical Technology Project has involved many people, institutions, and organizations over a five year period. Any attempt to classify their contributions as major or minor would be inappropriate.

In terms of continued support and encouragement for the project, credit must be given to Dr. Walter J. Brooking and others of the U. S. Office of Education staff who provided valuable assistance at many points. The Technical Education Research Center staff under the direction of Arthur H. Nelson gave executive leadership to the project. President Robert B. Kamm of the Oklahoma State University and the highly competent technical education specialists in the School of Occupational and Adult Education provided the facilities for the experimental program and the technical expertise for the development of instructional materials.

The developmental work of the project, under the able leadership of Donald S. Phillips, produced many volumes of instructional and program planning materials. Richard W. Tinnell provided technical expertise at all points and supervised the development and testing of instructional materials.

Finally, and with a deep sense of gratitude for his many years of service in the field of technical education, we credit the late Austin E. Fribance, a man whose vision and enthusiasm inspired all who were privileged to work with him in the early stages of the project.

TABLE OF CONTENTS

ABSTRACT

The Technical Education Research Centers, Inc. (TERC) of Cambridge, Massachusetts, has developed a two-year (four-semester) instructional program designed to prepare technicians for the emerging electromechanical occupations in industry. The project was supported by grant funds provided by the U. S. Department of Health, Education, and Welfare. The procedures, products, and results of this five-year project are contained in the Final Report, "Development and Evaluation of Educational Programs in Electromechanical Technology", and a series of forty-one additional documents that include complete instructional materials for sixteen specialized courses and a number of program planning guides.

The encompassing objective of this project was to assist two-year colleges in establishing electromechanical technician (EMT) training programs by developing the necessary planning and instructional materials and by providing direct program planning assistance. An experimental program conducted at the Oklahoma State University with two classes of students provided the setting for developing the instructional materials. Planning services were provided by a series of conferences and workshops and, in some cases, by direct consultative services.

The project was completed in August 1973. At that time, EMT project materials were being used in 30 states and planning assistance had been provided to 375 schools. At least 70 of these schools established new electromechanical technology programs using TERC-developed EMT materials.

The research effort of this project was to develop and test an integrated system of instruction built around discrete technical concepts that are basic to more than one technology and have multiple applications. The system, simply stated, requires that each concept be presented in a logical sequence with concurrent applications in Electricity, Mechanics, Physics, Mathematics, and Technical Communications. Student achievement was measured and recorded at all stages of the program. Instructional materials were student-tested, revised, and retested. Case studies were made to identify the administrative problems encountered in introducing the system in new as well as in existing two-year schools.

Post-project dissemination of the planning and instructional materials developed under this project is being effected through the contractor's (TERC) interactive network of schools and consultants and by the commercial publishers who distribute and market the instructional materials. A number of vendors have developed and marketed laboratory equipment designed to be used with these materials. Complete information on schools, consultants, publications, and equipment vendors is available from TERC, 44 Brattle Street, Cambridge, Massachusetts 02138.

SECTION I

INTRODUCTION

Electromechanical Technology is an emerging field of employment in which technicians are playing a significant part. The demand for trained technicians in this field is expected to increase rapidly during the next few years. These technicians are unique in that they deal with a broader scope of technology than do traditional specialists trained in either electronic or mechanical technology. Electromechanical technicians are, in a real sense, systems technicians, especially valuable in the installation, maintenance, and repair of complex industrial machinery that incorporates mechanical, hydraulic, pneumatic, electronic, optical, and thermal devices.

The Technical Education Research Centers (TERC), with headquarters in Cambridge, Massachusetts, have conducted an extensive program of research and development designed to be of assistance in establishing training programs to prepare technicians for this field. Prior to this research, it was generally felt that at least three years of study at the postsecondary level would be needed to prepare for the electromechanical occupations. This research demonstrated clearly that two years of carefully coordinated study can, in fact, provide the necessary combination of skills and abilities required for success in this new occupation.

Research in the field of electromechanical technology began with a nationwide study of technician needs, conducted by the School of Industrial Education at Oklahoma State University, Stillwater, Oklahoma. The results of this study,* reported in 1966, indicated a need for technicians with at least two years of specialized post-high school training. The skills and knowledge needed for these new occupations were identified by employers as differing significantly from those generally available in technician training programs offered by two-year colleges.

The U. S. Office of Education, recognizing the need for a systematic research and development effort in this new occupational field, provided a grant of funds to TERC in 1968 for this purpose. During the ensuing five-year period, TERC has developed and tested a unique program of instruction,

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*Roney, Maurice W., Electromechanical Technology, A Field Study of Electromechanical Technician Occupations, Part I, September 1966; A Post-High School Technical Curriculum, Part II, November 1966 derived from the specific occupational needs of electromechanical technicians as identified by employers, and designed for the unique capabilities of two-year colleges. This report summarizes the results of this effort and outlines the procedures used to develop and test the program. Details of the project are covered in a series of separate documents that include complete instructional materials, administrators' guides, staff planning guides, and equipment source books. A complete list of project materials is included in the Appendix.

The TERC project began in 1968 under the guidance and direction of a National Advisory Committee. The work of this committee was of utmost significance to the success of the project and will be treated in detail in a following section of this report.

The developmental phase of the project began at Oklahoma State University. A class of 27 students enrolled and began study in September 1968. Instructional materials were developed and tested with this class by a staff of experienced technical teachers in the School of Occupational and Adult Education. These materials were revised and tested again with a second class of 28 students starting in September 1969. Instructional materials for sixteen discrete courses were prepared during this phase of the project and were subsequently published by Delmar Publishing Company, Albany, New York.

Testing of materials and instructional systems developed at Oklahoma State University has continued at other locations throughout the country. In 1973 the E.M.T. publications were being used in 30 states. Several institutions have adapted the TERC-EMT program to their needs by producing additional materials to extend and improve the instructional system. It is estimated that by 1974 some 50 schools throughout the country will have invested a total of $2 million in facilities, equipment, and instructional materials in EMT training services.

A series of workshops and conferences have been held throughout the country to aid in the dissemination of the research products. Experienced consultants are now available in every section of the country to carry on the dissemination effort.

SECTION II

THE WORK OF THE PANEL OF CONSULTANTS

Both the initial field study of electromechanical technician needs and the development work that followed were aided in many ways by a select panel of consultants. Representing a balance of industry, government, and education, this group of 14 individuals provided guidance and direction at several key points.

1. They identified the kinds of technical occupations that require skills and knowledge beyond the customary single disciplines of electronics or mechanics.

2. They provided a list of probable employers -- industrial and government organizations.

3. They identified key individuals in each of the employing organizations and made the initial contacts with these individuals. This procedure resulted in a substantial saving of time in the conduct of the field study.

4. The panel assisted in the design of interview schedules used in the first stage of the field study and questionnaires used in the second stage.

5. Members of the panel assumed the responsibility for mailing requests for information to the employing organizations, a technique that proved very effective in getting valid up-to-date information for program planning.

6. The panel reviewed plans for the instructional program and helped recruit experienced technical specialists to assist in the developmental stages of the project.

It would be difficult to overstate the contributions made by this group of eminently qualified individuals. From the outset, they were enthusiastic in their support of the project, and without their productive effort, the entire project could have been misdirected or, at best, would have been far less valid in objectives and results.

Panel of Consultants

Ted Boaz
Del Mar Technical Institute
Corpus Christi, Texas

Roger W. Bolz
Editor, Automation Magazine
Cleveland, Ohio

Edward Broghamer
University of Illinois
Urbana, Illinois

Joseph E. Casey
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Bryn Mawr, Pennsylvania

Malcolm Easterday
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Joseph J. Gershon
Devry Institute of Technology
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G. R. Livingstone
General Electric Company
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Joseph A. Patterson
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Control Data Institute
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Sandia Corporation
Albuquerque, New Mexico

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Argonne National Laboratory
Argonne, Illinois

SECTION III

THE CURRICULUM

A primary objective of the EMT project was to develop and test an instructional program that could be adapted to the typical two-year college. This objective determined a number of curriculum design parameters which were considered along with the information from the field study as the curriculum was developed. This section is devoted to a discussion of the curriculum design.

A. Recommendations from the Field Study

Phase II of the Field Study** included a suggested curriculum outline for the preparation of electromechanical technicians. The design of this curriculum (see Appendix A) was influenced by two major considerations. The first was the experience of the project staff in the field of technical education. The second was the information obtained from the field study of electromechanical technician occupations as follows:

1. The training should put emphasis on electrical and mechanical principles rather than on specific applications of these principles.

2. Communication skills are extremely important in the work of electromechanical technicians and should be given special attention in the training program.

3. A study of the interrelationship of electrical and mechanical elements of systems and devices should be central in the specialized technical courses of the instructional program. Whenever possible, electrical and mechanical principles should be studied together, and not as separate entities.

4. Principles of electrical and mechanical physics are basic tools in the work of electromechanical technicians, and all technical instruction should develop analytical skills for which these tools are fundamental. In addition, there is an increasing need for the technician to work with new applications of other physical sciences such as: optical equipment, thermal energy devices, hydraulic and pneumatic controls, and a wide variety of measuring instruments.

**Roney, Maurice W., Electromechanical Technology A Post-High School Technical Curriculum, Part II, November 1966.

B. Design of the First Experimental Curriculum

The original curriculum recommendations provided a basis for the initial curriculum used in the developmental project. They served to guide the project staff in the first stages of the developmental program.

1. Decision Not to Use Existing Courses.

A careful analysis of the general guidelines from the Phase II report and other data from the Field Study indicated that the educational requirements for electromechanical technicians probably could not be provided in a two-year curriculum that merely assembled existing courses in electronics and mechanics. It was imperative that the lines separating technologies be eliminated if possible. It is important to understand that the successful electromechanical technician must be equally at home in either of the technologies. To achieve this requires careful planning and execution. Anything less is likely to produce a person who is a specialist in one technology with some limited competency in the other one.

While there may be advantages in using existing courses in the development of new programs, it seemed to the project staff that to do so in this field would not meet the new program objectives. Consequently, a decision was made to develop all courses to meet the unique requirements of the new technology.

2. Development of Unified Concepts

Once the decision had been made to start at Point Zero, it was then possible to develop a conceptual framework for program planning. Since many principles that appear in one technology are also found in several others, a decision was made to use a series of what are now called "Unified Concepts" as the conceptual framework for curriculum development. Credit for conceiving and promoting this idea goes to the late Austin Fribance.

This sytem of instruction is based upon the fact that all fundamental technical understanding relies upon a few technical principles which are applicable in several technologies. The project staff decided to build a curriculum around a series of "Unified Concepts" that are common to both electronics and mechanical technology. This curriculum form permits mutual support and learning reinforcement among the several courses and thereby facilitates learning. It was believed that this system would focus the attention on technical concepts as contrasted with special applications of these concepts.

The Unified Concepts have, indeed, had this effect and have become the core of several successful electromechanical technology curricula. These concepts have applications in thermal, fluidic, pneumatic, and optical devices, as well as in basic electronic and mechanical devices.

The Unified Concepts formulated by the Project Staff were:***

1. Differential Forces
2. Flow Rates
3. Real Opposition
4. Energy Storage
5. Time Constants
6. Impedances
7. Resonance
8. Waves and Fields
9. Amplication
10. Feedback and Stability

These concepts were used as a basis for developing all science and technology courses in the curriculum.

3. Constraints and Limitations

Decisions to develop all new courses and to use the Unified Concepts presented a number of opportunities and some temptations to the project staff. The opportunity to do away with the conventional course structure, to develop courses around specific concepts, to develop a language around the concepts, and to avoid using the languages that have been developed by the technologies was very real and appealing. A strong case could be built in defense of moving in this direction. It seemed obvious that the learning difficulty could be reduced if the student in devoting his undivided attention to learning one concept at a time would not have to be concerned with learning the vocabulary of several technologies.

On the other side of the case, there were three very important factors which argued against going in this direction. First was the project objective of developing an instructional program for broad dissemination. This objective implies adoption by a variety of institutional types: junior colleges, four-year colleges,

***For a more detailed discussion of the use of these concepts in electromechanical technology, see EMT PROGRAM COMPENDIUM, Section 5, Delmar Publishers, Albany, 1971.

technical institutes, etc. While there are differences among these types of institutions, there tends to be some commonalities. One of these is the use of courses built around disciplines organized on a semester or quarter system. A cursory review of the literature relative to the institutional adoption process reveals that the more a program resembles the institution's existing program, the more apt it is to be adopted. A second important consideration was the fact that the program graduate should feel equally at home in either electronics or mechanical technology. To accomplish this, it was absolutely essential that the individual learn the vocabulary of both technologies. The last factor to be discussed but of no less importance relates to faculty. One of the primary concerns of institutional program planners is faculty availability. Since the number of faculty with competence in both technologies was (and is) quite limited, it was necessary to design around this problem.

Consideration of these three factors led to the use of a curriculum structure that appears very conventional. Courses were developed around specific disciplines that could be structured on a semester or quarter system and could be taught by a competent specialist in the traditional disciplines. Within this conventional structure, each technology course was developed to:

a. Make a contribution to the teaching of the Unified Concepts.

b. Teach the terminology skills and techniques unique to the particular technology.

c. Have unity and continuity in and of itself.

4. <u>Use of Conventional Versus Individualized Instructional System</u>

The development of an instructional program using individualized instruction was also considered by the project staff. Again this idea had proponents who could build a good case in support of their position. This approach was rejected, however, for many of the same reasons that were used to justify the use of a conventional course structure. In short, not many institutions were capable of implementing an entire program using individualized instruction. It is also well known that this type of instruction is not well-suited for many students. The primary factors influencing the decision not to develop an individualized instructional program, however, were time and money. In addition to being very expensive, the development of such a system simply takes a long time. It was the consensus of the project staff that good instructor-led instructional materials would be most useful to individuals engaged in the development of individualized instruction in this field.

C. The First Experimental Curriculum

Initial testing of the curriculum and instructional materials with students was accomplished at Oklahoma State University. To facilitate this effort, the University approved the operation of a developmental program for two groups of students over a period of three years. To insure maximum flexibility for program development, many of the University rules were excepted, and permission to make exceptions in other areas was assured. For example, all courses including mathematics, physics, technical report writing and communications skills were assigned course prefixes which placed the responsibility for them with the project staff. At the same time faculty from these departments were made available to teach courses when it was deemed desirable for them to do so. While maximum flexibility was provided, the students enrolled in the program were granted regular admission to the University, and the Associate of Science Degree was awarded upon successful completion of the program.

The first group of students was enrolled in the 1968 fall semester. A copy of the initial curriculum outline used with this group is shown in Appendix A-2. As previously discussed, this curriculum was developed from the curriculum outline presented in the previous field study report.

1. The Balance of Electrical and Mechanical Content

A brief examination of this first outline reveals an imbalance between the treatment of electronics and mechanical technology. In addition to devoting twice as many credit hours to electricity as was devoted to mechanical technology, the type of treatment between the two areas was considerably different. The electricity course was taught from a somewhat analytical point of view. This meant that students were expected to learn certain laws and principles of technology and to use them in the solution of technical problems. Using this information the students were required to examine selected circuits, make calculations to predict specified outcomes, assemble the circuit, record data, compare predicted results with observed results and offer an explanation for any differences between the two. On the other hand, the mechanical course was primarily oriented to familiarize the students with machine tools and to develop rudimentary skills in using these tools.

This imbalance created serious problems. At a very early point, the students began to make important distinctions between the two technologies. In general, they felt that electronics was an intellectual pursuit worthy of time and study and that the mechanical was mundane and simple, requiring very little intellectual ability. Since one of the objectives of the program was to prepare technicians who are equally at home in either of the fields, these differences in attitudes indicated that this objective was not being met.

2. Laboratory Orientation

Curriculum planning begins with a consideration of what should be learned. Closely related to this, however, is the issue of how to teach those things that are deemed desirable or necessary. Considerations in this area are most important in educational planning in general and in technical education particularly. Educational methodology can greatly affect program costs. Data from the EMT field study suggested that a pre-employment educational program in this area should place major emphasis upon principles rather than specific applications of principles. While this concern is not new to education, it still causes problems. Many educational programs take the easy way out by giving little or no attention to applications. It is assumed that once an individual has learned the principles he will be able to recognize the applications. Most experienced technical educators have learned that this approach is rarely successful with technical students. One of the basic assumptions used in developing the experimental curriculum was that technical principles can be learned best by studying applications. In fact, numerous studies of learning have shown that when teaching principles, exposing the learner to a number of applications will increase the chances of generalizability. It has been shown also that the more the applications resemble actual conditions the more likely the individual is to recognize the principles which underlie the specific application.

Using this assumption, the project staff made the decision to make laboratory experiences the central focus of the educational program and to use laboratories to teach principles in addition to teaching techniques and skills. The operational philosophy adopted by the staff was that the "theory" part of a course should support the laboratory portion of the course. This system permitted considerable flexibility. For example, the faculty and materials developers felt quite free to introduce new principles in laboratory exercises and to use the "theory" portion to expand and amplify them. The decision to make laboratory instruction central to the program dictated the type of instructional materials that were developed by the project.

3. Treatment of Auxiliary and Support Courses

In planning the "EMT" curriculum, mathematics was considered a support area. This means that the primary objective of the mathematics courses was to aid the students in developing those competencies in mathematics that were considered essential for studying the technology. Selection and sequence of topics was determined by two factors: First, the necessity of the topic for study in the technical courses and secondly, the appropriateness of the topics in terms of pre-requisite knowledges and skills. Within the constraints of these two guidelines, every attempt was made to carefully integrate the mathematics courses with the science and technical courses.

Mathematics teaching has traditionally been one of the real problem areas in technician education, and most programs devote a substantial amount of time during the first semester to this area. Following a somewhat traditional approach, the EMT staff decided to devote five semester hours (approximately 30 per cent) of the first semester to mathematics. It was believed that this amount of time would be minimal for developing the required competencies. This time allocation would permit the instructor to spend time discussing applications of the rules and principles of mathematics to technical problems. During the first semester, it became apparent that the carefully coordinated program reduced the need for the mathematics instructor to deal with applications. Since the students were using their newly learned skills in the technical courses, it was not necessary for the mathematics teacher to be concerned with applications.

Treating mathematics as a tool course led to a discussion of whether or not a student who passes all of his technical courses can fail the mathematics course. This discussion led to experimenting with the idea of not giving examinations in the mathematics courses but using examinations in the technical courses to evaluate progress in mathematics. From the faculty point of view, this system was satisfactory, but it was not well received by the students. The absence of formal evaluation measures in the mathematics course was most frustrating, and the system had to be abandoned to reduce the anxiety level of the students.

As previously stated, the mathematics course was planned as a support course that would help develop these mathematical competencies required for study in the technical courses. A secondary, but important objective, was to help the students see the generalizability and utility of mathematics. For those students who have the ability to do so, this is a most important objective. It was believed, however, that the failure to achieve this objective should not be cause for a student's failure in the program.

One of the important competencies required of technicians is the ability to use the tools normally associated with the technology. These skills may be developed in a variety of ways. In some programs specfic courses are devoted to developing skills in using selected tools. In the EMT program a decision was made to introduce many of the skills in the first semester mechanics course. If it is necessary for the student to assemble a circuit or device of some kind prior to running his laboratory experiment, he can readily see the need for learning how to handle the tools and equipment necessary for making the assembly. Under this system each laboratory instructor is responsible for introducing proper techniques and encouraging students to follow them.

Drafting skills are also important to technicians. Again, many programs have a formal course in drafting. In the EMT program the decision was made to teach sketching, print reading, circuit diagram reading, and elementary fundaments of orthographic projection. Again, the method chosen to teach these skills was through the laboratory. For each laboratory session the student was required to write a brief report. In each report the student was instructed to include sketches, diagrams, and drawings where appropriate. This method provided numerous opportunities for students to develop skill in graphical communication. Some employers indicated agreement with this approach. Their position was that it would be easier for them to teach drafting skills on the job than it would be to teach the technology.

One of the significant findings from the EMT Field Study was the importance of communications skills. Data from this study indicated that the employers felt that the ability to communicate effectively was one of the most important competencies of electromechanical technicians.

Development of effective communication skills has long been one of the most difficult problems in all programs in science and technology. In general, technology students are weak in this area and have little interest in improving. Most two-year technology programs have one or two three semester hour courses devoted to communications skills during the first year of the program. The success of these courses has been less than spectacular.

In developing the EMT curriculum a rather unusual approach to this problem was tested. Rather than have the usual three-credit communications course in the first semester, a one-credit course in technical report writing was used. This course, taught by the University's English faculty, was designed to provide practical help in writing laboratory reports. The instructor met weekly with the other EMT faculty to identify problem areas and to seek ideas for instructional materials. In this system the English instructor was not responsible for major writing assignments, but served more as a resource person. The writing practice was provided in the laboratories. Each student was responsible for the preparation of six laboratory reports of three or four pages each week. This provided an opportunity for considerable writing practice.

During the second and third semester, no formal courses were concerned with communications skills. A three credit course in communications skills was included in the fourth semester of the program. This course was concerned with oral communications as well as written. In planning the program, it was expected that by the fourth semester the students would have become aware of the need for effective communications, would have identified some of their strengths and weaknesses, and would be more receptive to instruction in this area. It was also believed that the immediate concern of seeking employment would provide motivation and instructional opportunities. Such things as filling out application forms, assembling resumes, and writing letters of application can be excellent teaching tools.

This approach to teaching communications skills proved to be most satisfactory to both faculty and students. The faculty was pleased and impressed with the students' progress in written communications during the first semester, and the students liked the idea of not having a composition course. In fact some students indicated that they were attracted to the program by the absence of a composition course during the first semester.

A quick review of the preceding sections serves to point up the importance of good laboratory instruction in the EMT program. As previously discussed, the laboratories were used to: (1) teach technical principles, (2) teach sketching, print reading, circuit diagram reading and fundamentals of orthographic projection and (3) provide practice in writing. Good laboratory teaching is always challenging, but the task becomes difficult when these other responsibilities are associated with the laboratory. The success of this approach depends primarily upon a competent faculty with a willingness to plan to insure achievement of the several objectives.

Students enrolled in the developmental program at Oklahoma State University were expected to complete the requirements for an Associate of Science degree. One of the requirements for this degree is a three semester hour course in history and one in political science. To meet this requirement the EMT students were enrolled in the University's regular general education courses in these areas. The results were disappointing. Most of the students made their lowest grades in these courses. In fact three students did not complete the requirements for the associate degree because of a failure in one of these two courses.

It seemed to the project staff that this important area is one which needs a great deal of attention. Social science courses specifically designed around the needs, interests and abilities of technician students should be developed and tested for effectiveness. Toward this end a social science syllabus was prepared as part of the EMT project. Although this syllabus was not student tested, it may prove useful for use in technician education programs.

4. <u>Modifications During the First Year of Experimentation</u>

Throughout the program the project staff sought student feedback. This feedback deemed to be of upmost importance served to point out trouble spots that needed attention. Several changes were made as a result of student input.

One of the first changes made as a result of student input occurred in the first semester mechanical course. This course was primarily designed to teach elementary machine tool practices appropriate for electromechanical technicians. The course was taught using the project method, and the major project was a small screw jack. Completion of the project required the use of several machine tools to perform a variety of operations on different materials. At the same time the students were taking courses in mathematics, physics, electricity and electromechanical. From the students' point of view, these courses similar in content and method appeared to have unity and seemed to be related to their concept of electromechanical technology. They had considerable difficulty in seeing the relationship between these courses and the mechanical course. As a result, the students began to develop negative attitudes toward mechanics.

As soon as the project staff became aware of this problem, a decision was made to change the student project. It was hoped that having the students build an electronic signal injector rather than a mechanical screw jack would enable them to see the relationship between the several courses.

This program modification proved successful. As soon as the students started on the signal injector which looked more electromechanical, the expressions of concern began to subside. By the end of the first semester, most students professed to see the relationship between machine tools and the other areas. They did, however, view the area of mechanics as a skill area and of less importance than electronics which was taught as an analytical subject. These attitudes led to substantial changes in the program for the second group.

Student comments about the amount of credit devoted to mathematics also led to a significant program change for the second group. As noted from the program outline in Appendix A-1, five semester hours were devoted to mathematics and only four to electricity. The students felt that these were inappropriate since they spent more time studying electricity than mathematics. Consequently, the mathematics course was subsequently reorganized and reduced to three hours of credit bringing it more into line with the intensity of the other first semester courses.

D. The First Revision - Design II

Three major problems with the curriculum structure were identified during the first year. These were: (1) the structure of the physics courses did not facilitate the maximum use of the unified concepts, (2) a serious imbalance between electrical and mechanical technology existed, and (3) the amount of time devoted to formal mathematics instructions was considered excessive.

In an attempt to correct these problems, the curriculum outline and instructional approaches were changed. The curriculum outline for Group II is shown in Appendix A-3. The remainder of this section is devoted to a discussion of the major changes in the curriculum and instructional procedures.

1. Changes in Physics

The ten unified concepts discussed in a previous section were used as the basis of the first year of the program. During the first year an attempt was made to tie these in with a somewhat conventional treatment of physics. This generated several problems, the most significant being one of frustrations for the instructor. He simply did not have enough time to accomplish both objectives.

To overcome this problem the objectives of the physics courses were changed. The new objectives were to introduce each of the unified concepts to show applications in one area. During the first semester the applications were to be in fluids and during the second semester they were to be in optics. The physics instructor was not responsible for any other applications; these were the responsbility of the other instructors.

As shown in Appendix A-3 this was a four semester hour course with three theory hours and two laboratory hours. The instructor was to use two theory hours each week to discuss the generalizability of the concept and one hour to deal with the specific applications. This approach to the physics showing applications in fluids and optics added breadth to the program.

Once the concept had been introduced in the physics course, it was used in the electricity, mechanical, and electromechanical courses. In these courses modern devices and systems were used to show applications of the concept.

2. Improving the Balance of Electrical and Mechanical Content

Correcting this problem required much more than simply changing the amount of time devoted to the two courses. The instructional methods of one or both of the courses had to be changed. The project staff agreed to retain the methodology of the electricity course and to design a mechanics course with similar approaches.

The result of this was a mechanics sequence that departs rather significantly from the traditional treatment of mechanics. In addition to starting with a study of rotating devices, the course also uses a hands on laboratory approach. The students are afforded the opportunity to use standard hardware to assemble devices and to make measurements. These measurements can then be compared to predicted results and analyzed to determine causes for any differences between the two. This proved to be very motivational to the students.

This approach facilitates the use of mathematics which is similar to and at the same level as the mathematics used in the electricity course.

After completing this sequence, the second group of students had different attitudes toward mechanics than the first group. The second group expressed positive attitudes toward mechanics and the relationship between the two areas.

3. Changes in Mathematics, Hand Skills, and Drafting Skills

Curriculum development is a complex process, and a seemingly small change in one area can create major changes in other areas. Changes in the mechanics courses precipitated changes in several other courses. The additional time devoted to the mechanics course was obtained by reducing the time devoted to mathematics from five to three semester hours. At first glance this appears to be a substantial reduction in mathematics, but a more detailed look reveals that the amount of time that the student is concerned with mathematics is actually increased. Under the original curriculum the first semester student had four courses (mathematics, electricity, physics, electromechanical) that were mathematics oriented. These four courses totaled fifteen semester hours. The second group of students had five courses (mathematics, electricity, physics, electromechanical, mechanics) totaling seventeen semester hours that were mathematics oriented. The second group of students actually had more practice with mathematics than did the first group. Performance of both groups on standardized mathematics tests revealed that the two groups were very similar.

Eliminating the introduction of hand and machine tool skills from the first semester mechanics course necessitated other changes. This move increased the responsibility of the technical specialty instructors. It was now their sole responsibility to teach those skills that were appropriate to their specialty. It was also necessary to redesign the fourth semester "design course". This course was changed to a course called "Electromechanical Fabrication". The emphasis upon creative design was reduced while more attention was given to practical design and fabrication problems. This provided an opportunity for the students to use previously learned skills and to develop new skills that were essential for success in the course.

The development of skills in working drawings, circuit diagrams, and basic drafting was again assigned to the specialy instructors in the revised program. Students in the first group were judged to have made satisfactory progress in these areas; therefore, it was not necessary to change the instructional pattern for these skills.

4. Increased Laboratory Emphasis

The first group of students represented a wide range of background and abilities. There was considerable differences in achievement test scores, high school grades, high school programs, and mathematics courses taken. It is most difficult to serve a diverse group in one program. The project staff's success with the first group was most encouraging. Twenty-two of the original twenty-seven students completed the first year. Those students were very representative of the entering group. This is to say that there was no identifying characteristic of those who left the program. From conversations with students, it became evident that the laboratory emphasis of the program was a major factor in this success. In an attempt to further develop this emphasis, the revised curriculum placed more emphasis upon the laboratory and less on the theory. For example, the theory hours for the electricity course was reduced from three to two hours per week while the laboratory hours remained the same. This same time allocation was used for the mechanics course.

In contrast to the electricity and mechanics, three hours were assigned to the electromechanical laboratory. This was done to permit more time for the development of hand skills and drafting techniques. This course seemed to be more suitable for an extra emphasis in these areas than did the other courses.

E. Final Revision - Recommended Curriculum

Two groups of students were used in developing and testing the EMT curriculum. As previously discussed, student testing of the curriculum with the first group of students resulted in substantial changes. As the revised curriculum was used with the second group of students, several suggestions for improving the program were made. While the opportunity for student testing additional changes did not exist, the project staff felt a responsibility to make those changes which were believed to improve the curriculum. This Final Revision of the curriculum outline is shown in Appendix A-4.

A comparison of this outline with the Design II outline reveals that the recommendations for changes applied primarily to the second year. The only first-year change was the addition of one semester hour to the Electromechanical Motor Controls course permiting more time for study in the specialization.

This comparison also reveals several changes in the second year. Communications skills were moved from the fourth to the third semester. This change was made because students begin to job hunt during the later part of the third semester. It is most helpful to students to have instruction in writing letters of application, completing application forms and resume preparation prior to this. Changing the communications skills to the third semester necessitated other changes. The time devoted to the Transducers and Digital Electronics courses was reduced one semester hour each, and the total number of semester hours for the semester was increased by one.

The mechanics sequence for the third and fourth semester was also changed. A third semester course in Machines was added, and the Materials course was moved to the fourth semester. These changes provide for continuity in the mechanics throughout the four semesters. The machines course in the third semester is designed to build upon the first two mechanics courses by using the components used in those courses to study simple machines.

Again it should be mentioned that this arrangement was not student tested at Oklahoma State University. It is believed, however, that these changes would improve the curriculum.

SECTION IV

INSTRUCTIONAL MATERIALS DEVELOPMENT AND TESTING

The limited availability of appropriate instructional materials for use in technical curricula has been a long-standing problem for even the most traditional of programs. In recent years textbooks and laboratory manuals have become increasingly available. However, most of these materials, understandably, have been written for use in traditional courses.

Because of the unconventional nature of the Unified Concepts approach used in the project, it was decided that the project should undertake the preparation of a substantial part of the materials to be used. The format chosen called for an integrated set of action-oriented, laboratory centered texts and instructor's guides. The constraints placed on the format, as previously discussed, had an impact on the development of the materials. Since broad dissemination was an absolute requirement of the project, it was decided that the materials should be easily incorporated within existing school structures. Consequently, the materials were developed as a series of semester length courses using conventional course titles. The organization of these courses provided the coordination required to integrate the Unified Concepts.

To achieve the highly desirable integration, the first year courses were sequenced and paced in accordance with the introduction of the Unified Concepts. In this way, with reasonable faculty coordination, it was possible to achieve a high level of reinforcement between the various subject areas.

In the second year of the curriculum, no new Unified Concepts were introduced, and the instructional materials did not need to be correlated between courses. Indeed, the intent of the second year materials is to broaden the student's perspective in the various subject areas through application of the basic principles already learned. Throughout the program an effort was made to insure that each course should have several important characteristics. Firstly, they should fit existing school schedules. Semester length was used but with provision for relatively easy conversion to quarter or trimester length. Secondly, they must be sequenced and paced to conform to the introduction of the Unified Concepts thereby providing maximum transfer of learning between courses. Thirdly, each course must teach the technical terminology of the specialty area, allowing the student to continue his growth by using technical and professional journals, as well as supplemental texts. Lastly, an effort was made to produce materials that could be used in traditional programs.

A. Physical Facilities

The project classes were held in facilities provided by the Oklahoma State University on its main campus at Stillwater, Oklahoma. The actual space used was of two types, classrooms and laboratories. In the case of classroom space the project courses were scheduled in regular university classrooms. That is, the classrooms were in no way specially prepared for electromechanical courses. This arrangement was found to be quite satisfactory overall. However, it would have been convenient from time to time if the classrooms had been located adjacent to the laboratories thereby facilitating classroom demonstrations involving laboratory equipment.

The laboratory space that was used in the project consisted of two large (approximately 40 ft. x 60 ft.) rooms and one smaller (about 20 x 30) one. One of the larger rooms was set up as an electronics and optics lab while the other was used for mechanics and fluids. The smaller lab housed an IBM 1401 computer and other large training system equipment.

In general, the laboratories were very much like those found in a typical school offering electronics and fluids mechanics. Highly specialized facilities were not found to be necessary, and it is doubtful whether they would even be desirable. A somewhat more detailed set of recommendations about facilities requirements can be found in the EMT PROGRAM COMPENDIUM available through Delmar Publishers.

B. Research Staff

Initially, the research staff was composed of Dr. M. W. Roney (Project Director), Dr. D. S. Phillips (Associate Project Director), A. E. Fribance (Research Associate, Physics), L. P. Robertson (Research Associate, E.M.T.), and R. W. Tinnell (Research Associate, Elec.). The courses for the initial curriculum were planned, materials written, and the courses taught by these persons. At the end of the first year there was some concern that the success being achieved might be due to personal characteristics of these individuals. Also by that time, the demands for producing instructional materials were increasing rapidly. Based on both these factors, a decision was reached to rearrange the project staff assignments. The existing staff (named above) were assigned primarily to the preparation and revision of the instructional materials. Teaching of the courses was subsequently done by other teachers. Among these teachers were B. R. Hunter (E.M.T.), Theodore Ingram (Elec.), A. D. Kincannon (Mech.), and L. D. Briggs (Phys.). While these individuals were all experienced teachers, they had not previously been associated with a program of the type used in the project.

The high degree of success achieved in the project by these teachers was a strong indication that the program could be effectively presented by persons without a strong background in the EMT specialty.

C. Program Testing and Revision

The pattern followed in developing instructional materials was substantially the same in every case. Once the objectives for a given course were established, a lesson by lesson outline was developed by the project staff. The outlines for the first year courses had to conform to the order and timing of the unified concepts. Moreover, each lesson had to be one which could be readily developed into a laboratory exercise.

Based on the lesson outline, laboratory exercises were written and individually tested by the project staff. At the outset of the project a common format for the laboratory exercises was adopted. Using a common format throughout had two distinct advantages. First, it made it easier for the staff to produce the materials. Secondly, and perhaps most importantly, it allowed the students to go from course to course without the need to adjust to different formats. This simple arrangement allowed more materials to be produced and be used by students than is normally considered possible.

After a laboratory module was written and tested by the staff member, it was reviewed by the project coordinator (R. W. Tinnell) before being used by the students. This review was done to insure technical accuracy, consistent style and format, and appropriateness of level as well as content. After this review the modules were used with the developmental classes of students. The class teachers reported any difficulties they encountered and offered suggestions for improvements.

These comments as well as any feedback received from other cooperating schools were incorporated in the exercises when they were subsequently revised before second use with students.

Near the end of the project, all of the materials were reviewed by outside authorities, and their suggestions were included in the final revision before publication.

A list of the materials produced during the project is to be found in Appendix C. This listing gives some idea of the rather large amount of materials that were produced during the project.

SECTION V

STUDENT CHARACTERISTICS

A major assumption used in planning the EMT program was that this program would be most rigorous and would require relatively high admission requirements: high school graduation with mathematics through trigonometry, a laboratory science and mechanical drawing. The only alternative to these was believed to be a five-semester program. To test the validity of this assumption, a group of students with a wide range of abilities was recruited and admitted to the program.

This section discusses selected student characteristics and student achievement.

A. Measured Abilities

All students entering the EMT program were required to take the American College Test prior to admission. This test has four part scores and a composite score. The composite score is commonly used in comparing student groups. Composite scores for the EMT students are given in Table I. These data reveal a rather wide range of scores on this test. The group means for the two groups fall between the medians for "unselected high school seniors" and "college bound high school seniors". These scores also show considerable similarity between the two groups.

The EMT students were also required to take a university-developed test that is used to determine whether an individual is adequately prepared to enroll in freshman composition or whether he should be enrolled in a remedial course. The results of this test indicated that at least 75 per cent of the EMT students were not prepared for freshman composition.

Cooperative Mathematics Test scores are used to advise university students relative to mathematics placement. These tests were also administered to the EMT students. Results from this test showed that 50 per cent of the first group would have been eligible to enroll in college algebra. The others would have been required to take a lower course. Somewhat less than 50 per cent of the second group were eligible to enroll in college algebra.

On each of these tests there was a wide range of scores. In addition to this the students were different in other ways. Approximately one-half came from urban

Composite ACT Score	Group 1				Group 2			
	Fall 1968 N = 28	Spring 1969 N = 22	Fall 1967 N = 17	Spring 1970 N = 17	Fall 1969 N = 28	Spring 1970 N = 25	Fall 1970 N = 18	Spring 1971 N = 18
12	1	1	1	1				
13	2	2	2	2	2	2	1	1
14					2	1	1	1
15					1	1	1	
16	1	1	1	1	4	3	2	2
17	2	1	1	1	2	1	1	1
18	4	3	3	3	2	2	2	2
19	2	2	1	1	2	2	2	2
20	5	4	2	2	1	1		
21	3	2			1	1	1	1
22	2	1	1	1	1	1	1	1
23	1	1	1	1	4	4	4	4
24	4	4	4	4	3	3	1	1
25								
26					1	1	1	1
27								
28					1	1	1	1
29					1	1		
30					1	1		
Totals	27	22	17	17	29	26	18	18

	Composite ACT Mean	Composite ACT Median
Unselected high school seniors		15.6*
College bound high school seniors		20.4*
**Freshmen in typical colleges		18.05*
Group I, EM	19.4	
Group II, EM	19.7	

*Data taken from: USING ACT ON THE CAMPUS, 1966-1967 Edition.
**Includes junior colleges, technical institutes, and normal schools offering at least a two-year program of college level studies.

TABLE I

DISTRIBUTION OF ACT SCORES

high schools, the other half from rural high schools. Some had completed considerable mathematics and science, others very little. Some had completed high school programs in electronics or drafting and design, others had had very little contact with any aspect of technology. All of this added up to a very heterogeneous group of students.

B. Student Progress

Student progress was particularly satisfying to the project staff in some areas. One such area was English; the radically different approach was quite successful. At the end of the first semester the students were judged by the English instructor to be writing at the level of college sophomores. In addition the second group of students gained as much on the university-developed English test as did students in 14 randomly selected classes of freshman composition.***

Progress in mathematics was also considered satisfactory. Experienced technical instructors working on the project encountered no problems that could be traced to a lack of facility with mathematics.

In addition to using the Cooperative Algebra Test scores to compare the EMT students with other groups, these tests were also used to measure gain in mathematics achievement. A study comparing the gain of EMT students to technical students who took college algebra courses showed no differences between the groups.

An important factor related to successfully serving a diverse group of students was the evaluation system used. Recognizing that there are many different levels of technician jobs, the project staff decided to establish minimum levels of performance that would be considered satisfactory and required this of all students, but encouraged all students to achieve at the maximum of their ability. Very simply the minimum performance level for the laboratory courses was that the student attend the laboratory sessions, set up the experimental device, run the device, record the data and report the data. Those students who accomplished only this were given a grade of "C". Students who performed an analysis and who performed well on class tests were given higher grades. This system proved most effective in serving the two very heterogeneous groups of EMT students.

***A more detailed discussion of this result is given in the EMT PROGRAM COMPENDIUM, Delmar Publishers, Albany, 1971.

C. Student Feedback

In evaluating curriculum effectiveness, it is important to obtain student input. One of the things that the project staff attempted was to establish open lines of communication between students and faculty. During the first three semesters of the project this effort was very successful, and much valuable curriculum information was obtained from the students. During this period communication between the students and faculty was informal and on a random basis. While this system was productive and the project staff was satisfied with the results, an additional attempt to increase the feedback from students was made at the suggestion of a U.S.O.E. onsite evaluation team. The intent was to establish the formal system in addition to the informal system with student representatives attending weekly faculty meetings. Implementation of this suggestion created two problems. First, the faculty was somewhat inhibited and did not feel free to discuss problems that tended to be personal. Second, and much more important, was the student's response. The students tended to feel very threatened by the formal structure, and as a result the flow of information between faculty and student was inhibited. The primary result of the attempt to formalize student input was to develop a chasm between faculty and student, and to reduce communications.

SECTION VI

FIELD TESTING THE EXPERIMENTAL EMT CURRICULUM

The TERC electromechanical curriculum is unique in many respects, structurally different from single specialty two-year programs, requiring careful planning and continuous coordination. The critical imperative for planning and coordination is illustrated by the following case studies made in three separate institutions.

A. Three Case Studies

Institution A, a large urban community college, planned and developed a successful program by modifying and adding to the materials developed in the TERC experimental program. Institution B, a large urban technical college, experienced considerable difficulty in getting the program underway. Planning was limited by a lack of materials. Through careful coordination, using the revised and improved TERC materials, the program has become well-established and has had profound effects, some of which were not anticipated. Institution C, a technical institute, attempted the program with little planning or coordination and has not succeeded in establishing an EMT program.

Institution A began the program in 1972 after careful study and thorough planning. Interestingly enough, the availability of the TERC materials was a critical factor in the decision to undertake an electromechanical technology curriculum. Earlier studies by the staff, working with an industrial advisory committee, had led to the conclusion that a dual technology program was not feasible. The institutional policy of limiting programs to two years (four semesters) did not appear to permit study in more than one specialized field. The TERC curriculum plan provided an integration of electrical, mechanical, and physical science principles, making a two-year program practical for that institution.

Institution B began the program with minimum assistance in 1969. The experimental program was not yet fully implemented. Instructional materials were rough and underdeveloped, and it was not clear at that time just what the employment opportunities for graduates might be. The viability of the unified concepts system of instruction was, at best, speculative. In spite of these handicaps, the program eventually became well-established.

Institution C attempted to modify an existing electronics program, starting in 1970. TERC materials were used only for mechanics courses, and the responsibility for the program was lodged in the electronics department. No real enthusiasm for the unified concepts system of instruction ever developed, and the program was not successful.

The positive factors contributing to the success of the TERC-EMT system in Institutions A and B appear to center around administrative procedures. Both of these schools made provision for coordinating the work of teachers from the outset. As a result the unification of subject matter was accomplished. Improvisations were made when necessary to smooth out rough spots. In school A the physics and mathematics courses were paced with the subject matter in the specialized courses. Significant additions were made to the physics instructional material, and physics instructors utilized a fluids laboratory and an electrical laboratory to supplement the regular physics laboratory. Leadership at the operational level actually came from the physics department although it should be noted that, in this particular school, technology facilities and supporting services in mathematics and physics are contiguous, making coordination somewhat easier than in many schools.

A contrasting situation existed in school B. Mathematics, physics, and technology departments were housed in separate buildings, several blocks apart. Nevertheless, coordination was accomplished by scheduling regular meetings of the EMT teachers. In addition this school assigned a counselor extra time with the students in the EMT program. The work of this particular counselor was all-important, especially in the early, difficult stages of the new program.

B. Some Side Effects

Several interesting trends have appeared in the schools that have experienced success with the TERC-EMT program. The unified concepts approach to physics has had a profound effect on physics instruction. Always a vital element of technical education, physics has seldom been accepted as a full partner of the technologies. In the TERC system this is an imperative. There is reason to hope that the idea may spread to other clusters of occupations.

Students in large nonresident urban schools do not usually work or study together. At school B, however, students found that the unity of the EMT curriculum made it especially advantageous to exchange ideas. Where multiple applications of a common principle are being studied, it is inevitable that each student will understand some applications and will have difficulty with others. The students formed study groups at school B in spite of the difficulties encountered in getting to a common meeting point. One such study group met at 7:00 A.M., an astonishing development in view of the fact that many of these students worked long hours at outside jobs in addition to the time required in the full-time EMT program.

The reaction of teachers has been equally gratifying. Departmentalization of subject matter has always bred provincialism and, in some institutions, has led to the isolation of subject matter specialists. Unification of subject matter in the EMT curriculum has had the opposite effect. Teachers from the several disciplines have found many advantages in working together. Some found that homework assignments could be reduced without loss of student achievement. Coordination increased student motivation significantly because students realized that each subject was a vital part of the study program. Attrition for academic deficiency was reduced markedly. Students with personal problems were given special attention where counselors meeting with teachers were able to identify these problems and provide assistance before they became serious enough to cause a student's failure.

SECTION VII

DISSEMINATION OF EMT RESEARCH PRODUCTS

Dissemination of research products was an integral part of the Electromechanical Technology project from its initial stages. A standard operating policy, established at the outset, was to make materials available at all times to school administrators. This policy applied to all project materials considered useful in planning or operating EMT programs, even during the stages of development when materials were in rough and untested form.

The rationale for this policy was a desire to be of maximum assistance to schools at all stages of the project. The effects of this policy were positive in some respects and negative in others. In most cases those who received underdeveloped and incomplete materials understood and appreciated the reasons for their inadequacy. Some who were highly critical of the materials may have rejected the underlying concepts because they were not adequately presented. On balance, however, it was the consensus of the project staff that to withhold project materials until they had been perfected would be a disservice to those who were genuinely interested in developing electromechanical training programs. Over the five-year period approximately three hundred and seventy-five schools have been furnished information and have remained on the project mailing lists.

A. Dissemination Activities During The Project Development

This multidisciplinary program contains many similarities to single-discipline programs which encourage a school to consider the feasibility of program implementation:

- student admission (entrance) requirements
- course/semester structure
- totality of topics covered in each course series
- lecture-laboratory presentations
- applicability of courses to other technology programs
- use of field trips for industrial orientation.

The initial ALERT to schools involved a series of mailings over eighteen months:

- to schools that were presently using the experimental, draft laboratory texts.
- to schools that had written in to inquire about the experimental program and its status.

- to schools gathered from two existing mailing lists:

  Delmar Publishers and the American Association of Community and Junior Colleges

A one-page questionnaire was forwarded with a cover letter requesting data on school plans regarding an EMT-like program. More than 2,000 letters were mailed and more than six hundred were eventually returned with just under three hundred schools expressing various degrees of interest in the program.

TERC, coordinating with Delmar, sent information to schools twice each year, noting progress and inviting participation for reviews, workshops, etc. The list of interested parties grew over an eighteen month period to more than 375 names based on:

- word of mouth among school personnel
- presentations at conferences by members of TERC
- visits to individual school, and groups of schools-initiated by TERC

Those persons interviewed during school visits were asked how TERC could help them initiate the EMT program

- while USOE funds were available
- after the grant had ended

Many persons showing more than a casual interest were solicited for new ideas. In these ways the technical-education community was made to realize that their opinions were of value to the EMT research team.

It soon became apparent that another group of interested parties--the suppliers of EMT-like laboratory hardware--could assist in alerting potential users at no cost to USOE and TERC. More than three hundred potential suppliers were solicited by mail to see how TERC could best provide them with information concerning the EMT program. Thirty-three suppliers registered with TERC.

Both schools and suppliers needed to know more about each other and about the EMT program. A SOURCEBOOK OF SCHOOLS AND INDUSTRIAL SUPPLIERS was therefore conceived and published by TERC in January 1972. The contents included:

- brief description of the TERC-EMT program

- available materials and services, such as
  - planning information available
  - laboratory text listing
  - local consultant names and addresses
- school information, by state, for
  - participating (EMT-test) schools
  - schools interested in the TERC-EMT program
  - schools with a non-TERC-EMT program
- industrial suppliers
  - of preassembled kits of parts for each lab text
  - of individual items of hardware
- laboratory equipment, per lab text
  - in lists, with a brief description where helpful
  - in matrix form, by experiment, to simplify parts ordering

More than 750 of these sourcebooks were distributed. A second edition was published containing two additional suppliers and 175 new "interested" schools.

These various offerings and nonresearch (dissemination) assistance eased the concern of many school administrators who, often in the past, had lacked detailed new program documentation. The credibility of the program's research results gradually grew in stature, and schools began asking for permission to use the laboratory texts even in draft form. These materials were disseminated as complimentary copies or at cost when any school would respond with evaluative information.

As the TERC consultants, using schools and industrial suppliers, became supportive of each other, the need for further planning and implementation documentation was apparent. The list has grown to forty-one documents.

B. Published Materials

A major assist in disseminating EMT research products was provided by the Delmar Publishing Company. Sixteen action-oriented textbooks produced from the project have been published along with instructor guides for each text and a compendium describing the EMT curriculum in detail (see Appendix C). By 1972 textbooks in this series were being used in 30 states (see Appendix B) and Canada.

In addition to the materials published by Delmar, a number of special publications have been made available from the corporate headquarters office of TERC in Cambridge, Massachusetts. Included in these special publications is a very valuable source book that lists manufacturers and distributers of equipment and supplies used in electromechanical technology instruction. A list of publications available on August 1, 1973 is included in Appendix C of this report.

A number of workshops and conferences were held throughout the country to familiarize users with TERC-EMT materials. Presentations were made at professional meetings, and consulting services were provided for interested school officials. Training sessions were held for selected regional consultants whose services will continue to be available in future years.

The impact of these materials on EMT program development is difficult to evaluate. No criteria exist for such an evaluation. The goals at the outset, as previously outlined, were to respond to every request for assistance and to make the materials as widely known as possible. Within the limits of the time and funds available, this was accomplished.

It is known that in 1972 seventy schools were using TERC-EMT materials. At least one school has obtained program accreditation by the Engineers Council for Professional Development. Information gathered in conferences and workshops indicate that the need for electromechanical technicians is growing steadily. The obvious sucess of the TERC-EMT program in some well-established schools will serve to encourage others, and additional course materials now under development in these schools will improve the coordination of instruction.

C. Related Projects Stimulated by The EMT Research

The products of the EMT project have been used in a number of activities designed to improve occupational education services. Foremost among these activities and directly related to the development project at Oklahoma State University was an EPDA graduate fellowship program for EMT teachers. Another significant activity involved Oklahoma two-year colleges in a consortium effort designed to incorporate EMT materials in a technical core program.

Another activity supported by the National Science Foundation, in 1973, was a developmental program at a junior college, using the TERC-developed Unified Concepts as a base for a number of related technician training programs.

In all of these activities the significant element was the student-tested instructional materials developed in the TERC experimental programs and subsequently published by the Delmar Publishing Company. Details of these three projects may be obtained from unpublished reports and records at the School of Occupational and Adult Education, Oklahoma State University, Stillwater, Oklahoma 74074.

1. An EPDA Teacher Training Program

The Oklahoma State University, in cooperation with TERC, conducted an experienced teacher fellowship program for EMT teachers. Funds for this program were provided by the U. S. Office of Education with an EPDA grant entitled "Development and Evaluation of A Teacher Education Program in Electro-Mechanical Technology".

Fifteen experienced teachers were provided fellowships and were given an intensive one-year graduate study program on the OSU campus at Stillwater, Oklahoma, during the 1969-70 academic year. The teacher training program and the TERC-EMT developmental project were closely related. All instructional materials produced in the developmental project at OSU were made available to the EPDA Fellows. The Fellows were assigned as teaching assistants in the experimental program, produced a number of research reports, and contributed materially to the testing and evaluation of EMT instructional materials.

As a part of their study program, each of the 15 Fellows completed a field study to determine the specific skill and knowledge requirements for electro-mechanical technicians in his area of the country. Making full use of their experiences in the experimental program and the published EMT materials, these individuals have provided leadership in institutions throughout the United States in the development of EMT-type instructional services designed to prepare technicians in emerging occupations.

2. A Consortium Effort

Early success with the EMT curriculum led the project staff to give attention to the possibility of developing a first-year core of technical courses which could serve as a basis for several second-year options. This curriculum pattern, termed a "nucleate" curriculum was built around the Unified Concepts developed in the TERC-EMT project. Motivation to pursue this idea was provided by the administration of Oscar Rose Junior College at Midwest City, Oklahoma, during the planning stages of that institution. As a new institution in the metropolitan area of Oklahoma City, it was felt that this plan would have many advantages.

To assist with this development a consortium project between these six junior colleges and the Oklahoma State University was supported by the National Science Foundation. During the summer of 1971, three faculty members from each of the cooperating junior colleges worked with the TERC development team on the Oklahoma State University campus. Their two basic objectives were: (1) to develop instructional materials to be used on their local institution and (2) to update their technical competence.

During the 1971-72 academic year, the program participants met regularly on the campuses of the cooperating institutions to become familiar with the facilities, equipment, and offerings of the several institutions, and to exchange ideas about their programs. This was followed by an additional two months of detailed planning on the Oklahoma State University campus during the summer of 1972.

As other institutions began to examine this curriculum structure, additional interest was generated, and in the fall of 1970 four Oklahoma junior colleges had implemented some form of a "nucleate" curriculum and two others were in the planning stages.

3. An Institutional Development Project

The third project to be discussed was a materials development project supported by the National Science Foundation and conducted by Oscar Rose Junior College. This project was conducted during the period June 1972 - August 1973. As previously stated, Oscar Rose Junior College implemented the "nucleate" curriculum pattern for engineering technologies in 1970. This plan was a core of technical courses for the first year which serve as the basis for several second-year options. The first year core of technical courses used by Oscar Rose was the first year EMT courses developed in the demonstration project. As a new institution, Oscar Rose used the courses primarily as they were developed.

During the first two years, the faculty became aware of the need to make modifications in these courses to meet their unique situation. They also became aware of the need for further development of second-year courses to adequately support their second year options. With the support of the National Science Foundation, much work was done to refine these curricular offerings. That these efforts have been effective is evidenced by a 50 per cent increase in the technology enrollments at this institution in the Spring and Fall of 1972.

In summary, it was evident that close cooperation and coordination between these three projects and the EMT development project served to multiply the effectiveness of each activity. The published EMT materials were used effectively as a basis for planning new programs and/or modifying existing services. It is significant that each institution added to or modified the TERC developed materials in view of local facilities and needs.

D. A Problem of Acceptance

One serious handicap encountered in working with schools during the project was the reactionary attitude of some teachers. Specialists in certain disciplines appear to resent the implication that technology is changing the relative importance of their specialty. It is difficult for some teachers of electronics to accept the idea that mechanics should be an equal partner. Physics teachers, comfortable with the traditional order of physics instruction, may resent the reordering of topics required in the unified concepts approach. While the evidence is overwhelming that teachers, given the opportunity to work in a coordinated EMT program can and will change their attitudes, the number reached in this manner is small indeed. A major effort should be mounted to familiarize industrial teacher educators with the TERC-EMT system of instruction. Unless and until the positive values of coordinated instruction inherent in this particular program are accepted and promulgated by teacher education institutions, the full potential of this project will not be realized.

In summary, the impact of this has been felt throughout the country. The research products generated are useful, practical materials whether or not they are used as a part of the TERC-EMT program. Most significant of all, however, the project produced a new system of instruction, with implications that go well beyond the field of electromechanical technology. Case studies of three schools illustrating this impact were summarized in a previous section of this report.

Post-project dissemination of project materials will be a major determinant in the total impact of the EMT project. Any new program must compete with existing educational services. Much work remains to be done if technical school administrators are to be convinced that the limited funds available to them should be used for a new program rather than to expand existing services.

The contractor (TERC) is dedicated to a continued dissemination effort during the next few years that will make the best use of the material developed under the project grant. Whatever resources are available will be used to insure that this tested and proven system of instruction is not absorbed and emasculated by traditionalists in the education system.

SECTION VIII

SUGGESTIONS FOR ESTABLISHING NEW EMT PROGRAMS

One of the major problems encountered in establishing new educational programs through research is the "N.I.H." syndrome--"Not Invented Here". Many teachers are reluctant to use materials, techniques, and programs developed outside of their own sphere of influence. Often, the rationalization used is that "local" needs preclude the use of materials designed for more general use.

The EMT curriculum is designed to provide great flexibility in the second year. It became apparent, however, in the early stages of the project that the first-year studies program must be tightly structured if the Unified Concepts system was to be effective. This requirement has, admittedly, been a deterrent to some schools. Instead of making modifications in existing courses, it is necessary to install a completely new program, even though the content of some of the course work is not entirely new. The justification for this somewhat radical step is quite clear. Where there has been an executive commitment to the objectives of the EMT system followed by an administrative plan for implementation, the system has been successful.

The preceding case studies illustrate the significance of administrative planning. Based on these case studies and experience with several other institutions, the following program planning elements are recommended:

A. An Analysis of The Need for Technicians in This New Field

There is much evidence that the job title "Electromechanical Technician" is not yet in general use. Nevertheless, when the job functions of technical personnel are studied, it is clearly evident that technicians in many industrial production and field service activities do require skills and knowledge beyond those provided in traditional single technology programs. Advisory committees with representation from these industries with these activities can verify this need.

B. <u>An Analysis of The Relationship of The New Program to Existing Programs in The Institution</u>

It is extremely important at an early stage in the planning that the relationship between existing programs in electronics, mechanical technology, and physics be understood and that all possible use be made of existing personnel and facilities. Some aspects of these relationships are described in the EMT PROGRAM COMPENDIUM available from the Delmar Publishing Company, Mountainview Avenue, Albany, New York 12205. Direct consulting services can be obtained from the Technical Education Research Centers, Cambridge, Massachusetts 02138, or any of the several regional TERC offices.

Two-year institutions with ongoing programs will normally have most of the facilities and staff required for the first year of the EMT program. The critical element is a clear understanding of the facilities scheduling and the teacher coordination required. Administrative decisions as to responsibility and authority for program development are also critical at this stage.

C. <u>Identifying Equipment Requirements</u>

The published instructional materials include a comprehensive analysis of the equipment needed for each course. In addition, a Sourcebook of Schools and Suppliers is available from TERC, Cambridge. This sourcebook will save valuable time in locating some of the newest equipment for laboratory use in the program.

D. <u>Staff Orientation and Training</u>

Perhaps no single activity is more important to the success of the program than a thorough orientation of teachers. This initial orientation should be followed by a scheduled program of meetings during the first year of the program. Case studies of successful programs clearly reveal that the benefits accruing from this kind of teacher involvement far outweigh the expense and time required to schedule the activities. At one school, over a four-year period, the attitude of teachers was observed to change from interest, to skepticism, to hostility and, finally, to enthusiastic cooperation.

In summary, the normal reaction to a new program is one of doubt, apprehension, and concern for established, successful education services. It is imperative that administration, staff, and faculty be convinced that the need for a program of services in genuine; that it will strengthen and support other institutional services; and that it will be personally and professionally rewarding. The EMT program can meet these criteria if strategic and tactical planning is adequately effected.

APPENDIX A-1

FIELD STUDY CURRICULUM OUTLINE

	ELECTRO-MECHANICAL COURSES *	PHYSICS COURSES	ELECTRICAL-ELECTRONIC COURSES	MECHANICAL COURSES	MATH & GENERAL EDUCATION COURSES	
1st TERM	CLASS 1 LAB 3 CR. 2 MECHANICAL COMPONENTS AND INTRODUCTION TO ELECTROMECHANICAL SYSTEMS	CLASS 3 LAB 2 CR. 4 TIME AND SPACE UNITS BASIC ENERGY SYSTEMS MECHANICS (STATICS, DYNAMICS) MECHANICAL MEASUREMENTS - TEMPERATURE, PRESSURE	CLASS 3 LAB 4 CR. 1 ATOMIC AND MOLECULAR STRUCTURE (CONDUCTORS, SEMI-CONDUCTORS) BASIC ELECTRICAL UNITS D. C. CIRCUITS A. C. CIRCUITS	CLASS 1 LAB 3 CR. 2 USE OF HAND TOOLS FITS AND FINISHES THREADS AND FASTENERS MACHINES AND MACHINE PROCESSES	CLASS 5 CR. 5 REVIEW OF INTERMEDIATE ALGEBRA TRIGONOMETRY ADVANCED ALGEBRA	CLASS 1 CR. TECHNICAL REPO WRITING
2nd TERM	CLASS 1 LAB 2 CR. 2 FLUID DEVICES HIGH VACUUM SYSTEMS HIGH ENERGY LIGHT SYSTEMS	CLASS 3 LAB 2 CR. 4 SOLID STATE PHYSICS PRINCIPLES OF HEAT AND HEAT TRANSFER LIGHT AND OPTICS FLUID MECHANICS	CLASS 3 LAB 4 CR. 4 A. C. CIRCUITS (CONTINUED) VACUUM TUBES SEMI-CONDUCTORS AND CIRCUITS POWER SUPPLIES AMPLIFIERS	CLASS 3 LAB 2 CR. 4 MATERIALS TESTING ENGINEERING MATERIALS HEAT TREATMENT CORROSION	CLASS 3 LAB 0 CR. 3 APPLICATION OF ANALYTIC GEOMETRY AND CALCULUS	
SUM					OPTICAL SUBJECTS - ASSOCIATE DEGRE REQUIREMENTS, CHEMISTRY, ETC.	
3rd TERM	CLASS 3 LAB 2 CR. 4 SYNCHROS, RESOLVERS SERVO-MOTORS AND GENERATORS CHOPPERS, TACHOMETERS SERVO AMPLIFIERS FLUID SERVOS DIGITAL-ANALOG CONVERTORS TELEMETERING DEVICES RECORDERS, PLOTTERS	CLASS 3 LAB 2 CR. 4 ELECTRICAL MOTORS AND GENERATORS SPEED CONTROL TRANSMISSIONS CLUTCHES & COUPLINGS SERVO MECHANISMS INTRODUCTION TO CLOSED LOOP SYSTEMS	CLASS 3 LAB 4 CR. 4 LOGIC CIRCUITS LOGIC SYSTEMS SYSTEMS ANALYSIS. TIMING & WAVE SHAPING CIRCUITS MEASURING INSTRUMENTS ELECTRICAL TRANSDUCERS	CLASS 3 LAB 3 CR. 4 GEARS AND GEAR TRAINS PLANE MOTION DIFFERENTIAL MOTION MECHANICAL INTEGRATION TORQUE AMPLIFICATION AND FORCE AMPLIFIERS BEARINGS	CLASS 2 LAB 0 CR. 2 NUMBER SYSTEMS LOGIC SYSTEMS BOOLEAN ALGEBRA	
4th TERM	CLASS 3 LAB 3 CR. 4 ELECTRO-MECHANICAL SYSTEMS DESIGN PRINTERS DIGITAL READOUT MISSILE CONTROL ELEVATOR CONTROL TAPE TRANSPORTS TELETYPEWRITERS DATA STORAGE AND RETRIEVAL	CLASS 3 LAB 3 CR. 4 ELECTRICAL, MECHANICAL, HYDRAULIC PROCESS CONTROLLERS VARIABLE POWER DEVICES COMPUTERS CLOSED LOOP SYSTEMS	CLASS 1 LAB 6 CR. 3 PROBLEM ANALYSIS DATA COLLECTION TECHNIQUES DATA EVALUATION TECHNIQUES PROBLEM SOLUTION(S) SOLUTION EVALUATION SOLUTION IMPLEMENTATION VERIFICATION		CLASS 3 Cr. 3 ECONOMOICS	CLASS 3 CR. COMMUNICATIONS

* THE DEVICE AND SYSTEMS TO BE USED WILL BE SELECTED INDUSTRIAL APPLICATIONS. THE ITEMS SHOWN ARE TYPICAL.

ADMISSION REQUIREMENTS:
HIGH SCHOOL ALGEBRA, TRIGONOMETRY, MECHANICAL DRAWING AND A LABORATORY SCIENCE
A PRE-TECHNOLOGY TERM WILL BE NECESSARY FOR STUDENTS NOT MEETING THESE REQUIREMENTS.

APPENDIX A-2

INITIAL CURRICULUM
(Group I)

First Semester

COURSE NUMBER	TITLE	T	L	C
ELME 1015	Applied College Mathematics	5	0	5
ELME 1001	Technical Report Writing	1	0	1
ELME 1012	Machine Processes	1	3	2
ELME 1202	Introduction to EM Technology	1	3	2
ELME 1204	Mechanics and Dynamics (Physics)	3	2	4
ELME 1004	Fundamental Concepts of Electricity	3	2/2*	4
		14	12	18

Second Semester

COURSE NUMBER	TITLE	T	L	C
ELME 1304	Fluids, Mechanics, Heat and Light (Physics)	3	2	4
ELME 1114	Electronic Devices & Amplifiers	3	2/2	4
ELME 1104	Engineering Materials & Testing	3	2	4
ELME 1113	Applied Diff. & Integral Calculus	3	0	3
ELME 1302	Hydraulics & Vacuum Technology	1	2	2
		13	10	17

Third Semester

COURSE NUMBER	TITLE	T	L	C
ELME 2104	Automatic E M Control Systems	3	2	4
ELME 2004	Mechanisms & Dynamic Analysis	3	3	4
ELME 2014	Electronic Logis & Meas. Systems	3	4	4
ELME 2114	Electromechanical Control Devices	3	2	4
		12	12	16

Fourth Semester

COURSE NUMBER	TITLE	T	L	C
ELME 2213	Communications Skills	3	0	3
ELME 2223	Design Problem	1	6	3
ELME 2234	Closed Loop Process Control	3	3	4
ELME 2234	Automatic Control Output Devices	3	3	4
		10	12	14

*Indicates 2-2 hour laboratory periods per week

T = Theory - Hours per week
L = Laboratory - Hours per week
C = Credit - Hours per semester

APPENDIX A-3

REVISED CURRICULUM
FOR
GROUP II

First Semester

COURSE NUMBER	TITLE	T	L	C
ELME 1001	Technical Report Writing	1	0	1
ELME 1102	EM Devices	1	3	2
ELME 1124	Unified Physics I (Fluids)	3	2	4
ELME 1104	Electricity	2	2/2*	4
ELME 1114	Mechanical Drives	2	2/2	4
ELME 1103	Algebra and Trigonometry	3	0	3
		12	13	17

Second Semester

COURSE NUMBER	TITLE	T	L	C
ELME 1202	EM Motor Controls	1	3	2
ELME 1204	Unified Physics II (Optics)	3	2	4
ELME 1214	Electronic Amplifiers	2	2/2	4
ELME 1224	Mechanical Linkages	2	2/2	4
ELME 1233	Calculus & Analytic Geometry	3	0	3
		11	13	17

Third Semester

COURSE NUMBER	TITLE	T	L	C
Hist 2493	American History	3	0	3
ELME 2104	Digital Electronics	3	2	4
ELME 2114	Transducers	3	2	4
ELME 2123	Controls I (Automatic Controls)	2	2	3
ELME 2103	Materials	2	2	3
		13	8	17

Fourth Semester

COURSE NUMBER	TITLE	T	L	C
ELME 2003	Communications Techniques	3	0	3
PolSC 2013	American Government	3	0	3
ELME 2214	Electromechanical Fabrication	2	6	4
ELME 2224	Electronic Communications	3	2	4
ELME 2233	Controls II (Servomechanisms)	2	3	3
		13	11	17

*Indicates 2-2 hour laboratory periods per week

T = Theory - Hours per week
L = Laboratory - Hours per week
C = Credit - Hours per semester

APPENDIX A-4

FINAL REVISION
RECOMMENDED CURRICULUM

First Semester

COURSE NUMBER	TITLE	T	L	C
GE 1111	Technical Report Writing	1	0	1
EM 1202	Electromechanical Devices	1	3	2
PH 1104	Unified Physics I (Fluids)	3	2	4
ET 1104	Electricity	2	2/2*	4
ME 1104	Mechanical Drives	2	2/2	4
MA 1103	Algebra & Trigonometry	3	0	3
		12	11	18

Second Semester

COURSE NUMBER	TITLE	T	L	C
EM 2103	Electromechanical Motor Controls	2	3	3
PH 1204	Unified Physics II (Optics)	3	2	4
ET 1204	Electronic Amplifiers	2	2/2	4
ME 1204	Mechanical Linkages	2	2/2	4
MA 1203	Calculus & Analytics	3	0	3
		12	13	18

Third Semester

COURSE NUMBER	TITLE	T	L	C
GE 2103	Social Science I	3	0	3
ET 2103	Digital Electronics	2	2	3
ME 2203	Machines	2	2	3
EM 2103	Transducers	2	2	3
EM 2203	Automatic Controls	2	2	3
GE 2213	Communications Skills	3	0	3
		14	8	18

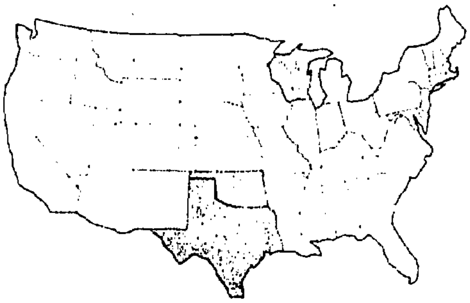
Fourth Semester

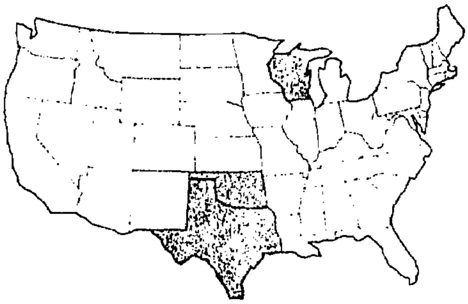
COURSE NUMBER	TITLE	T	L	C
GE 2203	Social Science II	3	0	3
EM 2214	Electromechanical Fabrication	2	6	4
EM 2204	Servomechanisms	3	3	4
ET 2213	Electronic Communications	2	2	3
ME 2103	Materials	2	2	3
		12	13	17

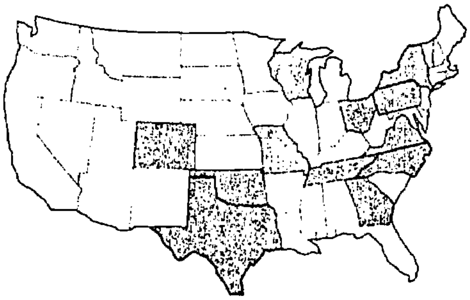
*Indicates 2-2 hour laboratory periods per week

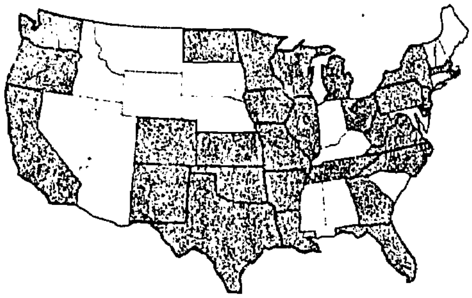
T = Theory - Hours per week
L = Laboratory - Hours per week
C = Credit - Hours per semester

GROWTH OF SCHOOL USAGE
TERC ELECTROMECHANICAL TECHNOLOGY PROGRAM MATERIALS









CALENDAR YEAR	STATES	SCHOOLS INVOLVED*
1968	1	1
1969	3	3
1970	3	6
1971	12	21
1972	30	70

*School purchases of TERC EMT program texts for students in one or more courses.

TERC Technical Education Research Centers
44 Brattle Street, Cambridge, Mass. 02138

Appendix C
Materials Produced

ELECTROMECHANICAL TECHNOLOGY Project No. 8-0219

PUBLICATION NUMBER	PUBLICATION TITLE
110-001.	United Physics/FLUIDS Laboratory Text
110-002.	United Physics/FLUIDS Instructor's Data Guide
110-003.	Electronics/ELECTRICITY Laboratory Text
110-004.	Electronics/ELECTRICITY Instructor's Data Guide
110-005.	Mechanisms/DRIVES Laboratory Text
110-006.	Mechanisms/DRIVES Instructor's Data Guide
110-007.	Electromechanisms/DEVICES Laboratory Text
110-008.	Electromechanisms/DEVICES Instructor's Data Guide
110-009.	Unified Physics/OPTICS Laboratory Text
110-010.	Unified Physics/OPTICS Instructor's Data Guide
110-011.	Electronics/AMPLIFIERS Laboratory Text
110-012.	Electronics/AMPLIFIERS Instructor's Data Guide
110-013.	Mechanisms/LINKAGES Laboratory Text
110-014.	Mechanisms/LINKAGES Instructor's Data Guide
110-015.	Electromechanisms/MOTOR CONTROLS Laboratory Text
110-016.	Electromechanisms/MOTOR CONTROLS Instructor's Data Guide
110-017.	Electronics/DIGITAL Laboratory Text
110-018.	Electronics/DIGITAL Instructor's Data Guide
110-019.	Mechanisms/MACHINES Laboratory Text
110-020.	Mechanisms/MACHINES Instructor's Data Guide
110-021.	Electromechanisms/TRANSDUCERS Laboratory Text
110-022.	Electromechanisms/TRANSDUCERS instructor's Data Guide
110-023.	Electromechanisms/AUTOMATIC CONTROLS Laboratory Text
110-024.	Electromechanisms/AUTOMATIC CONTROLS Instructor's Data Guide
110-025.	Electronics/COMMUNICATIONS Laboratory Text
110-026.	Electronics/COMMUNICATIONS Instructor's Data Guide
110-027.	Mechanisms/MATERIALS Laboratory Text
110-028.	Mechanisms/MATERIALS Instructor's Data Guide
110-029.	Electromechanisms/SERVOMECHANISMS Laboratory Text
110-030.	Electromechanisms/SERVOMECHANISMS Instructor's Data Guide
110-031.	Electromechanisms/FABIRCATION Laboratory Text
110-032.	Electromechanisms/FABRICATION Instructor's Data Guide
110-050.	EMT Program Compendium
110-051.	EMT Sourcebook of Schools & Industrial Suppliers
110-052.	Data Processor Comparisons
110-053.	D. C. Motor Comparisons
110-055.	Administrator's Guide
110-056.	Staff Training Guide
110-057.	EMT Mathematics Syllabus
110-058.	EMT Communications Skills Syllabus
110-059.	EMT Social Science Syllabus

APPENDIX D

HIGHLIGHTS OF EMT PROJECT

Development of Career Opportunities for Electro-Mechanical Technicians

ajor Project Activities

EMT Project Begins

Pilot Program Begins, Oklahoma State University
First Year Instructional Materials Drafted

First Year Materials Tested at OSU
Second Year Materials Drafted
EMT Summer Workshop
First National Project Evaluation

First Year Materials Tested at OSU and Five Pilot Schools
Second Year Materials Tested at OSU
Publisher Selected
Compendium Published
EMT Summer Workshop Held
Second National Project Evaluation

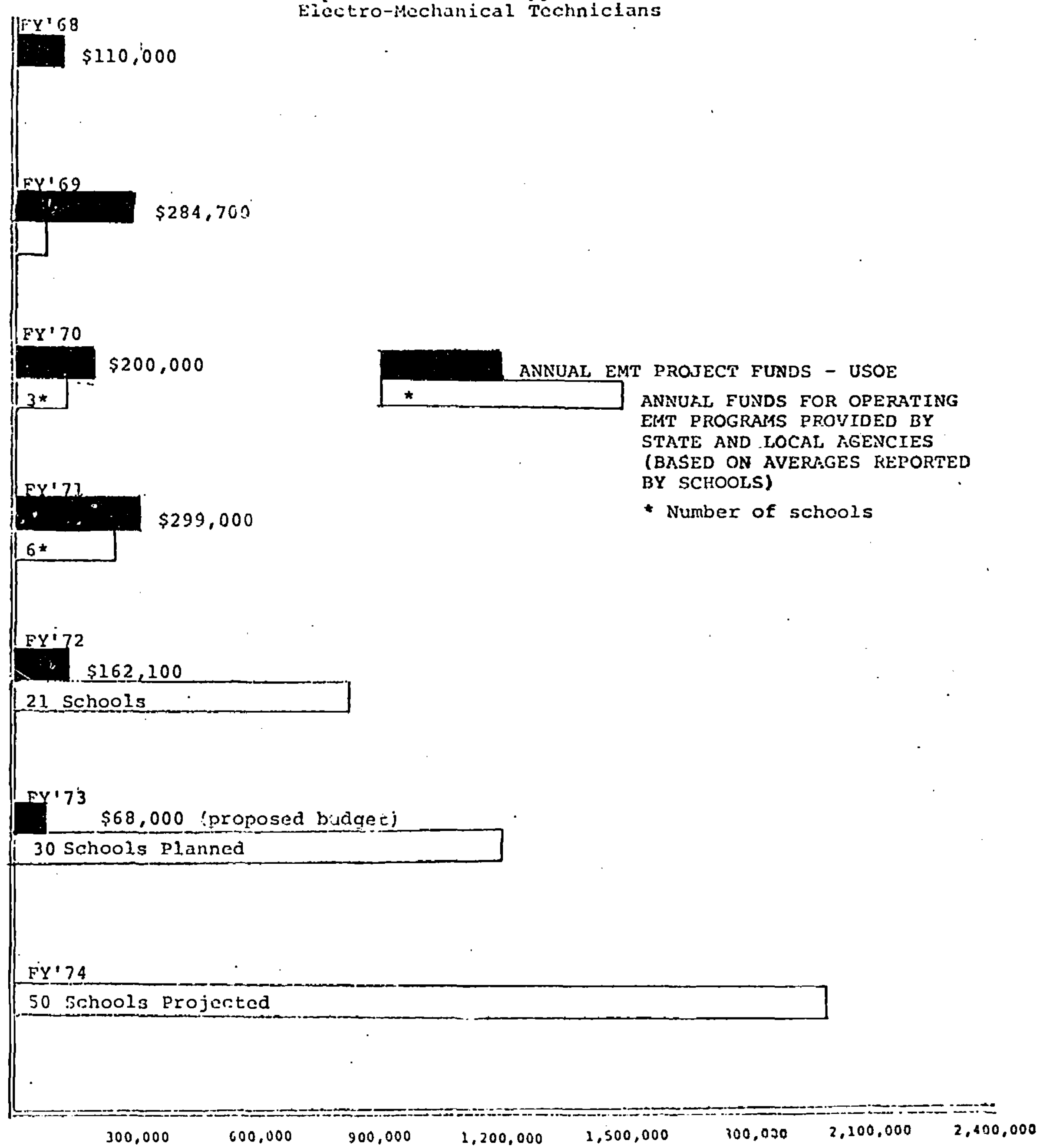
First Year Materials Published
Sourcebook Disseminated
Case Study-Milwaukee Area Tech College

ajor Project Activities Planned

Second Year Materials Published
Administrators Planning Guide Completed
Staff Training Guide Completed
Final Project Report

rmination of USOE Funding

Projected Operation and Continued Expansion of EMT Educational Programs in Schools



Annual Expenditures by Fiscal Years for EMT Project and EMT Educational Programs