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ABSTRACT

The report describes the Biomedical Equipment Technology project carried out by Technical Education Research Centers between 1967 and 1974. The project developed a curriculum and a program for training biomedical equipment technicians in two-year schools. The report discusses the three phases of the project: development of pilot programs, coordinated program development, and dissemination and implementation. Details are provided on the development of a curriculum guide, the development and testing of instructional modules (17 modules in medical electronics and instrumentation are described briefly in an appendix), the development and dissemination of the educational program, and the internal and external evaluation of the project. Appendixes comprise approximately half of the report and include: a summary of project goals and materials developed; a description of the field trials of the medical electronics and instrumentation modules; lists of institutions, business, and industries involved in the project; figures on the dissemination of project products; and reprints of three relevant articles. (PR)

# BIOMEDICAL EQUIPMENT TECHNOLOGY



## Final Report

## Project No. V-257998

## Grant No. OEG-0-8-000973-1873(085)

Technical Education Research Centers
Northeast Center
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January, 1975

U.S. Department of Health, Education & Welfare
Office of Education

Technical Education Research Centers TERC

FINAL REPORT

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# DEVELOPMENT AND EVALUATION OF EDUCATIONAL PROGRAMS IN BIOMEDICAL EQUIPMENT TECHNOLOGY

Technical Education Research Centers, Inc.
44 Brattle Street
Cambridge, Massachusetts 02138

January, 1975

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

Technological advances require new skills and knowledge which in turn create a demand for new kinds of technicians and specialists. Shifting social priorities can also cause the rapid emergence into prominence of hitherto seldom-mentioned paraprofessions. In either case, the nation suddenly needs many new programs for educating the support personnel who assist managers and professionals making the advances and responding to the shifting priorities.

During the last decade, the United States has experienced a growing need for programs in many new and emerging technical occupations. These "emerging technologies", as they are often called, include such occupations as biomedical equipment technician, environmental health technician, recreational land management specialist, electro-mechanical technician, marine technician, child care center specialist, nuclear technician, paralegal specialist, and laser electro-optics technician.

In an emerging technical field, there typically exist rapidly growing employment opportunities for well-prepared support personnel. Because few, if any, schools have high-quality technical education programs for preparing such personnel when an occupation emerges, 50 to 100 community colleges, technical institutes, and other post-secondary institutions should establish programs for each new occupation during a decade. These programs are needed to increase the productivity of employers and to provide students with paths to attractive careers.

Development and implementation of a program in an emerging technical occupation presents a very difficult problem for individual schools or even for educational planners in a state system. The specifications of the occupation, typically require that a school initiate a full-time, two-year program with several new technical courses, rather than improve a single existing course. Furthermore, because an emerging field usually is diffuse and rapidly changing, employers do not offer schools a consensus on objectives for program development. New fields also frequently lack instructional materials and experienced instructors and a school or community seldom can afford to develop the materials and train instructors. Consequently more than ten years generally elapse between the time employers seek new kinds of support personnel and the time educational institutions first graduate a substantial number of these specialists. This lag is costly in a rapdily changing technological society.

The Biomedical Equipment Technology (BMET) project is one of four projects carried out by Technical Education Research Centers (TERC) between 1967 and 1974 whose overall purpose was to reduce this time lag and to catalyse development of needed technical education programs throughout the nation in four critical emerging technologies: Biomedical Equipment Technology, Electro-Mechanical Technology, Nuclear Medicine Technology, and Laser and Electro-Optical Technology. Each of these projects utilized a new kind of curriculum development process and was a nationally coordinated program development project. Each project has succeeded in its purpose. The specific strategy and tactics and the research model employed in each of these projects has varied according to the technology of the emerging occupation, its labor market and the specific cooperating educational institutions involved.

Taken together these four projects demonstrate that coordinated program development projects can effectively catalyse nationwide development of needed educational programs in emerging technologies. These projects provide guidelines for future program development projects in other new and emerging occupations. The experience gained from these four projects can be the basis for a systematic national approach to the growing challenge of keeping our educational system responsive to the constantly changing needs of new and emerging occupational fields.

The BMET Project was addressed to the particular eudcational needs of the emerging field of Biomedical Equipment Technology--a rapidly growing technology which is critical to the quality and efficiency of the nation's health care system. This report describes this multiphase project which was carried out during the period 1967-74 in cooperation with more than 70 community colleges, technical institutes, and other institutions in 28 states and with the involvement of 260 industrial employers, 510 hospital employers, 159 health planners and educators, 71 societies, and many other interested individuals and institutions.

# ACKNOWLEDGMENTS

The Biomedical Equipment Technology Project has involved over two thousand individuals, institutions and organizations over a seven year period. It would obviously be impossible and inappropriate to attempt to recite their contributions. Although credit is due to all of them, only a few of these contributors are listed in the appendix.

The BMET Project is particularly indebted to the administration and staff of the original pilot schools--Springfield Technical Community College and Texas State Technical Institute. The administration and staff of the seventy community colleges, technical institutes and other institutions who have implemented BMET programs also deserve special mention for their participation in the planning and development activities of the project and in testing the BMET Project products.

In terms of continued support and encouragement for the project, credit is due to Dr. Walter J. Brooking and others of the U. S. Office of Education staff who provided valuable guidance and assistance throughout. Key TERC project personnel who provided research direction for the project include Dr. P. John Cadle, Dr. Joseph L. Hozid, and Dr. John W. McWane. Many other TERC staff personnel have provided vital inputs to the Project. Ms. Margaret B. Wilkins played a major role in TERC's assistance to institutions implementing BMET programs, and in the preparation and editing of BMET Project products.

Despite many individual contributions, the BMET Project was in essence a unique collaborative venture by researchers, developers, disseminators, implementors, educators, employers, and many others concerned with the emerging field of Biomedical Equipment Technology. Only by the combined efforts of all of them has the Project been able to contribute so significantly to improving the quality and availability of BMET education throughout the nation.

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# SUMMARY

National and regional surveys during the late 1960's and early 1970's showed an urgent national need for development of new educational programs in the field of Biomedical Equipment Technology. Biomedical Equipment Technicians (BMET's) are employed by hospitals to repair, operate, and maintain the complex instrumentation used in hospitals and other medical settings for diagnosis and treatment of patients. They may also be employed by biomedical equipment manufacturers, and by medical research laboratories. The BMET is increasingly considered an integral member of the health care team and human life often depends on his knowledge and skill. This new field offers a wide range of excellent career opportunities for young people who are able to obtain the necessary BMET technical education--typically two years at the college level. Despite the urgent and growing need for BMET's, individual schools and states are often unfamiliar with the employment opportunities and lack the expertise to develop quality programs in this new field. As a result when the BMET Project began in 1967 there were only two civilian BMET educational programs in the United States graduating fifteen students, despite documented needs for 50-100 programs graduating 2000 BMET's per year.

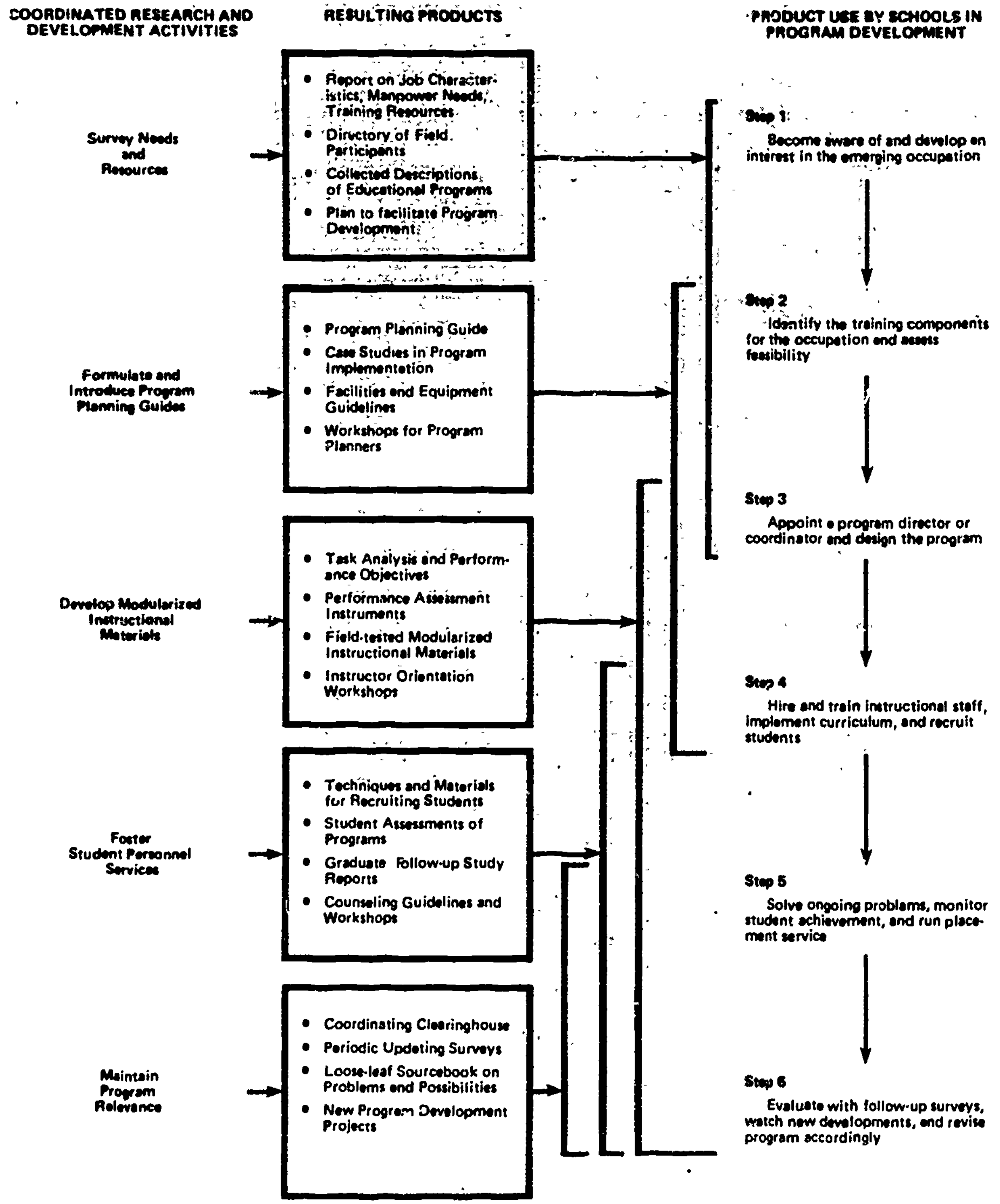
The BMET project was developed in response to this serious imbalance between the needs of employers and available school programs in this critical emerging field. The project was initiated in July 1967 as a nationally coordinated program development project whose purpose was to catalyze the development of needed BMET programs in schools throughout the United States

Since coordinated program development of this sort is new the original research model of the BMET project was necessarily rather general. The detailed project design was developed year by year in close cooperation with more than 70 community colleges, technical institutes, and other educational institutions in 28 states and with the assistance of professional associations and a broad spectrum of employers in the BMET field.

The overall strategy of the project was to carry out those research and development activities and to develop those products which would most effectively assist interested schools in going through the six steps leading to the implementation of BMET programs. The types of research and development activities, resulting products, and product use by schools is outlined in Figure 1.

FIGURE 1

Facilitating The Establishment Of New BMET Programs

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During the first two years the project focused primarily on developing and testing BMET programs at two pilot schools - Springfield (Massachusetts) Technical Community College and Texas State Technical Institute. Since 1969 the BMET project has worked cooperatively with all community colleges, technical institutes and other institutions known to be interested in BMET education together with a broad spectrum of employers, professional associations and others involved in the field of Biomedical Equipment Technology. Virtually all of the more than forty BMET educational programs now operating in the United States have been established and carried on in association with this project. At least thirty additional schools are currently planning or considering BMET educational programs utilizing BMET project materials and services. The project has resulted in a broad body of tested program planning materials, instructional materials, and expertise which are now available for use by schools desiring to establish new BMET programs.

In addition to developing new programs for Biomedical Equipment Technicians the BMET project has tested new procedures and products for coordinated program development which are applicable throughout technical education and also in other kinds of education. The BMET project has pioneered new techniques of involving local innovational "champions" throughout the country in the development process through the BMET Interactive Network. It has also developed new kinds of laboratory based instructional modules which should have influence far beyond the BMET field.

A major thrust of the BMET project since its inception has been to develop techniques for "transplanting" BMET programs throughout the country. During the last two years, the project staff have conducted extensive experimentation to determine the most effective strategies and techniques for disseminating and implementing BMET programs. Techniques utilized have included:

1. BMET program displays at AVA Conventions and ATEA-USOE National Clinics on Technical Education;

2. BMET program need surveys of approximately 2,000 community colleges, technical institutes and other agencies;

3. Providing consulting services and technical assistance services to schools for planning, implementation and evaluation of new BMET programs;

4. Mailings of information on BMET publications and apparatus;

5. Publication of an issue of the TECHNICAL EDUCATION REPORTER focused on emerging technologies and featuring descriptions of exemplary BMET programs;

6. Experimental workshops and short courses particularly on BMET Instructional Modules;

7. Development of a comprehensive Program Development Catalog including a broad range of BMET materials and services;

8. BMET Interactive Network operations;

9. An experimental program for BMET State Coordinators in ten states.

Figure 2 shows highlights of the BMET project from its inception in 1967 through its completion in December 1974. This Figure shows for each year the major project activities, Federal project funds expended, the number of operating BMET programs in schools, and the approximate funding of these programs from state and local sources. Figure 3 shows the yearly geographical growth of BMET programs in schools throughout the country.

A measure of the effectiveness of the BMET dissemination and implementation strategies can be seen from Figure 2 by comparing the annual BMET Project Funds (Federal) with rapidly increasing annual State and local investment in BMET programs stimulated by the BMET Project.

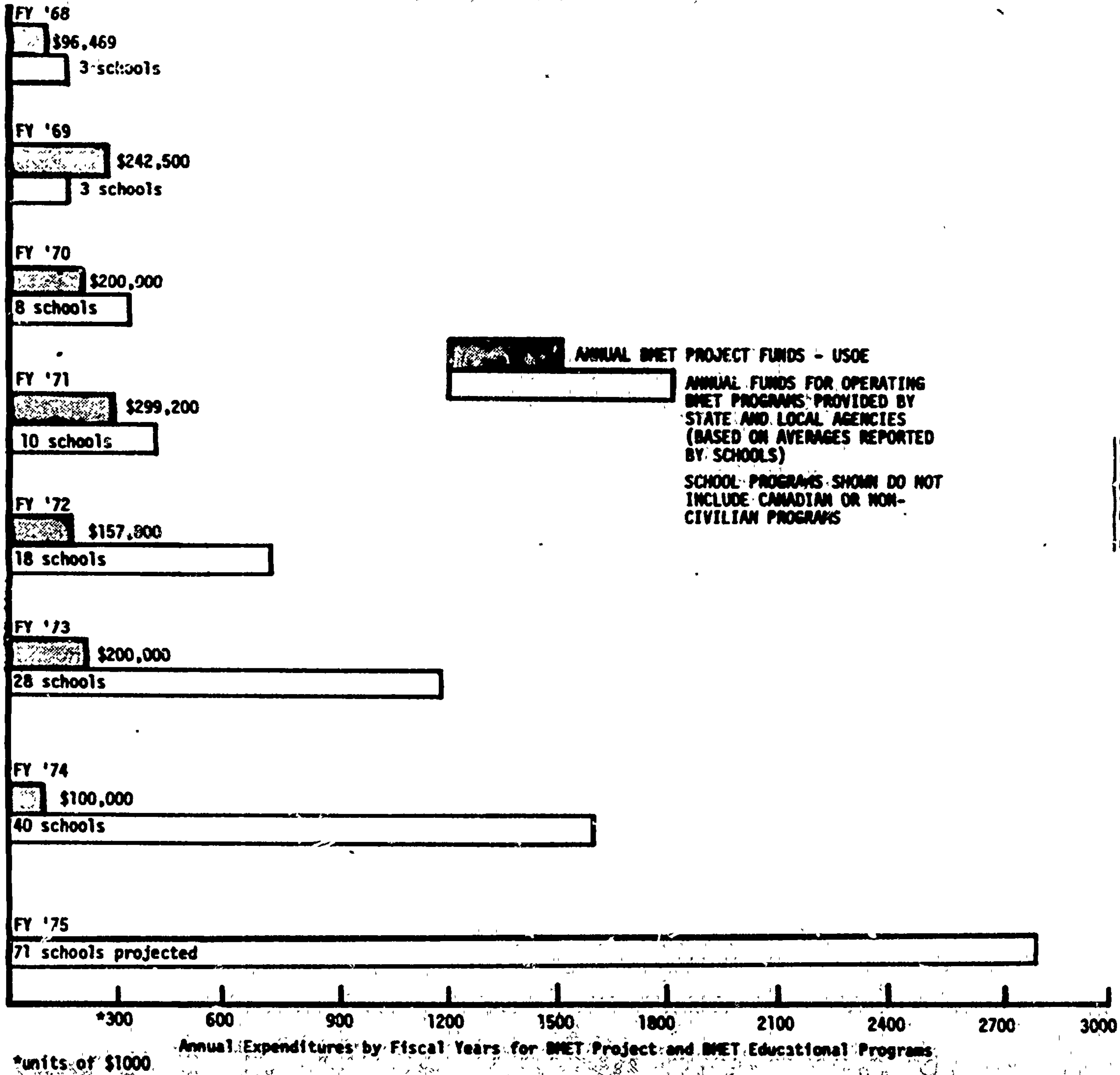
| | Percentage of BMET Educational Expenditures Provided By: | |
|---|---|---|
| | BMET Project Funds (Federal) | State and Local BMET Program Funds |
| 1968 | 42% | 58% |
| 1969 | 64% | 36% |
| 1970 | 36% | 64% |
| 1971 | 40% | 60% |
| 1972 | 18% | 82% |
| 1973 | 14% | 86% |
| 1974 | 6% | 94% |

As these figures indicate the BMET project funds served as "seed money" to stimulate major state and local investments in BMET education and as such proved to be a highly cost effective use of Federal funds. By 1974 state and local sources were providing more than $15 in support for BMET education for every Federal dollar expended by the BMET project. These results confirmed by similar results of the other three emerging technology projects provide strong evidence of the effectiveness of Federally sponsored coordinated program development products in emerging technologies.

FIGURE 2

# HIGHLIGHTS OF BMET PROJECT

Development of Career Opportunities for Bio-Medical Equipment Technicians




__r Project Activities__

BMET Project Begins
Pilot Program, Springfield Technical Community College (STCC)

Pilot Program Expanded, Texas State Technical Institute
BMET Film Completed
First Interactive Network Conference
First Experimental Texts

16 Experimental Units Developed
National Survey-BMET Needs/Resources
Second Interactive Network Conference
First National Project Evaluation
Pilot Program Expanded

Case Study-STCC Program
Compendium of Educational Programs
Hospital Administrators Workshop
Second National Project Evaluation
Task Analysis by Selected Criteria

Materials and Guidance Workshops
6 Educational Modules Developed/Tested
BMET Sourcebook Disseminated
Bibliography of Instructional Materials
Case Studies of 3 Programs
BMET Recruitment Brochures Developed

Curriculum Guide Drafted
Educational Modules Developed/Tested
Teacher Training Workshops Held
Planning Conferences Held

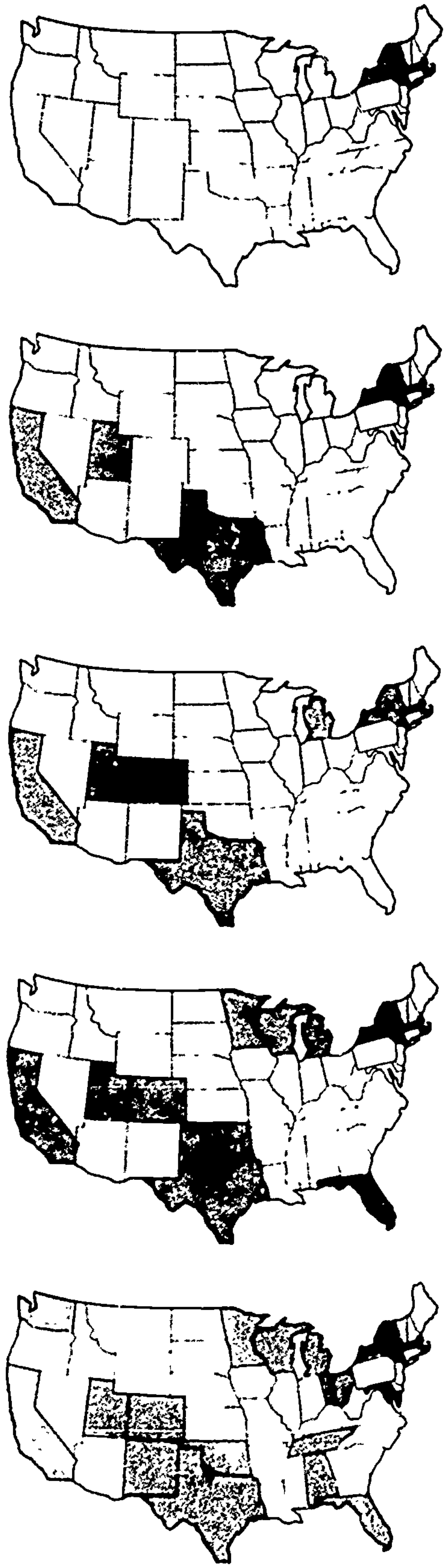
Curriculum Guide Printed
Program Implementation Workshop
Planning Conference Held
Instructional Materials Published
Final Project Report

__After Termination of USOE Funding__

Projected Operation and Continued Expansion of BMET Educational Programs in Schools

FIGURE 3

## GROWTH OF SCHOOL PROGRAMS
## TERC BIO MEDICAL EQUIPMENT TECHNOLOGY PROJECT



| YEAR | STATES | SCHOOLS INVOLVED* |
|---|---|---|
| 1969 | 2 | 3 |
| 1970 | 5 | 8 |
| 1971 | 7 | 10 |
| 1972 | 11 | 18 |
| 1973 | 17 | 28 |
| 1974 | 22 | 40 |

*Does not include Canadian or non civilian programs.

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The BMET project has succeeded in establishing a sound base for BMET education in the United States. More than forty community colleges, technical institutes or other institutions have now implemented BMET educational programs in cooperation with the Project. This is a good beginning but does not yet fully meet the needs of this rapidly expanding field. Although the research and development phase has now been completed there is a continuing need for systematic BMET dissemination and implementation activities until operating BMET programs have been established in nearly every state so as to provide convenient models for the establishment of new BMET programs by schools anywhere in the United States.

To meet this need it is recommended that a BMET dissemination/implementation project should be carried on at a relatively low level of funding for a period of three years. This might be done as a part of a broader dissemination/implementation project for emerging occupations or career education programs. The objectives of the dissemination/implementation project would be to facilitate the implementation of additional BMET programs throughout the country; to assure that existing BMET programs remain relevant to the changing needs of employers and students; and to work with leaders in the field for the further development of the BMET occupations. Project activities should include:

1. Disseminating BMET planning and instructional materials;

2. Maintaining an active communications network among educational institutes, hospitals, employers, professionals and all others concerned with BMET education and employement needs in order to maintain the relevance of the BMET program;

3. Providing consultative service and technical assistance to states and schools wishing to implement new BMET programs or wishing to improve existing programs;

4. Conducting conferences, short courses, and staff training workshops for teachers and administrators in the BMET field.

Such a dissemination/implementation project would further increase the impact of the BMET program development project and would be a model for effective dissemination/implementation of other programs developed under USOE sponsorship.

# INTRODUCTION

## Background

The rapid application during the past several years of electronics and other instrumentation to the field of medical research, diagnosis, care and treatment has resulted in the development of hundreds of new specialized bio-medical instruments and systems for use in hospitals and medical research centers. This equipment is becoming increasingly specialized and complex as bio-medical equipment technology becomes more sophisticated. Bio-medical equipment technology is rapidly becoming a major factor in achieving the national objective of increasing the overall efficiency and quality of health services in the United States. This new technology, properly used, has the capability of both reducing the cost and improving the quality of the nation's health services and of making possible more effective medical research.

The rapid development of bio-medical equipment technology coupled with the introduction of increasingly complex and critical bio-medical equipment has created an increasingly serious need within hospitals and medical research centers for well prepared technicians who understand this new technology and who are capable of operating, maintaining, calibrating, and in some cases, modifying or adapting this equipment. Human life may frequently depend upon the ability and training of such technicians. Similarly trained technicians are needed in great numbers by bio-medical equipment manufacturers to assist in the development, manufacturing, testing, technical sales, and servicing of bio-medical equipment.

Educational research in the field of Bio-medical equipment technology began in May 1966 with a fourteen month study of the national needs for Bio-Medical Equipment Technicians (BMET). This occupational research study was carried out by Technical Education Research Centers under the sponsorship of the U. S. Office of Education (Grant No. OEG-1-6-000366-0658) between May 1966 and June 1967 and assessed the developing needs of hospitals, medical research laboratories, bio-medical equipment manufacturers and other employers for trained BMET's. This field study found that based on existing and developing employment opportunities there was an immediate and continuing need for training at least 2,000 BMET's per year in the United States in postsecondary associate degree type programs and that this annual need was growing every year. By contrast at the time of the field study only two U. S. civilian schools were preparing BMET's and together were graduating a total of approximately 15 BMET's per year. To rectify this serious imbalance between the needs of employers for trained BMET's and available BMET graduates it was necessary that BMET programs should be initiated as quickly as possible in fifty to one hundred technical institutes, community colleges, or other postsecondary institutions.

Unfortunately, despite the urgent needs for BMET education virtually no new BMET programs were being planned and few were likely to be planned since virtually none of the normally available planning and instructional materials were available to assist schools in implementing new BMET programs. The technical occupations within the technology had not been structured, defined or publicized, the knowledge and skill requirements had not been identified; curricula had not been developed; and there was a serious lack of appropriate instructional materials such as textbooks, laboratory guides, classroom demonstration equipment and laboratory equipment. Finally, there was a paucity of trained teachers and specialized laboratory facilities. It was quite clear that unless systematic steps were taken to facilitate the development of BMET programs throughout the United States, the shortage of adequately educated Biomedical Equipment Technicians would become critical within a few years. It would adversely affect many national health programs and would impair the quality and efficiency of our nation's health services.

The overall objective of the BMET project was to catalyze the development of a broad spectrum of postsecondary education programs in Biomedical Equipment Technology. The project was conceived of as falling into three phases:

First Phase--Development of Pilot Programs in two schools

Second Phase--Coordinated Program Development

Third Phase--Dissemination and Implementation

These three phases overlapped somewhat but the primary focus was on the First Phase in 1968-69; on the Second Phase in 1970-72; and on the Third Phase in 1973-74.

First Phase

The objectives for the First Phase of the BMET project encompassed two major areas:

1. Develop, test, and evaluate a curriculum for a two year associate degree program in biomedical equipment technology.

2. Develop, test, and evaluate instructional materials which could be used by institutions desiring to use the curriculum.

Springfield Technical Institute, Springfield, Massachusetts [later renamed Springfield Technical Community College (STCC) and referred to by this name in the report] was selected as the first site. The BMET program at STCC began September 1967. The plan was to transfer the curriculum to James

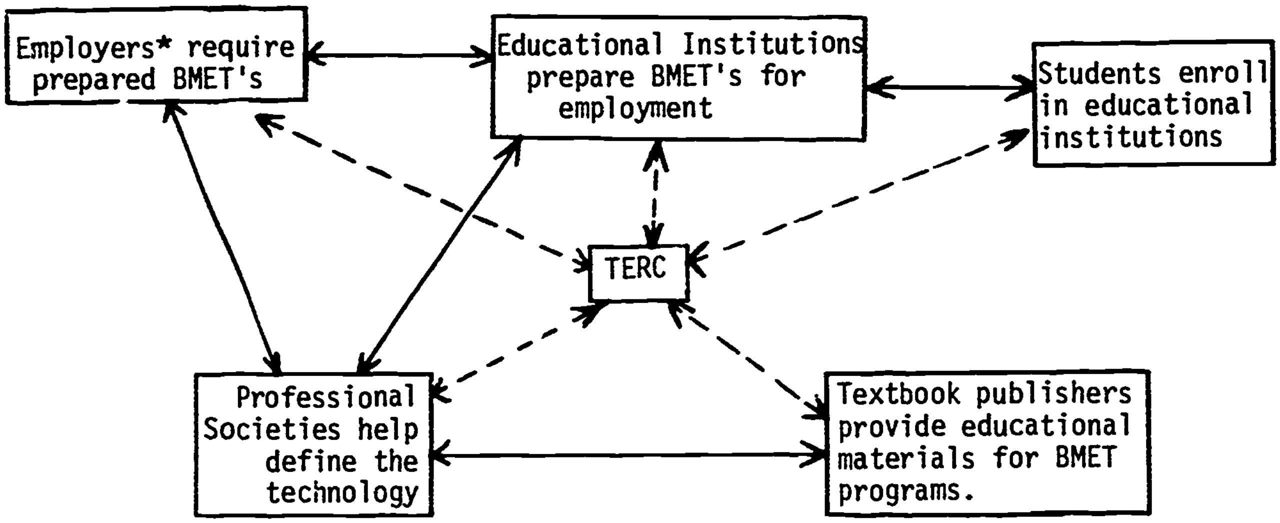
Connelly Technical Institute, Waco, Texas [later renamed Texas State Technical Institute (TSTI) and referred to by this name in the report]. The TSTI program began September, 1969.

The goals of this phase of the project were achieved but not as well as TERC had expected. Funding was delayed so that there was insufficient planning for the first class at STCC. The Springfield Technical Community College curriculum did not readily transplant to Texas State Technical Institute since the two institutions had different internal constraints and goals. Therefore, in planning the Second Phase of the BMET project, TERC approached the problem of developing BMET educational programs a different way. The project began to look at all the interlocking forces and interest groups that comprise the BMET field and not just at the two pilot educational programs. This wider view of a constituency for the BMET project was the basis on which the Second Phase was developed.

Rationale for Second Phase

The related interest groups in the BMET field are summarized in Figure 4 below along with the objective of each group.

FIGURE 4




* The word "employer" includes the various kinds of employers who hire a technician called the BMET. BMET's work for hospitals, for equipment manufacturers, for research and development organizations, or for profit or non-profit organizations that repair equipment in several hospitals

All five of these areas of interest are composed of many individuals acting either singly or in concert. For BMET's to be adequately prepared for employment, communications among members of each group (e.g. educators to educators) and among the various interest groups (e.g. employers and educators) must flow smoothly.

In 1969, when the Second Phase was planned there were several problems within the BMET field. Some of these problems were faulty communications. Other problems, such as gaps in knowledge and materials, needed effective communications to help solve them. These problems were as follows:

1. Because few BMET's were available, the job functions of the BMET were performed by various individuals, and the need for a trained technician was not always recognized. In hospitals especially, those responsible for job structuring were slow to set up job categories for BMET's.

2. Few employers who had BMET jobs available were aware that educational programs existed. Therefore employers recruited only from the ranks of electronics technicians, not recent graduates of programs.

3. Because employers did not know about BMET educational programs they had little say in shaping curriculum.

4. Since BMET program directors did not know one another, they could not share information especially on instructional material that could be adapted for biomedical equipment technology courses.

5. Since college administrators did not know about BMET programs, they could not find out how to avoid problems in establishing such programs.

6. Educators had few instructional materials, and textbook publishers were uninterested in developing materials. Since there were only a few programs to use them, the market did not justify any investment in developing materials.

7. Professional societies required some job definition for the technician before establishing a certification examination to increase recognition for the BMET.

8. Educators needed recruitment materials to alert potential students about this little advertised specialty.

9. Students needed to know location and stature of the BMET programs.

All these problems required that various kinds of information--recruitment materials, instructional materials, job definitions, and lists of BMET programs--be available and disseminated. In addition, some of the problems could best be solved by sharing information and experiences among BMET program directors, college administrators, and employers. For example, the first phase of the project had indicated that a pilot tested curriculum could not be transplanted without extensive revision. However, curriculum planners did need to know how other educational programs had evolved their curricula. They needed to know problems others have encountered and how these problems had been solved.

Such a sharing of information between and among those involved in the BMET field is not automatic. In planning the second phase of the project, the BMET project sought to act as a facilitator of these needed communications. TERC was to initiate accumulation of information and materials that would help the five interest groups summarized in Figure 4. As planning continued for this interactive network, it became clear that the network had a great deal of potential. It was planned that in the first year, the BMET project would play the most important role in the network. But in future years, the project could assume a less central role as communications modes became established. Thus the interactive network could be a vehicle for project continuity. The BMET field itself would continue the goals of the project when funding ceased.

<u>Second Phase Goals and Activities</u> (1970-72)

During the Second and Third phases detailed project goals and activities were planned each year in response to the expressed needs of participating schools which were implementing BMET programs in cooperation with the project. The following goals were developed and carried out in 1970:

1. Survey BMET field to determine job performance tasks, types of BMET's, and to better understand their functioning within the hospital environment.

2. Plan, organize, and administer a development conference to promote a greater understanding of the objectives of existing and planned programs through the participation by two or three teachers from each institution. The development conference eventually became the Denver Conference, a key in the establishment of the interactive network. This conference, while including BMET program directors, included employers and professional society representatives as well. The conference itself was designed to give TERC feedback, based on the findings of the national survey on BMET job performance as to problems and preferred solutions to them. Several individuals important to the network were identified.

The following three goals were established in 1970 and were key activities throughout the Second and Third Phases being completed in 1974:

1. The organization and administration of an Interactive Network that would provide assistance to TERC in development of instructional materials and would eventually function within and among the participants to provide project continuity.*

2. Develop instructional systems including on the job tasks performed by BMET's, based on equipment most frequently worked on by the BMET. This information is key to the development of instructional modules for BMET programs.

3. Survey needs and interests of institutions establishing BMET programs and existing programs and develop materials and services to assist them.

In 1972 the following new activities, based on feedback from the interactive network, were instituted:

1. Develop materials for BMET Program counselors and guide for follow-up surveys of BMET graduates.

2. Refine and explore implications of BMET career ladders.

These two goals were perhaps the least well realized of all the goals for the BMET projec. Materials were developed for both as the appendix materials will indicate. Recruitment and guidance materials were developed and warmly received by the field. However, follow-up surveys of graduates in a field that still had few graduates was a bit premature. A career ladder was developed but no attempt was made to explore its implications because a more serious career problem was subsequently identified. Hospital administrators' failure to hire BMET's was causing a crisis for the BMET programs. In mid-1971 the project used resources designated for career ladder to operate a workshop for hospital administrators in cities with

* As later discussions of the BMET Interactive Network will indicate, the concept was not fully developed until 1972. At that time it was clear TERC activities had led to significant changes in communications. Initially the Interactive Network participants were to be reviewers to insure TERC's relevance to the BMET field. Through 1970-71, it became clear that interactions between others in the network were becoming as important as TERC's contribution to the network. At that point, TERC began to fully realize that the network was a vehicle for project continuity.

programs beginning that September. Thus TERC's flexibility and response to the field allowed for a more productive activity than was planned for initially.

The Third Phase (1973-74)

As the appendix material indicates, the BMET Project had developed a great many products by 1973. The interactive network system had begun to disseminate many of them. During the Third Phase BMET project activities focused on two basic types of activities: synthesis of the lessons learned by the project into one document, and more effective dissemination and implementation of BMET products and programs. As a part of this effort two specific new goals were established:

1. Develop and evaluate a curriculum guide that will summarize a model program for biomedical equipment technology based on the most successful aspects of all BMET programs. This document will assist program planners in establishing curricula for BMET programs.

2. Survey community colleges and technical institutes to determine whether additional materials are required other than those already available for establishment of BMET programs.

These goals were accomplished by the end of 1974.

During the Third Phase a continuing effort was made to experiment with various techniques for disseminating of BMET project products and for facilitating the development of BMET programs throughout the country. Some of these techniques are outlined in the section on Dissemination and Implementation and are believed to be applicable to the dissemination and implementation of other types of educational programs.

Project Products

As a part of the BMET project more than fifty program planning materials, instructional materials, and other project products were developed and disseminated to meet specific project goals. The appendix contains a summary of the specific project goals outlined above together with a list of project products which were developed in response to each goal.

# CURRICULUM DEVELOPMENT

## Introduction to Springfield Technical Community College

The Biomedical Equipment Technology program at Springfield Technical Community College in Springfield, Massachusetts is beginning its eighth year of operation. Six classes have graduated. The program is a strong addition to the technical offerings at the college. When the program began in September, 1967, only two other civilian schools in the United States had BMET programs. The planning experience for this program was necessarily difficult. There were no previously established curricula to follow. There was no consensus of what BMETs needed to know. Therefore, the problems encountered at STCC had several important lessons to teach other BMET programs and research organizations such as TERC.

## Summary of Lessons Learned

When the idea for the BMET program at STCC was developed in March, 1967, the original plan called for an experimental BMET class to enter in September. The state funding was dependent on this plan. The BMET project funding was expected to be received in June, 1967 and the STCC faculty and TERC project staff were supposed to begin work on curriculum development at that time.

Because of delayed funding of the BMET project the STCC staff had to bear the entire burden for planning the program until October, 1967, when the project funding was received. The faculty were overworked because, in addition, on short notice, the campus was moved to a new location during the summer of 1967. The faculty carried full time teaching loads, administrative responsibilities for the relocation, and BMET program planning responsibilities.

In retrospect, the program might have had a smoother course the first two years if the first students had entered September, 1968. The program would have benefited from a planning year and funding delays would not have caused such serious problems for the faculty members. During the first year of the program the STCC curriculum was in the process of development. Some students found their course of study confusing. Part of the problem perhaps springs from the nature of emerging technologies. Even the experts were not certain about what information should be included in a BMET curriculum.

## Curriculum Content

It was planned that the curriculum was to be developed based on the occupational survey of the BMET occupations conducted by TERC in 1966-67. This survey was not designed to provide detailed performance objectives but did provide general guidance that the curriculum should include electronics, physics, and biomedical electronics. The curriculum, according to the project plan, was to provide a two year associate degree curriculum with all courses--electronics, physics, mathematics, and even English--integrated into the BMET curriculum. It was planned that the curriculum content of the pilot BMET program would be based on the occupational survey supplemented by the advice of experts in the field of Biomedical Equipment Technology.

The first problem surrounding curriculum development which is typical in an emerging occupation was that the expert opinion frequently differed. It was impossible, without a firm data base on which all could agree, to come to consensus. All the curriculum planners had had extensive experience in the field of medical instrumentation. Given the undefined state of biomedical equipment technology, each of their differing opinions were probably somewhat correct. These disagreements did take time to resolve and curriculum development did not proceed at the pace anticipated.

When the planners attempted to integrate all courses into the BMET curriculum, they discovered that non-technical courses could not be changed. Massachusetts regulations concerning community colleges would not permit changes. The community college system stresses transferrability of credit, and non-technical courses are the keystone to this transfer. The curriculum planners and project director therefore limited further development of the curriculum to those courses concerned with biomedical equipment technology.

Instructional Materials

The curriculum and course outlines were to be supported with the development of needed instructional materials for the biomedical courses. Other text materials were available for the electronics and physics courses that could support the BMET curriculum.

A major problem encountered with materials developed by instructors was lack of time. The instructors developed instructional materials that were adequate for their use in the classroom. However, these materials were not suitable as disseminable products without a great deal of refinement. The instructors did not have time nor the funds to refine, revise, and polish their materials. Educational publishers were understandably not interested in texts that could be sold to only a handful of BMET programs in the country.

Summary of the STCC Program in 1969

By the time the First Phase ended at STCC, despite all these problems, the BMET program was well established. Although the integrated curriculum was not fully realized, BMET students were pursuing a rigorous course of study that included nine semester courses in biomedical equipment technology. The instructors were using the materials they had developed.

The TERC/STCC effort to establish a BMET program had one underlying problem. In defining the scope of work, the planners had assumed that they could achieve on limited funding more than was realistically possible. The most important aspect of the plan of work had been successfully achieved. STCC had an operating program in biomedical equipment technology. Considering the problems involved with emergi g technologies, the establishment of the program was an important achievement.

## The STCC Experience Today

The BMET program at STCC has clearly flourished. Each year, approximately 20 students enroll in the program. These students have heard of the program from many sources. Some come directly from high school. Several come from military programs.

The STCC program director is proud of the placement record of his graduates. The placement experience reflects one of the strengths of the program. The curriculum provides preparation in the specialty of biomedical electronics but also provides diversity so that students may, if they chose, pursue careers in related electronics fields. For example, in 1974 the BMET program graduated 12 students. Two graduates went to work repairing hospital equipment; six graduates secured employment in electronics-related fields; two transferred to four year programs; one is unemployed and one has lost contact with the school.

The initiative and drive of the graduates is exemplified by four students who formed their own company. They provide medical equipment repair services to eight hospitals in the Springfield region. In addition they are the sales representatives for three medical electronics firms. This company has begun hiring other graduates of the STCC program.

## Transplanting the Program to TSTI

The original plan was to transplant the STCC BMET curriculum directly to the second pilot school, Texas State Technical Institute. This did not prove possible. There were several differences between the schools that suggested from the beginning that major changes would have to be made in the curriculum. STCC had a semester calendar, TSTI had trimester. STCC provides students with equal options for employment or transfer to a four year program. TSTI emphasis is employment not transfer at completion of a technical program. STCC acquired an intensive care system for the laboratory from TERC's Laboratory Equipment Assistance program. TSTI had no such system but had operating room equipment instead. The differences may be best summed up in their names. STCC is a community college and TSTI is a technical institute.

When TSTI began offering its BMET program in 1969, the Institute was spared some of the confusions that surrounded the early planning experiences at STCC. The TSTI program planners had all the course outlines and other curriculum materials that had been developed at STCC. However, they felt that these materials were not appropriate for their institution and began seriously rewriting and revising the curriculum to suit their needs.

From participating in this transplant, TERC learned some important lessons about curriculum development and especially dissemination. The TSTI curriculum planners insisted on making changes in the STCC curriculum. These were not changes for changes' sake. Rather, the instructors had invested their own effort and thus had a better understanding of a curriculum that they themselves had helped design. However, they did draw on the STCC materials and as a result the course outlines and curriculum were developed faster at TSTI than at STCC.

In reviewing the experience, TERC had learned two very important lessons about program planning. The first lesson was that direct curriculum transplants are very difficult from one school to another. The second lesson was that externally developed planning information and curriculum materials is needed by program planners to speed up their work.

## The TSTI Program Today

The TSTI program has operated for six years and has produced four classes of graduates. It is clear from the employers' response to these graduates that the program is flourishing. In 1974, there were 12 graduates, five went to work in hospitals, six for equipment manufacturers, and one was employed in a field unrelated to BMET. There were many more requests from hospitals for BMET graduates than students to fill these positions.

The program has been successful from the students' point of view. Enrollment has been no problem. Approximately 30 students enroll in the program each year. Several of these drop out and later return to the program. Others secure employment before they graduate and some transfer to other programs. However, those that return to discuss their new jobs usually report that they enjoy the challenge of their positions. Few appear to be dissatisfied whether they work for equipment manufacturers or hospitals.

## Developing a Curriculum Guide

The First Phase experiences of 1967-69 had convinced the BMET project personnel that development and dissemination of a single curriculum was not feasible. Schools would not use a curriculum implemented at another school without adapting it to their needs. The curriculum guide, while still a future possibility, became a secondary issue. It was concluded that it was premature to write a curriculum guide until considerable experience with BMET programs existed in a variety of schools.

By 1972 there were 32 BMET programs operating, and TERC had provided materials and services to all of them. Some of the program directors had attended workshops, others had supplied information for many of the products that were developed in 1969-72. In a new approach to the curriculum guide in 1972, TERC sought to synthesize the different strategies these BMET programs had developed for their curriculum. However, the results were fragmentary and confusing.

The final plan for the curriculum guide formulated in 1973 involved a new conception as to the use of the document. TERC knew from experience that a curriculum would be adapted by each school. Instead of selecting one curriculum from among the 32 operational programs as the "one", TERC addressed itself to devising a model program. The model program included the best characteristics of all the programs that had been studied. The model curriculum would be a summation of the best program an instructor would like to develop if there were no restrictions on resources and funding. It set an "ideal" that probably would never be achieved. But the existence of the model would assist in establishing quality programs and upgrading existing ones.

Once the function of the curriculum guide was clearly defined, an additional problem developed. TERC research indicated that a BMET who worked for an equipment manufacturer was likely to require different preparation from the BMET who worked in a hospital. Was a curriculum to be devised to prepare both technicians? TERC and its advisors concluded that for the curriculum to be a successful model, it must provide the strongest recommended curriculum for preparation of clearly defined jobs. Since discussion with BMET program directors indicated that they felt the most challenging employment for the BMET was in the hospital, the curriculum was designed primarily for a BMET to be employed in a hospital.

## The Model Curriculum

The Curriculum Guide titled Biomedical Equipment Technology: A Suggested Two-Year Postsecondary Curriculum offers guidelines for a model BMET program. Several of these suggestions for establishing a program are the direct result of the STCC and TSTI and other school experiences. The Guide contains several overall guidelines for schools considering establishing a BMET program as follows:

1. A community college with less than 5,000 full-time students is not likely to have resources for establishing a comprehensive BMET program.

2. A school should have an electronics program, and two-three allied health programs before considering a BMET program.

3. Faculty members must be dedicated to integrating the technical core of the BMET program.

4. The school should hire a full-time BMET program director one year before the students are admitted to the program.

5. An occupational needs survey is required before initiating the program to determine job availability and tasks the BMET's will be required to perform for local employers.

6. A BMET program should have a clinical program of at least 500 hours in a hospital.

7. The curriculum guide recommends 608 hours of BMET courses, 528 hours of technical subjects, 320 hours of sciences, and 144 hours of related courses. In addition 900-1,000 hours of clinical experience are recommended.

An outline of the model BMET curriculum is shown on the following pages.

# The Curriculum

## Biomedical Equipment Technology

### FIRST YEAR

| | Class Hours | Lab Hours | Outside Study | Total Hours |
|---|---|---|---|---|
| **FIRST SEMESTER** | | | | |
| Electronics Fundamentals: AC, DC Circuits, Basic Circuits and Electronic Devices | 3 | 6 | 6 | 15 |
| Technical Math I: Algebra | 3 | 0 | 6 | 9 |
| The BMET at Work: Introduction to the Hospital and Industry | 2 | 0 | 4 | 6 |
| Medical Terminology | 2 | 0 | 4 | 6 |
| Technical Physics | 3 | 3 | 6 | 12 |
| Basic Shop Practices | | 2 | | 2 |
| TOTALS | 13 | 11 | 26 | 50 |
| **SECOND SEMESTER** | | | | |
| Intermediate Electronics: Amplifiers, Signal Processing Circuits, and Power Supplies | 3 | 5 | 6 | 14 |
| Technical Math II: Trigonometry and Advanced Algebra | 3 | 0 | 6 | 9 |
| Operation of Biomedical Instrumentation | 2 | 3 | 4 | 9 |
| Technical Chemistry | 3 | 3 | 6 | 12 |
| Communications Skills | 3 | 0 | 6 | 9 |
| TOTALS | 14 | 11 | 28 | 53 |

SUMMER

1) Work experience: 0 40 0 40
Clinical practicum (10-12 weeks) in hospital performing safety checks, inventory, and training hospital personnel in operating procedures.

2) Studies to meet special requirements of State or institution, if necessary.

## COMPREHENSIVE BMET CURRICULUM

### SECOND YEAR

| | Class Hours | Lab Hours | Outside Study | Total Hours |
|---|---|---|---|---|
| **THIRD SEMESTER** | | | | |
| Advanced Electronics: Feedback Systems, Signal Processing, Telemetry | 2 | 3 | 4 | 9 |
| Digital Electronics | 2 | 3 | 4 | 9 |
| Electromechanical Systems | 2 | 2 | 4 | 8 |
| Biomedical Instrumentation: Patient Monitoring, Clinical Lab | 2 | 5 | 4 | 11 |
| Anatomy and Physiology | 3 | 0 | 6 | 9 |
| Technical Report Writing | 3 | 0 | 6 | 9 |
| TOTALS | 14 | 13 | 28 | 55 |
| **FOURTH SEMESTER** | | | | |
| Biomedical Instrumentation: Troubleshooting Techniques | 1 | 3 | 2 | 6 |
| Biomedical Equipment Selection and Design | 2 | 3 | 4 | 9 |
| General Medical Instrumentation | 3 | 3 | 6 | 12 |
| Biomedical Instrumentation: X-Ray and Nuclear Medicine | 3 | 3 | 6 | 12 |
| Social Psychology for the Health Sciences | 3 | 0 | 6 | 9 |
| TOTALS | 12 | 12 | 24 | 48 |
| **SUMMER** | | | | |
| Work experience: Clinical practicum (10-12 weeks) in hospital - repair and maintenance of equipment under close supervision | 0 | 40 | 0 | 40 |

# INSTRUCTIONAL SYSTEMS DEVELOPMENT

During the First Phase of the BMET project, a study was made to assess the most serious gaps in available BMET instructional materials and to determine what new materials were most urgently needed to facilitate the development of new BMET programs. It was found that the most serious need was for the development of a series of laboratory based instructional modules which would familiarize the student with the basic components, electronic circuits and systems most commonly found in biomedical equipment. One of the important objectives of the Second and Third Phases of the project, therefore, was to develop and test the needed instructional materials. This work was carried out by TERC's Curriculum Development Laboratory in Cambridge with the cooperation of 16 community colleges and technical institutes and resulted in the development of 17 independent learning modules and associated laboratory apparatus.

The module development was based on the BMET occupational analysis as reported in the Interim II Report: Survey of Job Characteristics, Manpower Needs and Training Resources and on the BMET Task Analysis by Selected Criteria. Each module was designed with specific learning objectives. Taken together the modules form a hands-on laboratory program in the basics of biomedical equipment technology. Although specifically designed for BMET programs these materials may be used in many general electronics or instrumentation courses as well as in allied health programs.

The Medical Electronics and Instrumentation (MEI) learning modules are of three types each covering a different aspect of medical instrumentation--Operation and Measurement Modules, Systems Analysis Modules, and Component Analysis Modules.

*Operation and Measurement Modules* discuss methods of operating an instrument and the medical applications of the data. They are designed to provide the student with a background on the source of signal for a given instrument, the basis on which the measurement is made, and the use of the results. An experiment instructs the student in the proper operating technique for the instrument and the method of analyzing the data.

*System Analysis Modules* give a systems overview of the design of an instrument, explaining the function of each circuit and transducer component. In these modules the student analyzes an instrument system in terms of the flow of information from the source to a particular output display mode or feedback loop. In the laboratory, the student assembles and calibrates a functioning system from the component blocks and studies the problems of their interfacing.

*Component Analysis Modules* give an in-depth analysis of circuits and transducers which are used in instrument design. Each module includes experiments so that students can get hands-on experience with the equipment. In these modules the hardware component is discussed, an analysis of its operation is presented in terms of input-output characteristics, and a laboratory exercise is given for the students to assemble the circuit and study its operation.

A brief description of the seventeen MEI modules and of the associated student apparatus which was developed to be used with them may be found in the appendix.

After initial development and testing in Cambridge the MEI modules were field tested during 1973-74 in sixteen cooperating schools. A report on these Field Trials is contained in the appendix.

In accordance with the procedures of the U. S. Office of Education relating to instructional materials developed under USOE grants, a Publishers Alert was issued to all publishers and apparatus manufacturers interested in the MEI modules. A briefing session was held in Cambridge in April, 1974 attended by two publishers and six apparatus manufacturers. Interest from four additional publishers was received after the briefing session. Requests for proposals for publishing the modules and manufacturing the student apparatus were provided to all interested publishers and manufacturers. Proposals were received from two manufacturers but none were received from publishers. TERC queried those publishers which had expressed initial interest as to the reasons they had not made proposals. The reasons in each case were that the potential market was too small for adequate profitability. Several publishers also indicated that they were very reluctant to go into new publishing areas because of the current economic uncertainties.

In view of the fact that no commercial publishers are available for the MEI modules, TERC plans to publish the modules as developer under a limited Copyright to be authorized by the USOE and plans to appoint PASCO Scientific Company of San Leandro, California as the designated manufacturer of the student apparatus.

# PROGRAM PLANNING MATERIALS

## The Development Model

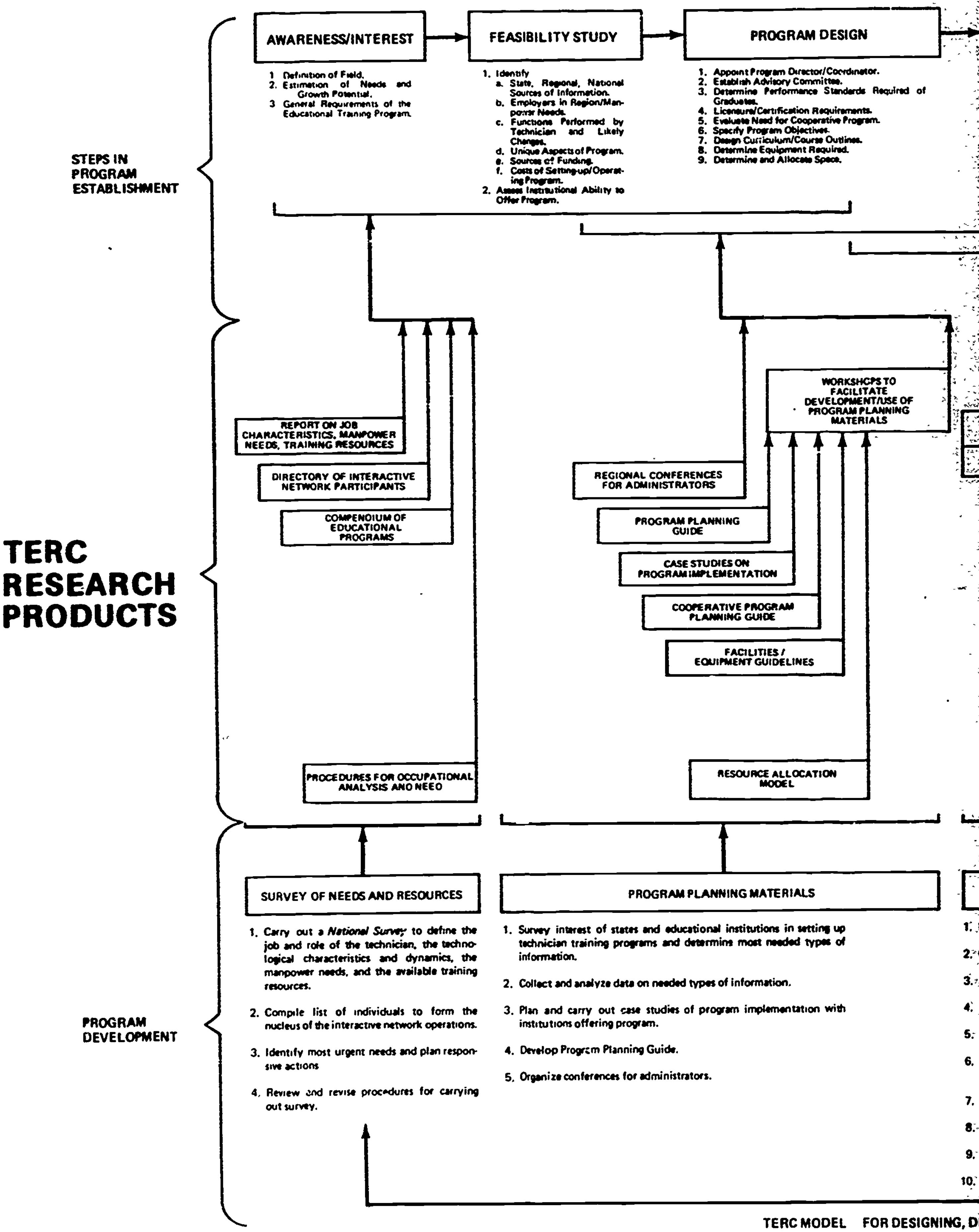
When the Second Phase of the BMET project began in 1970, the project plan was focused on the development of products designed to assist schools in planning and implementing BMET programs. As a first step a model for designing, developing, and establishing a new educational program was conceptualized and a number of needed research products were identified. This model is shown as Figure 5. The steps that an educational institution must take to establish a new program are shown horizontally across the top of the model. These include awareness / interest, feasibility study, program design, program start-up, ongoing program operation, and ongoing evaluation and revision. A program development project such as the BMET project can effectively assist schools to establish new programs by developing and disseminating a series of products and services each of which is keyed to one of the five steps. Some of these types of products and services are shown as "TERC Research Products" across the middle of Figure 5. These products and services result from a series of program development activities shown along the bottom of the model. This conceptual model was adopted by the BMET project in 1970 as the basis for the second and third phase activities. An "interactive network" strategy was adopted as a mechanism to facilitate both the development and dissemination of these products. The development of several specific BMET program planning products will be described below. The development and utilization of the interactive network will be described in the following section.

## Interim II Report: Development of Job Opportunities for Biomedical Equipment Technicians--June, 1970

The STCC planning experience had indicated that TERC did not have sufficient information on the tasks BMETs perform to form a sound basis for curriculum development. Therefore a nationwide survey of employment opportunities for BMETs was instituted. The survey was designed to determine how BMET's functioned for hospitals and equipment manufacturers and to update and refine the occupational analysis which had been carried out in 1966-67.

The survey was completed March, 1970 and published in June. The findings for the first time identified the variety of the jobs covered by the term Biomedical Equipment Technician. The report indicated that personnel involved with medical equipment ranged from janitors with a high school education to highly specialized technicians with impressive job preparation. The equipment these BMETs repaired ranged from patient's TV sets to the sophisticated cardiac monitoring systems in the intensive care units.

FIGURE 5


STEPS IN PROGRAM ESTABLISHMENT
AWARENESS/INTEREST
1. Definition of Field.
2. Estimation of Needs and Growth Potential.
3. General Requirements of the Educational Training Program.
FEASIBILITY STUDY
1. Identify
a. State, Regional, National Sources of Information.
b. Employers in Region/Manpower Needs.
c. Functions Performed by Technician and Likely Changes.
d. Unique Aspects of Program.
e. Sources of Funding.
f. Costs of Setting-up/Operating Program.
2. Assess Institutional Ability to Offer Program.
PROGRAM DESIGN
1. Appoint Program Director/Coordinator.
2. Establish Advisory Committee.
3. Determine Performance Standards Required of Graduates.
4. Licensure/Certification Requirements.
5. Evaluate Need for Cooperative Program.
6. Specify Program Objectives.
7. Design Curriculum/Course Outlines.
8. Determine Equipment Required.
9. Determine and Allocate Space.
TERC RESEARCH PRODUCTS
REPORT ON JOB CHARACTERISTICS, MANPOWER NEEDS, TRAINING RESOURCES
DIRECTORY OF INTERACTIVE NETWORK PARTICIPANTS
COMPENDIUM OF EDUCATIONAL PROGRAMS
PROCEDURES FOR OCCUPATIONAL ANALYSIS AND NEED
WORKSHOPS TO FACILITATE DEVELOPMENT/USE OF PROGRAM PLANNING MATERIALS
REGIONAL CONFERENCES FOR ADMINISTRATORS
PROGRAM PLANNING GUIDE
CASE STUDIES ON PROGRAM IMPLEMENTATION
COOPERATIVE PROGRAM PLANNING GUIDE
FACILITIES / EQUIPMENT GUIDELINES
RESOURCE ALLOCATION MODEL
PROGRAM DEVELOPMENT
SURVEY OF NEEDS AND RESOURCES
1. Carry out a National Survey to define the job and role of the technician, the technological characteristics and dynamics, the manpower needs, and the available training resources.
2. Compile list of individuals to form the nucleus of the interactive network operations.
3. Identify most urgent needs and plan responsive actions
4. Review and revise procedures for carrying out survey.
PROGRAM PLANNING MATERIALS
1. Survey interest of states and educational institutions in setting up technician training programs and determine most needed types of information.
2. Collect and analyze data on needed types of information.
3. Plan and carry out case studies of program implementation with institutions offering program.
4. Develop Program Planning Guide.
5. Organize conferences for administrators.
TERC MODEL FOR DESIGNING, DE

## PROGRAM START-UP

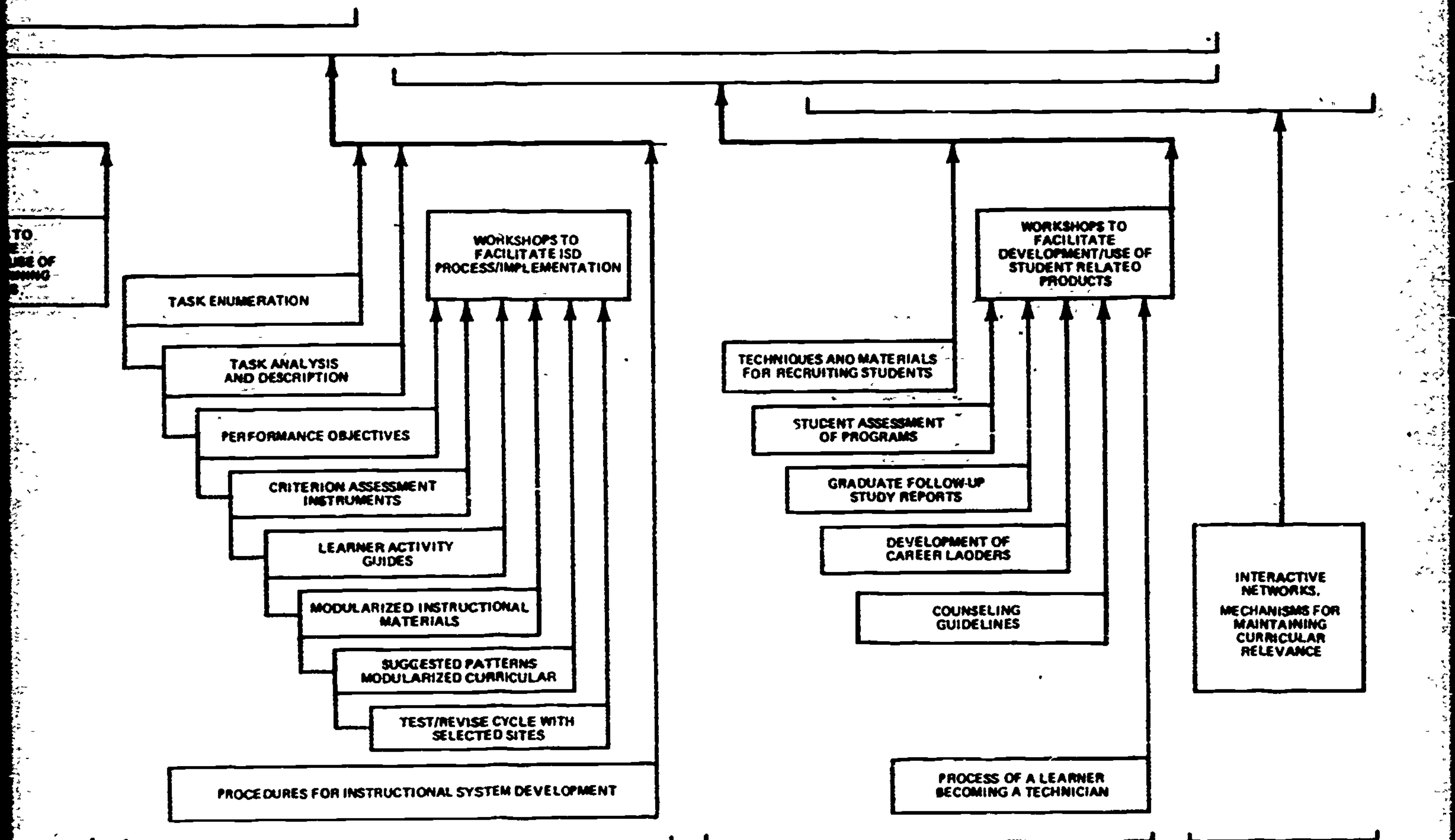
1. Hire Needed Instructional Staff.
2. Organize In-service Training/Orientation Program for Support Staff.
3. Detail Course and Instructional Objectives and Teaching Strategies/Media.
4. Develop Evaluation Plan.
5. Select and Purchase Instructional Materials, Aids, and Equipment.
6. Sign Contracts with Cooperating Employers.
7. Promote Program.
8. Recruit and Select Students.

## ONGOING PROGRAM OPERATION

1. Identify Problem Areas and Find Solutions.
2. Monitor Student Ability to Achieve Stated Objectives.
3. Maintain Placement Services and Organize Follow-up Studies.
4. Operate Regular Conferences of Instructional and Guidance Staff.

## ONGOING EVALUATION AND REVISION

1. Carry Out Graduate and Employer Follow-up Studies.
2. Monitor and Assess Implications of Changing Technological Requirements for Training Program.
3. Monitor and Assess New Developments in Instructional Technology, Materials, Aids, etc.
4. Periodically Upgrade Teachers.
5. Revise Program Objectives when Appropriate.




## INSTRUCTIONAL SYSTEM DEVELOPMENT

1. Define job family and possible career ladder.
2. Classify tasks by frequency, job level, and other factors.
3. Analyze tasks for skill and knowledge requirement.
4. Define standards of performance, and develop performance objectives.
5. Develop criterion assessment instruments.
6. Determine needed instructional materials and aids, and identify new material needs.
7. Organize and fund development of instructional modules
8. Design modularized curricula.
9. Develop student and instructor modules.
10. Select and contract with schools to test materials.

## STUDENT PERSONNEL SERVICES

1. Collect/annotate/develop materials for use in recruiting students into field.
2. Plan and organize follow-up studies of employees and program graduates.
3. Analyze feedback and suggest curriculum changes.
4. Organize and analyze student assessment of program and program components

## MAINTENANCE OF PROGRAM RELEVANCE

1. Systematize the process of interaction between technical educators and employers through
   - operating a clearing house to facilitate exchange of data, materials and information and,
   - funding development activities in response to need
   - development of instruments and procedures for regenerative feedback from the changes in the technology.

DESIGNING, DEVELOPING AND ESTABLISHING A NEW EDUCATIONAL PROGRAM





Technical Education Research Centers TERC

This survey collected information to assist BMET schools establish their programs. The survey found that the three most frequently mentioned pieces of equipment and the three most frequently repaired by BMETs were--the Electrocardiograph, Spectrophotometer, and Cardiac Monitor. The following skills and knowledge were judged essential to a BMET educational program:

1. Troubleshooting and making major and minor repairs.

2. Instrument theory, with emphasis on integration of relevant concepts in electronics, optics, mechanics, and physics.

3. Transducers and their role in a component's transformation of input signals into output signals.

4. Procedures and standards for calibration and preventive maintenance.

5. Equipment operating techniques.

6. Related aspects of physiology, chemistry, anatomy, and biology.

One of the key findings was the updated estimate of occupational needs over the next five years. The report indicated that in 1970 hospitals would require a total of 3,000 technicians and equipment manufacturers 5,600--by 1975 hospitals would need 5,180 BMETs and equipment manufacturers 11,100. Each year educational programs would have to graduate 1,900 BMETs to fill this need.

The Interim II Report was designed to provide information on which systematic BMET program developed could be based. First, more specific information than ever before was provided on what BMETs in the field actually do on the job. Some general guidelines were developed for BMET program planners as to the skills and knowledge BMET's require and the equipment types BMET's most frequently will encounter. Second, and equally important, the extensive profile of the BMET was potentially as valuable to employers as to educators. Based on this information the hospital administrators and equipment manufacturers could determine more clearly what a BMET could do for them.

Task Analysis by Selected Criteria: A Manual (1972) (TASC)

A task analysis approach was also undertaken as a complementary effort to the Interim II Report. Interim II provided general guidelines to the schools on establishing their BMET program. The TASC report was a more rigorous study of the actual job performance of various BMETs in many different job situations. From the analysis of expert opinion, TERC concluded that there are 230 tasks BMETs have been known to perform in the field. These 230 tasks then were ranked according to numerous selected criteria. These were reported in the TASC Manual which was designed to assist schools and others in several ways:

1. Since tasks were ranked by various criteria, the BMET educators could determine which tasks were most important and most frequently performed. These tasks could form the basis for curriculum development.

2. Since there was a method for selecting tasks essential to the BMET's education, performance objectives could be task based.

3. If a curriculum was designed to prepare technicians to perform a selected number of tasks, a more flexible program would result. Technicians with previous experience who could demonstrate competency in several sets of tasks could complete the program in a shorter length of time. Students could pace their own learning experiences.

4. Employers were no longer at a loss to understand what a BMET could do. The employer could structure a job by selecting from among those 230 tasks those that were essential for his institution. The BMET's job performance could be measured also on a task basis.

5. Professional societies could have a clearer definition of the jobs that BMET's perform in the field. This material could be the basis on which certification examinations were established.

## The BMET Workshops

Several kinds of BMET workshops were conducted from 1970-72. All workshops were designed to bring various key people together to become involved in solving some of the problems surrounding BMET education. The process of involving people with these problems was in many instances as important as the solution they proposed.

The first BMET workshop was for hospital administrators in July, 1971. The Second Phase of the BMET project had a commitment to implementing career ladders for BMET. Although a career ladder had been developed, discussions with BMET program directors indicated that TERC's concern with career ladders was premature. The program directors were concerned with their graduate's difficulties securing hospital employment. A career ladder could not be implemented in a hospital until hospitals were aware of what BMETs could do in solving their problems with medical equipment.

Consequently, 18 administrators from hospitals in cities loated where BMET programs were being established were invited to Chicago for a workshop in September, 1971. These administrators were sent questionnaires about how they maintained their medical equipment. From the analysis of the data, the hospital administrators concluded that many of them had not fully considered the importance of systematic maintenance of their medical equipment and the role the BMET can play. In discussing the role of the hospital in BMET education, these potential employers also concluded that they themselves had a responsibility to assist in the development and operations of BMET programs in their areas.

These employers were not directly involved in BMET educational programs at the time the workshop was held, but their cooperation was essential to the future success of the programs in their area. This workshop was one of many project activities in the BMET field to convince hospital administrators that BMETs are valuable. TERC's workshop and other organizations' efforts helped develop an understanding of the BMET among employers. An informal survey of BMET program directors two years later (October, 1973), indicated that the job possibilities for BMETs were rapidly expanding. Many program directors reported that they had more requests for BMETs for hospital jobs than BMETs to fill them.

A companion workshop to the hospital administrators workshop was the Instructional Resources Workshop (September, 1971). The purposes of this workshop were:

1. To introduce the TASC manual to employers and educators as a communications tool.

2. To assist educators and employers to identify any gaps in BMET education that were not being filled.

3. To identify gaps in educational materials.

When the educators and employers sorted through the task lists for BMET, each was asked to identify tasks that the newly graduated BMET could be expected to perform. There was a considerable gap between the tasks that the equipment manufacturers required and those that the educators prepared. Although the sample was quite small, the workshop results indicated that electromechanical tasks were more important to employers than they were to educators. Although no attempt was made to determine whether the educators actually used the task approach to defining their curriculum with employers, several of the schools that attended the workshop ordered materials that would help them do so.

The Guidance Workshop (December, 1971), was a joint effort with the Nuclear Medicine Technician project--10 representatives of five (5) BMET schools and 10 representatives from five (5) NMT schools attended. Each school sent an instructor and a guidance counselor. The workshop attempted to sensitize instructors and counselors to one another's problems, thus providing a more favorable climate for the students. Following the workshop, communications with the participants for several months indicated a great deal more interaction was taking place between instructors and counselors than before the workshop began.

Although the first two workshops were followed by reports that were disseminated to the field,* the principal outcome was one difficult to measure. Based on the understanding of the importance of cooperation and communications within the BMET field, the interactions stimulated by the workshops were important to the development of BMET programs. Analysis of the interactive network indicates that after these workshops, communications amont participants began to become significant to the BMET field.

The BMET Compendium of Educational Programs (June, 1971) and the BMET Digest of Educational Program (March, 1974)

The Digest is an updating and expansion of the Compendium. The BMET Compendium was the first list that TERC compiled of the BMET programs and their characteristics such as enrollment, instructors, entrance requirements, and tuition. This Compendium listed 14 educational programs including two (2) military and two (2) Canadian programs. This was the first time TERC had made an attempt to define and describe these programs. The Compendium was designed to fill several communications gaps in the field. On the basis of the Compendium:

1. Educators would know of the existence of other programs and could share information.

2. BMET program planners could contact operational programs for information on how to begin their program.

3. Students and guidance counselors would know where BMET programs were located.

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* The "Instructional Resources Workshop Report" became part of the Sourcebook of Working Papers. Later it was retitled "What Does the BMET Need to Know?" and issued separately. The hospital administrators workshop was summarized in The BMET in the Hospital. This document was issued separately.

4. Employers had a list of the programs whose graduates they could hire.

When the Compendium was revised and retitled Digest of Educational Programs, the purpose of the Digest was slightly expanded from that of the original Compendium. All the information included in the Compendium was updated in the Digest. Eighteen new programs were added plus an entirely new section summarizing the curricula of 26 of the 32 programs. One of the most frequent requests from those planning programs was for information on the curricula of BMET programs. This Digest provided a significant sharing of information to those who used it.

Sourcebook of Working Papers, Biomedical Equipment Technology (March, 1972)

The Sourcebook was conceived as an essential key in TERC's attempts to insure all those interested in BMET education were able to effectively share information. The Sourcebook, which was a loose leaf document, was a series of process papers concerning various aspects of BMET education.

For example, before conducting the Instructional Resources Workshop, BMET instructors were surveyed about available instructional materials in the field. These results were reported, sent to workshop participants, and included in the Sourcebook of Working Papers. The results of that survey were updated and expanded into a Digest of Educational Materials (BMET) 1974,* which became too large for the Sourcebook. However, the initial survey was rendered obsolete by the information the BMET instructors had supplied for the listing of educational materials.

Other materials included in the Sourcebook were case studies of Monroe Community College and British Columbia Institute of Technology, a summary of hospital administrators workshop report, curriculum lists of eight (8) BMET schools, the Instructional Resources Workshop Report, and a report on the status of the certification effort for BMETs by the Association for the Advancement of Medical Instrumentation. All of these materials were presented as tentative statements

* The BMET Digest of Educational Materials served the same purpose for the field as its predecessor survey--instructors could share their information on the usefulness of existing materials for their biomedical courses.

about the status of an emerging field. Comments and criticisms were always welcomed from any reviewer. The Sourcebook with its flexible format and open posture to problems in the field attempted to assist the field in the following ways:

1. BMET program planners could learn from the experience of others through the case studies and curriculum lists.

2. BMET program directors shared their information on instructional materials already available to the field.

3. The Association for the Advancement of Medical Instrumentation could provide information to all program directors about the current status of their certification efforts.

Recruitment Materials

In September, 1971 a nine month effort to devise recruitment materials was launched under the Second Phase of the BMET project. The recruitment materials were to include several products: a brief brochure, and description of an average BMET's day, a slide/tape presentation for use by schools, and a survey of other recruitment materials available for BMET. Although a draft of the last two products was completed under the project, additional funds, not forthcoming, were required to complete them. The materials that had been developed were seen as adequate to meet the need.

A recruitment brochure, summarizing the possibilities for BMETs and the programs available, was printed in 1972 and was reissued and updated in 1973. Over 10,000 copies were distributed, mostly to schools that were establishing programs. One measure of the effectiveness of the brochure was the number of schools that used most of the material from the brochure in designing their own individualized descriptions of their BMET programs. At least six school program descriptions were based extensively on these recruitment brochures.

In addition, a short pamphlet, A BMET's Day was developed and printed. These were distributed to educators and students. Had funds been available additional copies would have been made available to students to help acquaint them with the day to day activities of a typical Biomedical Equipment Technician.

# THE INTERACTIVE NETWORK--A MECHANISM FOR PROGRAM DEVELOPMENT AND DISSEMINATION

## The National Conferences on BMET Education

As a first step in involving schools throughout the country the BMET project sponsored the First National Conference on BMET Education which was held in Atlantic City, New Jersey, April 17-18, 1969. This meeting was arranged to coincide with the annual meeting of the Federation of American Societies for Experimental Biology (FASEB). This conference was attended by nine (9) schools comprising virtually all schools which at that time were operating or were considering establishment of a BMET Program. The schools represented were: Air Force Medical Service School, Texas; Algonquin College, Canada; Army Medical Maintenance Training Branch, Denver; British Columbia Institute of Technology, Canada; James Connally Technical Institute, Texas; Medical College of South Carolina; Monroe Community College, New York; Northeastern University, Evening Division, Boston; and Springfield Technical Community College, Massachusetts.

Topics discussed included teacher recruitment and training, instructional materials, equipment, administration, curriculum development, certification, and student personnel services. This conference produced good interaction among the schools attending and the BMET project staff. It was the consensus of participants that a similar conference should be held during the following year.

The Second National Conference on BMET education was planned for Denver in August, 1970. The Denver Conference included educators from both civilian and military programs, employers, and representatives of professional societies. Individuals were selected because they were deeply interested in the BMET field and were likely to carry on activities that would support the BMET project goals. It was hoped that the participants could advise the BMET project as to which project activities should receive most emphasis in the future. At the time the conference was planned, the participants were viewed primarily as "reviewers" and informal advisors on the conduct of the project. Their value as persons active in the BMET field who would work apart from TERC but towards the essential goals of the project became clearer much later.

The Denver Conference on Biomedical Equipment Technician Training was held as planned in Denver, August 17-21, 1970. It was attended by 38 participants including representatives of 13 schools conducting or planning BMET programs and representatives of a variety of biomedical equipment manufacturers, service companies, hospitals, and medical specialty organizations. The Denver Conference in addition to providing important information exchange among the attending schools, employers, and BMET project staff members made several important recommendations as to the current priority needs for assistance to schools interested in establishing BMET programs. These recommendations which provided the basis for many BMET project activities during the Second and Third Phases of the project were as follows:

1. Job descriptions should be made available to educators and employers. (The TASC Manual accomplished this goal.)

2. Educators need information on curriculum development and equipment lists. (The BMET Curriculum Guide served this need.)

3. A cost effectiveness study of the hospital with a BMET was needed to convince hospital administrators of the need for this technician. (The BMET in the Hospital although not a cost effectiveness study attempted to achieve the same end.)

4. Certification of BMETs would help them gain recognition. (TERC participated in the initial efforts but withdrew as AAMI took over. Information on certification was included in the Sourcebook of Working Papers.)

5. Student recruitment materials were needed. (Materials were developed.)

6. Information on available instructional materials should be made available to educators and new materials developed to fill the gaps. (Both of these were accomplished.)

7. Some ongoing mechanism should be developed to continue the work of the conference and to keep others besides TERC active in the field. (The BMET Interactive Network served this purpose.)

Initial Product Dissemination Efforts

The first major BMET product dissemination effort was the dissemination of the Interim II Report. All 265 participants in the survey received complementary copies. All the reports were issued free of charge, since at that time the report was viewed as a way of interesting people in the field. The Regional Medical Programs and state directors of vocational education received unsolicited copies. The remaining 800 copies of the report were distributed on a demand basis. Announcements about the availability of the report along with summaries of the findings were reported in several professional journals. By November, 1971, there were no more copies of the report available. All those who requested them were referred to others in their area who had copies. At the time this referral was viewed as a convenient way for people to secure copies. As it turned out, this was also a way of getting people interested in BMET in contact with one another.

After the Compendium and Interim II Report was disseminated free of charge, the project considered charging for materials. All subsequent announcements included a price for materials to cover the costs of printing and handling. When 1,000 members of the BMET interactive network were told that the Sourcebook was available for a nominal fee, 300 of them ordered it. Charging for materials did not seem to dampen the enthusiasm. In fact, the project often received requests to pay for xeroxing materials out of print.

The BMET project learned several lessons about distributing materials. First, it is essential to determine the audience that will be most interested in the document and concentrate efforts on well defined populations. Individual announcements are costly and should be limited to those audiences most likely to purchase. Second, the productive life of a journal advertisement in this field is about six months. Periodic announcements are required to keep the subject active. Third, although the loose leaf format of the Sourcebook of Working Papers was planned to provide maximum flexibility for the project, as a dissemination idea, it was costly to implement. When 500 Sourcebooks are printed, it was costly to keep an accurate record of those who had received each of the materials. Each mailout of materials to update the Sourcebook required more elaborate record keeping than mailing out a new product.

## Formation of the BMET Interactive Network*

The BMET Interactive Network concept grew out of the national conferences on BMET education, the initial product dissemination efforts, and the many informal interactions between the BMET project and educators and employers throughout the country. The BMET Interactive Network was conceived of as a mechanism for systematically involving in the BMET project a large number of key individuals and institutions throughout the country who were concerned with BMET education. The Network was planned to be an ongoing mechanism for facilitating development and implementation of BMET programs both during the BMET project and after the funded project was completed.

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* The formation and early growth of the BMET Interactive Network is described by L. Allen Parker in "Interactive Networks for Innovational Champions: A Mechanism for Decentralized Educational Change", Cambridge, Massachusetts: Doctoral Thesis, Harvard Graduate School of Education, 1971.

When the Interim II report was issued in June, 1970, planning seriously began for implementing an interactive network for those interested in BMET educational programs. The Interim II Report was a map of the current status of the field, but the problem remained how to most effectively involve the maximum number of the "activists" in the BMET field in the work of the BMET project.

The individuals who received copies of the Interim II Report were the initial members of the BMET Interactive Network. New participants were added as additional documents were produced and disseminated. For example, in June 1971 when the Compendium of Educational Programs was developed, all those who were surveyed and indicated an interest in establishing a BMET program were added to the interactive network list. All subsequent products were publicized both by sending announcements to the interactive network and by placing announcements in journals. The journal announcements added to the list of participants. During the six months TERC kept extensive records on the BMET Interactive Network, between 20 and 30 new names were added to the list each month because they initiated a request for information. During several months as many as 100 new names were added because the project had found a new group that was interested in the field. For example, the state directors of health careers programs were added when recruitment materials were being developed. A summary of network participants by categories as of May, 1973 is as follows.

Summary of BMET Interactive Network
Participants by Categories

May, 1973

| | |
|---|---|
| Hospitals or hospital administrators | 510 |
| Medical Schools or M.D.'s | 62 |
| Health Planners or health educators | 159 |
| Equipment manufacturers or other potential employers | 260 |
| BMETs | 242 |
| Four-year colleges | 157 |
| Two-year colleges | 131 |
| Technical Institutes | 98 |
| Other educators | 160 |
| Other or unknown | 209 |
| Societies | 71 |
| TOTAL | 2,059 |

Notice that the participants in the interactive network are by in large the constituency that TERC set out to serve during the Second Phase of the project.

## Role of the Network Coordinator

An Interactive Network Coordinator was appointed who was responsible for all BMET dissemination plans as well as all other activities of the interactive network including record keeping. The role of this coordinator was key to the successful operations of the network. The coordinator (and other BMET project personnel as well) was responsible for responding to all telephone and mail inquiries. These ranged from requests for information on recruitment brochures to wanting assistance in planning a BMET program. When there was a simple answer to a question, the coordinator would send materials and any information that was available. However, a frequent request was for information on establishing a program. In these instances the person was referred to the closest program. Thus began an informal net of referrals. These program planners did co.tact the BMET programs nearest them.

In the process of coordinating the network, the project itself received a great deal of information. When an employer called for information on BMET programs nearest to him, he would often discuss his attitudes towards certification, his opinions about the kind of BMET he requires, or the information he would like to have about BMET curricula. Those BMET program directors were in frequent contact with the BMET project because many of them were workshop participants or were pilot testing the BMET instructional materials. A great deal of information that appeared in the curriculum guide was initially derived from these contacts. The network was a two-way system--the BMET project collected as much information on the status of the field as it disbursed in the process of operating the network.

## Strengths and Weakness of the Network Concept

Based on the experience of the BMET project, the Interactive Network concept is a powerful mechanism for dissemination and communications. The network stresses communications with the field at all stages in product development. All BMET materials at various stages were developed and/or reviewed by those who would finally use them. The model curriculum, for example, was reviewed by 12 BMET program directors. By using key individuals in the field to assist in product development, all of these people have a commitment to the final product.

TERC believes that the BMET Interactive Network was also a major factor in the rapid growth of BMET educational programs throughout the country. The emphasis on program planning materials--Sourcebook, Compendium, TASC, etc.--assisted many schools in the initial phases of their development. Although a curriculum guide was not available until

1974, other curriculum materials such as the curriculum section of the Digest gave some guidance to program planners. TERC assisted many programs through the network because the network strategy was flexible and open. Any school wanting to establish a BMET program could contact TERC for information, specific and general, without fear that TERC was selling a packaged curriculum. This open attitude combined with a wide array of materials was one of the greatest assets TERC had in spreading the word about BMET education. One program director said recently, "For the longest time, TERC was the only place you could go when you wanted information. You helped us when no one else could."

The interactive network has a third advantage in insuring project continuity after project funding has ceased. The network has established linkages between those who are active in the field--BMET program directors know one another and have contact with one another. The BMET program planners visit operational program in their area to gain first hand knowledge of problems. Hospitals know where the educational programs are located and contact them to hire their graduates. The schools have developed a variety of contacts in the field. For example, TSTI has worked with the local hospital association in establishing an electrical safety program for local hospitals. Los Angeles Valley College provides workshops for nurses and doctors in electrical safety.

The major drawback of the interactive network is that it is time consuming and requires a substantial commitment of project resources. Maintaining an organized network of 2,000 people (the maximum attained by the BMET Interactive Network) is clerically a time consuming task. The informal role of the Coordinator does not lead readily to any measurable product. The Coordinator's correspondence with the field may provide assistance to hundreds of people, yet all the project has to show for that assistance is a list of names. One can issue reports on the numbers of people involved in the network, but the network is a process, not a product. As such its impact is difficult to assess quantitatively except in terms of the number and quality of new programs established.

# DISSEMINATION AND IMPLEMENTATION ACTIVITIES AND ACCOMPLISHMENTS

Product dissemination and program implementation have been major objectives of the BMET project from its inception. Previous sections of this report have described dissemination and implementation activities during the First and Second Phases with special emphasis on the dissemination activities of the BMET Interactive Network. During the Third Phase the BMET project focused major experimental effort on strategies and techniques for dissemination and implementation of BMET products and programs. This effort was coordinated with similar efforts being carried out in connection with the Nuclear Medicine Technology project. Some of the dissemination techniques and activities tried include:

1. BMET program displays at AVA Conventions and ATEA-USOE National Clinics on Technical Education;

2. BMET program need surveys of approximately 2,000 community colleges, technical institutes and other agencies;

3. Providing consulting services and technical assistance services to schools for planning, implementation, and evaluation of new BMET programs;

4. Mailings of information on BMET publications and apparatus;

5. Publication of an issue of the TECHNICAL EDUCATION REPORTER focused on emerging technologies and featuring descriptions of exemplary BMET programs;

6. Experimental workshops and short courses particularly on BMET Instructional Modules;

7. Development of a comprehensive Program Development Catalog including a broad range of BMET materials and services;

8. BMET Interactive Network operations;

9. An experimental program for BMET State Coordinators in ten states.

Although time and funding limitations precluded definitive findings as to relative effectiveness of each of these dissemination techniques, there was no doubt that each of these techniques has value and that effective dissemination and implementation of a major program innovation such as the BMET program requires a carefully orchestrated combination of all of these techniques and perhaps others.

Since successful establishment of new BMET programs is the ultimate goal of dissemination and implementation perhaps the best measure of the BMET project's effectiveness in dissemination and implementation activities is in terms of the growth in the number and variety of new programs implemented in association with the BMET project. In 1968 only three civilian schools in the United States were providing a BMET curriculum. State and local sources were investing about $150,000 per year in these programs. The BMET project budget for that first year was $96,469. By 1974 there were 40 operational BMET programs, virtually all established with the active assistance of the BMET project. These programs operated on state and local budgets of approximately $1,600,000 compared with a BMET project budget in 1974 of $100,000. An additional 30 schools are planning BMET programs utilizing BMET project planning and other materials. If all of these programs materialize the 70 schools operating BMET projects will have operating BMET budgets of $2,800,000. A list of seventy schools which have been actively involved in the project in pilot testing, operating BMET programs and using project materials is shown in the appendix. Charts of annual growth of BMET programs are shown in Figures 2 and 3 of the Summary section.

A second measure of BMET project accomplishments in dissemination is in terms of the number and variety of program planning and instructional materials which have been developed and tested, to facilitate the establishment and operation of BMET programs in schools. The appendix details the dissemination of more than 20,000 copies of the more than fifty different program planning publications and student publications which were developed under the BMET project to meet specific project goals. Although these publications are not commercially available because of their small market, TERC expects to continue to make many of these publications available to schools at the lowest possible price which will cover the costs of reproduction and distribution taking into account the small quantities of each publication produced.

A third measure of BMET project impact is the large number and variety of individuals and institutions which have been involved in various ways in the BMET development and testing of BMET project products. Each of these involved institutions helped spread the word about BMET education within its community. The appendix lists more than 20 universities, 90 businesses and industries, 160 hospitals, and 60 professional associations which have been involved in the development of project products. Also listed are 34 postsecondary schools, universities, and employers which were involved in the testing of the products. The appendix also lists 13 BMET Workshops and Conferences sponsored and conducted by the project.

The appendix also analyses the 2,059 individuals who have been members of the BMET Interactive Network and who have received BMET project documents. The appendix shows an analysis of the dissemination of project products categorized by type of institution and by HEW region.

The appendix also lists 26 articles and presentations by the BMET project staff members on various aspects of the BMET project. In view of its particular relevance a copy of the article entitled "Program Development for New and EMerging Technical Occupations" by Nelson and Parker which appeared in the April, 1974 issue of the Journal of Research and Development in Education is reprinted in the appendix. This article contains an overview of the lessons learned from the BMET project and the three other emerging technology projects conducted by TERC. A copy of articles describing typical BMET programs which appeared in the July-August, 1974 issue of the Technical Education Reporter is in the appendix.

In a very real sense the BMET project's dissemination and implementation activities have been a key factor in the growth and development of BMET education during its most critical years as an emerging technology. Many of the problems in the BMET field which existed when the project began have been resolved. The BMET project has structured a broadly acceptable job definition for BMET's and has sent at least 500 of these documents to hospitals and other potential employers to help them with job restructuring. BMET program directors no longer feel that hospital administrators say, "What is that?" when asked if they have a BMET.

The American Hospital Association has become actively involved wtih developing educational materials for hospital administrators, alerting them to the BMET as one possible solution to medical equipment repair problems. The Association for the Advancement of Medical Instrumentation has grown as rapidly as the BMET field and now provides certification for BMET's. In the last meeting the BMET's were discussing the possibility of establishing their own organization. TERC has developed instructional materials for the 40 schools that are operating in 1974, and those materials combined with surveys of existing materials have in large part solved the instructional materials crisis.

The BMET field is moving out of the category of an "emerging" technology. The BMET project was privileged to play an important role in that change.

# EVALUATION ACTIVITIES

Major external evaluations of the entire BMET project by evaluation teams selected by the U. S. Office of Education were carried out in 1969 and in 1971 and were very helpful to the planning of the project. The first site evaluation was conducted by a seven man team in 1969. The second site evaluation was conducted by an eleven man team selected by the USOE in 1971. Both evaluation teams visited both the BMET project staff in Cambridge, Massachusetts and the two BMET pilot schools in Springfield, Massachusetts and Waco, Texas. Both site evaluation teams provided very useful project planning suggestions and both teams strongly recommended continued funding of the BMET project to completion.

Internal evaluation of project activities and products was a continuous process throughout the BMET project. Evaluation of certain individual instructional modules was successfully executed using performance objectives, criterion reference tests and validation with a sample from the target populations. However it was learned by the project that formal evaluation of entire courses or entire programs was not feasible. Confidential case studies and student questionnaires was found to be so threatening that further cooperation with educational institutions would have been unlikely if the project had persisted in their use. However informal evaluations which occurred during confidential case studies, workshops, and consultations did result in significant revisions of courses and programs.

Evaluation of Program Planning products developed in the BMET project was ongoing during the data collection and various writings and rewritings. Those involved in the field were frequently central in the actual data collection--all the workshop reports spring from information provided by the participants. The TASC Manual for example was the sum of "expert" opinion in the field. At various stages in the development of each product, it was sent out for review. When reviewers felt that any idea had een slighted or given too much emphasis, that comment was included in a reviewers section of the report. This review process was designed to make all of the products responsive to the needs of the field.

In addition, in planning project activities, the requests rom the field, both formal and informal, were considered. The Denver Conference was convened to secure participant's assistance in defining what needed to be done. In the Third Phase of the project, an advisory committee met twice with the project staff to provide guidance, especially in the area of program continuity. One informal suggestion that was implemented, was that information in the Instructional Resources Survey (included in the Sourcebook) be expanded and updated by instructors in the field. That information was made available to other BMET programs in the form of the BMET Digest of Educational Materials.

Although no formal evaluation was completed on whether those who received materials actually used them, informal indications from the field were that many programs found the materials useful. The Interactive Network record keeping system was viewed as one way of evaluating the potential impact of these products. For example, in March, 1972, within one month, the 1,000 interactive network participants were sent announcements of the availability of the Sourcebook and Compendium. While some had already received free copies of the Compendium, both documents were offered at a price. There were 150 orders for these products within the month. In the six months during which extensive records were kept (January-June, 1972), TERC had at least 20 requests for the Interim II Report which was out of print. This report had been issued two years previously. There was a constant demand for TERC's products from the field, including requests each month to be put on a mailing list so that the correspondent would receive any future announcements.

# SUGGESTIONS FOR FUTURE COORDINATED PROGRAM DEVELOPMENT PROJECTS

In carrying out this new type of national program development project represented by the BMET project, TERC and the BMET project staff has held a very unusual relationship to the BMET field during the seven years of the project. Although TERC has worked very closely with schools in developing new BMET programs, especially the two pilot programs, TERC did not itself operate any technician education programs. Its role was that of developer, facilitator, coordinator, and disseminator. As such it has been able to obtain unique insights into the entire process of developing BMET programs. It has learned several important lessons as to how to deal effectively with developing emerging technologies and as to how to intervene effectively with state and local educational systems in order to facilitate the development of needed new programs. Some suggestions for future projects concerned with program development in emerging occupations are outlined below.

In encouraging schools to establish new programs, legitimate differences between institutions must be respected. It is axiomatic that a school will modify any model curriculum for their own use. This process tailors the program to the school and establishes a commitment on the part of the instructors who design it. However, in an emerging technology, especially in schools that are pioneering curricula, this modification process may serve another essential function.

At STCC, the TERC staff and instructors found that there was little agreement as to the content of the curriculum--how much electronics, physiology, and biomedical equipment technology should be included--was much in dispute. Until 32 additional schools had developed their own curricula, TERC was unable to firmly establish a suggested curriculum. In an emerging technology, the curriculum development process should not be prematurely discouraged until enough experience is gained to justify establishing a model.

The most effective strategy for disseminating a curriculum in an emerging technology is using a flexible and non-judgemental manner to distribute essential information. During the first five years that an occupation in "emerging", program planners require three minimum essentials--digests of other educational programs, instructional materials and/or lists of them, and curricula lists from other programs. After 15-20 schools have evolved curricula, these experiences can be evaluated and synthesized into a suggested curriculum for others to follow and can replace curriculum lists.

Information for educational programs is only one part of an effective approach to an emerging occupation. The entire system in which the schools function, including employers, professional societies, publishers, and students is important. Technician education programs operate within a larger system than just schools, and the quality of the graduates of such programs is affected by many factors.

In viewing an emerging occupation as the concern of educators, employers, publishers, professional societies, and students, the BMET project has followed a process that insured relevant products. In an emerging occupation there typically is no consensus as to the content of a good BMET program. TERC developed a kind of consensus for that by involving all these groups in the BMET project in development, evaluation, and use of all materials. TERC became a conduit and synthesizer of ideas that came from the BMET field. By the time these ideas were translated into products, those who had helped develop and evaluate materials had a commitment to using them. By using this technique TERC assisted in creating a body of expert knowledge and experience that was to shape educational programs. In an emerging occupation, especially, a catalyst such as TERC can accelerate the growth of educational programs with this process.

Perhaps the most important lesson TERC learned about pioneering programs in emerging occupations from the BMET project was the importance of an accurate and functioning communications system. TERC called its system an interactive network. This network provided feedback and evaluation to the project. In the beginning, the network was primarily TERC's reaching out into the field with products and requests for information. Slowly, educators and employers became aware of TERC and contacted the BMET project for information. From these contacts, TERC established a series of referrals. As TERC products provided more information on those active in the field, the TERC role gradually became less critical and those involved in the field took over. This kind of communications network is one of the most significant accomplishments of the BMET project. During the life of the project, the network was the BMET project's vital link to the field. It is believed that the Network will continue to provide benefits to the field after the BMET project is completed.

# APPENDICES

SUMMARY OF PROJECT GOALS AND

MATERIALS DEVELOPED

## APPENDIX

### Summary of Project Goals and Materials Developed for Them

### The First Phase

| Goals | Materials |
|---|---|
| 1. Develop, test, and evaluate a curriculum for a two year associate degree program in biomedical equipment technology. | Kenneth Dupont. Topics in Biomedical Measurements (1969) |
| 2. Develop, test, and evaluate instructional materials which could be used by institutions desiring to use the curriculum. | Dean DeMarre. Topics in Bio-Technology |

Dean DeMarre. Topics in Bio-Technology:

- Transducers
- Optics
- Chromatography
- pH Measurement
- Spectrophotometers
- Radiation
- Power Supplies
- Specialized Amplifiers
- Cardiovascular Measurement

Springfield Community College Case Study (March, 1971)

Experimental Instructional Modules in Biomedical Equipment Technology (Draft 1)

- *CM-1.1 Introductory Cardiovascular Measurement
- *CM-1.2 Lab for CM-1.1
- *CM-2.2 Intermediate Cardiovascular Measurement Featuring the Cardioverter
- *CM-2.3 Intermediate Lab for CM-2.2
- *CM-3.2 Advanced Cardiovascular Measurement Featuring the Cardioverter
- *CM-3.3 Advanced Lab for CM-3.2
- *TR-1 Specialized Amplifiers: Introductory Solid State Theory
- *TR-2 Specialized Amplifiers: Equivalent Circuits

| | |
|---|---|
| *TR-3 | Specialized Amplifiers: R-C Coupling |
| *TR-4 | Specialized Amplifiers: Chopper Amplifiers |
| *TR-5 | Specialized Amplifiers: Operational Amplifiers |
| *ICU-1.1 | Intensive Care Units: Introductory and Featuring Hewlett-Packard |
| *ICU-1.1A | ICU featuring the Remore installation |
| *ICU-1.1B | ICU featuring the Pacemaker |
| *ICU-1.1C | ICU featuring the Viso-Scope |
| *ICU-1.1D | ICU Safety |

## The Second Phase

| | |
|---|---|
| 1. A survey of the BMET field to determine job performance tasks, types of BMET's, and to better understand their functioning within the hospital environment. | Interim II Report: Survey of Job Characteristics Manpower Needs, and Training Resources. (June, 1970)<br><br>TASK Analysis by Selected Criteria: A Manual (March, 1972)<br><br>BMET Task Lists<br><br>BMET Task Sort Cards |
| 2. Plan, organize, and administer a development conference to promote greater understanding of the objectives of existing and planned programs through the participation by two or three teachers from each institution. | Report of the Denver Conference on BMET Education (August, 1970) |
| 3. The organization and administration of an Interactive Network that would provide assistance to TERC in development of instructional materials and would eventually function within and among the participants to provide project continuity. | Interim II: Report: Survey of Job Characteristics Manpower Needs, and Training Resources. (June, 1970)<br><br>The Report of the Denver Conference on BMET Education (August, 1970) |

| | |
|---|---|
| | <u>BMET Compendium of Educational Programs</u> (June, 1971)<br><br><u>BMET Digest of Educational Programs</u> (March, 1974) <u>(including Curricula compilation)</u><br><br><u>BMET Sourcebook of Working Papers</u> (February, 1972)<br>Instructional Materials Survey<br>Monroe Community College: Case Study<br>British Columbia Institute of Technology Case Study<br>Curriculum Lists<br>What Does the BMET Need to Know: Instructional Resources Workshop Report<br>Status Report on Certification<br><br><u>Biomedical Equipment Technology: A Suggested Two Year Postsecondary Curriculum</u> (December, 1974)<br><br><u>BMET Digest of Educational Materials</u> (September, 1972) |
| 4. Develop instructional systems including the job tasks performed by BMET's, a list of equipment most frequently worked on by the BMET, information key to the development of instructional modules for BMET programs. | <u>Task Analysis by Selected Criteria: A Manual (March, 1972)</u><br><br><u>BMET Task Lists</u><br><br><u>BMET Task Sort Cards</u><br><br><u>Operation and Measurement Series</u><br>*Electrocardiography<br>*Blood Pressure Meansurement<br>Spectrophotometry<br><br><u>Component Analysis Series</u><br>*Linear Operational Amplifiers<br>*Power Amplifier<br>*Voltage Level Detector<br>*Monostable Multivibrator<br>*Low-Pass Filter |

| | |
|---|---|
| | Unijunction Oscillator<br>*Wheatstone Bridge<br>Differential Amplifier |
| | System Analysis Series<br>*ECG Monitor<br>*Electrocardiograph<br>*Cardiotachometer<br>*Electronic Clinical Thermometer<br>Spectrophotometer |
| 5. Surveys of needs and interests of institutions establishing BMET programs and existing programs. | BMET Compendium of Educational Programs (June, 1970) |
| 6. Develop materials for BMET program counselors and guide for follow-up surveys of BMET graduates. | "Frontiers of Technology--The Biomedical Equipment Technician" 16mm.<br>BMET Recruitment Brochure<br>A Description of the BMET's Day<br>Biomedical Equipment Technology: A Suggested Two Year Postsecondary Curriculum<br>BMET Compendium of Educational Programs (June, 1970)<br>BMET Digest of Educational Programs (March, 1974) |
| 7. Refining and exploring implications of the BMET career ladder. | The BMET in the Hospital: Report of Hospital Administrator's Workshop |

## The Third Phase

| | |
|---|---|
| 1. Develop and evaluate a curriculum guide that will summarize a model program for biomedical equipment technology based on the most successful aspects of all BMET programs. | Biomedical Equipment Technology: A Suggested Two-Year Postsecondary Curriculum |
| 2. Contact schools to determine needs for additional material. | |

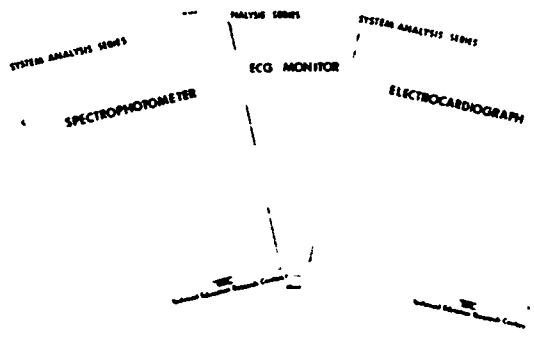
DESCRIPTION OF MEI LEARNING MODULES

# NEW MODULAR PROGRAM IN ELECTRONICS AND MEDICAL INSTRUMENTATION

**Developed By CURRICULUM DEVELOPMENT LABORATORY**
**A Part Of TECHNICAL EDUCATION RESEARCH CENTERS**

## Student Materials

The student materials consist of a series of curriculum materials designed to help electronics and medical technology students to understand body functions and to maintain and use medical instruments. Developed with funding from the U.S. Office of Education, these materials consist of 17 independent learning modules and associated laboratory apparatus. Although specifically designed for programs in biomedical equipment technology, these materials may be used in many general electronics or instrumentation courses as well as ir allied health programs.




## Learning Modules

The learning modules that comprise the software for the curriculum combine text and laboratory exercises. They are of three types, each covering a different aspect of medical instrumentation:

*Operation and Measurement Modules* discuss methods of operating an instrument and the medical applications of the data. They are designed to provide the student with a background on the source of signal for a given instrument, the basis on which the measurement is made, and the use of the results. An experiment instructs the student in the proper operating technique for the instrument and the method of analyzing the data. Operation and Measurement modules include:

#059 - Electrocardiography
#060 - Blood Pressure Measurement
#062 - Spectrophotometry

*System Analysis Modules* give a systems overview of the design of an instrument, explaining the function of each circuit and transducer component. In these modules the student analyzes an instrument system in terms of the flow of information from the source to a particular output display mode or feedback loop. In the laboratory, the student assembles and calibrates a functioning system from the component blocks and studies the problems of their interfacing.

System Analysis modules include:

#071 - ECG Monitor
#072 - Electrocardiograph
#073 - Cardiotachometer
#076 - Electronic Clinical Thermometer
#074 Blood Pressure Recorder
#077 - Spectrophotometer

*Component Analysis Modules* give an in-depth analysis of circuits and transducers which are used in instrument design. Each module includes experiments so that students can get hands-on experience with the equipment. In these modules the hardware component is discussed, an analysis of its operation is presented in terms of input-output characteristics, and a laboratory exercise is given for the students to assemble the circuit and study its operation. Component Analysis modules include:

#063 - Linear Operational Amplifier
#064 - Power Amplifier
#065 - Differential Amplifier
#066 - Voltage Level Detector
#067 - Monostable Multivibrator
#068 - Low-Pass Filter
#069 - Unijunction Oscillator
#070 - Wheatstone Bridge

*FOR FURTHER INFORMATION WRITE:*
**TERC Publications/Services**
**Technical Education Research Centers**
**44 Brattle St., Cambridge, Massachusetts 02138**
*A Non-profit Public Service Corporation*

# Student Apparatus

The laboratory hardware associated with the curriculum has been designed around integrated circuits and other contemporary components. Six functioning medical instruments can be constructed with the laboratory apparatus. Hardware components are as follows:

Input Sources and Simulators

- ECG Simulator - Produces a well-defined ECG Waveform with variable heart rate.
- Cardiovascular Simulator - Simulates the human circulatory system: produces actual blood pressure waveforms and readings.

Transducers

- Electrodes - Three standard plate electrodes with leads and straps.
- Pressure Transducer - Diaphragm bellows and strain gauge in clear plastic housing; measures both dynamic and static pressures in fluid or gas systems.
- Thermometer Thermistor Probe - Small thermistor mounted in tubular plastic holder; measures oral temperature
- Pneumograph - Rubber bellows used to detect respiration rate.
- Photo-Plethysmograph - Transducer used to measure pulse rate by photo-optical means.

Amplifiers

- Operational Amplifier - 741 op-amp and off-set potentiometer, mounted on printed circuit board.
- Power Amplifier - Designed to deliver up to 5 watts for driving such devices as the strip chart recorder and speaker.

Signal Processors

- Input Selector Switch - A convenient means of connecting EKG electrode leads.
- Wheatstone Bridge - Basic 4-arm bridge on a circuit board; can be used with a variety of resistive and capacitive elements.
- Level Detector - Modified Schmitt trigger circuit; can be variably set to trigger on a given positive slope signal.
- Multivibrator - 741 op-amp functions as a monostable (one-shot) multivibrator.
- Low-Pass Filter - 741 op-amp, preceded and followed by simple RC filters.
- Unijunction Oscillator - Conventional unijunction transistor oscillator circuit: used as audio tone generator and alarm

Output Display Devices

- Heart Rate/Temperature Meter - High-quality 3½" taut band movement.
- Strip Chart Recorder - Simplified version of standard lab recorder; records EKG.
- Speaker - Standard 2½" P.M. speaker mounted on a P.C. board.

Medical Instruments

From the hardware components listed above, six functioning medical instruments can be assembled: ECG monitor (visual, audio), electrocardiograph, cardiotachometer, blood pressure recorder, respiration rate recorder, and clinical thermometer. The operation and use of these instruments, the data collected, and the medical use of these data can then be observed and studied.

DESCRIPTION OF MEI

MODULE FIELD TRIALS

# FINAL REPORT
## MEDICAL ELECTRONICS AND INSTRUMENTATION FIELD TRIALS

The further development of Medical Electronics curricular materials by TERC in modular form has been greatly aided by the many comments, suggestions, and criticisms put forward by the MEI Field Trials participants. This report is intended to summarize and convey several of the more general remarks and ideas for improvement which have been suggested during the course of in-house workshops, on site visitations of the participating institutions and in other ways.

The MEI program encompasses two distinct but closely related avenues of development: 1. the instructional medium in which the material is presented or "software" and 2. the apparatus or "hardware" to accompany it. The assessment of the suitability of both of these items for use in established MEI instructional programs has been made from separate points of view, that of the instructor and that of the student.

In all, sixteen institutions participated in the field trials, and on-site visitations were made at nine of them. The feedback elicited was gathered in several forms, including summarization sheets for both student and instructor response, instructor-annotated copies of the software modules, and personal interviews with both instructors and students.

It is fair to say that the overall general reaction to the modular approach is one of enthusiasm. There is no lack of interest in both the progress in refining the current materials and the development of new modules. Although the division of the modular materials into three distinct sub-divisions Operations/Measurements, Components, and Systems, is felt to be a good idea by most respondents, the requirements which each type of module fulfills are different. For example, the Operations/Measurements modules have enjoyed a good reception in those programs where heavy emphasis is placed on the physiological aspects of medical electronics measurements. These include the operator-oriented curricula. On the other hand, at several places where the dominant emphasis is purely on electronics and repair techniques, these modules have not been found to be more than marginally useful. This dichotomy in the type of preparation which two year institutions provide for MEI majors is reason for concern, but nevertheless is not likely to change in the foreseeable future.

The Component and Systems modules however, were met with almost universal interest and enthusiasm. Leaving aside any comments about specific errors in typography or content, most general criticisms of these modules concern the format. Some of the most common remarks deal with the question of inclusion of algebraic derivations in the Discussion sections of the modules and whether they contribute to the clarity and readability of the text of not. On this particular point, no clear consensus of opinion was reached, except to say that the present practice of skipping several steps in an algebraic derivation is unsatisfactory.

Several instructors desire full and complete derivations, while most students have indicated the mere mention of the final result in the body of the text is sufficient. It is felt that one resolution of this problem which would seem to be acceptable to all, would be to follow the students' suggestions, but to also relegate the full derviation to a separate summary page.

A second point on which there appears to be full agreement by both sides is that the Experiments section as presently constituted in the modules is not clearly written. Many students have expressed a desire for more direct succinct procedural instructions, with less use of erudite language. The presently used system of reference to figures and equations located back in the Discussion part of the module apparently causes a great deal of confusion. Furthermore, there is inadequate provision for the recording of data in the present format. In order to remedy this problem, a new format for the Experiments section is suggested, wherein each procedural step is accompanied by a specifically indicated means of recording the data. In addition, each circuit diagram or figure would be included alongside the procedural steps as it is needed. These comments stem from the indicated desire of both instructor and student to have a more formalized method of measuring progress toward the understanding and completion of an experiment.

Of all the software, the "Linear Operational Amplifier" component module appears to enjoy the most widespread interest. It is clear from the field trial results that the discussion of the operation of the device is made at about the right level for the technical college student. Except for minor changes, the presentation of the material is easily understood by the student, and is in fact written in such a way as to increase his interest (comments to this effect were heard several times in interviews with students.) Although it is certainly true that some of the interest in this particular module can be attributed to the fact that the device under study represents the current state of the art in electronics and students with such a bent are quite naturally enthusiastic about it, there are definite indications that the TERC software module is regarded as offering a good introduction to the subject, mainly because the available textbooks cover operational amplifiers at a fairly advanced level (i.e. from a design standpoint). One unforseen development regarding this aspect of the component modules which was noted in discussions with electronics instructors, is the possibility of their being adopted as part of the regular electronics instruction program in the two-year colleges.

The Operation/Measurement and System modules, on the other hand, are more likely to be used only in BMET programs due to their specific nature. A common comment of instructors regarding the content of the System modules was the expressed desire for more formalized troubleshooting procedures which would exemplify some of the more common system faults encountered in actual commercial equipment. While it is realized that most equipment presently in the field is typically not based on intergrated circuity, the systems concept is a common feature which can be applied to any device as an aid in localizing the part of a circuit where any fault lies.

As for the TERC hardware components, several general comments concern the size and ruggedness (i.e. the physical weight and strength of the circuit boards used, particularly the operational amplifier module. The type of solderless connections which are to be used is of some concern to both instructors and students, but the consensus is generally in agreement with the thought that some sort of spring-clip or spring-socket type of connector is best. There is some feeling that a kind of "mother board" should be used in assembling the systems hardware, but this is felt by most instructors to be an idealization which does not properly take the added cost of such a system into account.

Another point which was well-taken is the observation that the schematic-style markings on the circuit boards are not consistently done. In particular, the Op. Amp. board has no discrete components marked, while other boards give no indication of the values of certain permanently-mounted components such as potentiometers. These deficiencies only lead to confusion for the student and should be corrected. It is also recommended that all of the boards be of uniform size with standard connection points for input, output, and grounds, in addition to the existing standard power connection.

In conclusion, it is clear that the field trials have provided TERC with definite suggestions for improving both the software and hardware modules. Although various methods of obtaining information from field trials participants were utilized, the type of information gained was found to be a strong function of the response mode. In particular, corrections to specific errors in content are transmitted best by means of instructor-annotated copies, whereas the most valuable source of suggestions for modification of the format and content is in personal interviews with both students and instructors. In this same connection, the summary forms were found to be of limited value.

## APPENDIX - A SCOPE OF THE FIELD TRIALS PROGRAM

### I. Participating Schools

A list of the participanting schools and faculty is given below. Only two failed to respond with follow-up evaluations of one sort or another of the TERC materials. The places where a personal visitation was made are indicated by an asterisk.

| SCHOOLS | LOCATION | PARTICIPANT |
|---|---|---|
| *Utah Technical College | Salt Lake City,Utah | Mr. William Walker |
| *Spokane Community College | Spokane, Washington | Mr. J. Wesley Todd |
| *British Columbia Inst. Technology | Vancover, B.C. | Mr. Finn Bauck |
| *Grossmont Community College | San Diego, Calif. | Mr. W.E. Delegar |
| *Springfield Tech. Community College | Springfield, Mass. | Mr. Kenneth Dupont |
| *Kettering College of Medical Arts | Kettering, Ohio | Mr. Stanley Applegate |
| *Los Angeles City College | Los Angele, Calif. | Mr. Forrest Barker |
| *Texas State Technical Institute | Waco, Texas | Mr. William Short |
| *New York City Community College | Brooklyn, New York | Mr. Arthur Roitstein |
| Los Angeles Valley Community College | Los Angeles, Calif. | Mr. Joseph Labok |
| Michael Owens Community College | Toledo, Ohio | Mr. Thomas Robinette |
| Amarillo College | Amarillo, Texas | Mr. M. Parten |
| Catonsville Community College | Catonsville, M.D. | Mr. John Walstrum |
| Tulsa Junior College | Tulsa, Oklahoma | Mr. Lawrence Jones |
| County College of Morris | Dover, New Jersey | Mr. Martin Hollander |
| Monroe Junior College | Rochester, New York | Mr. Lester Laskowski |

### II. Type of Student

The typical classroom situation in which the TERC materials were utilized was the instructional laboratory. A breakdown of the major courses being pursued by the students who either used the materials of had them demonstrated is given below.

| MAJOR | NUMBER | PERCENTAGE |
|---|---|---|
| Electronics (Technical ) | .29 | 4.7% |
| Nursing | 298 | 48.3% |
| BMET | 271 | 43.9% |
| High School | 11 | 1.8% |
| Other, non students (e.g. Faculty | 8 | 1.3% |
| Total | 617 | 100% |

LIST OF SCHOOLS ACTIVELY

INVOLVED IN BMET PROJECT

## SCHOOLS ACTIVELY INVOLVED IN BMET PROJECT*

May, 1973

| | Pilot Testing | Using Project Materials: In Operating Programs | Using Project Materials: In Planned Programs |
|---|---|---|---|
| **ALABAMA** | | | |
| Regional Technical Institute | | | X |
| **ARIZONA** | | | |
| Glendale Community College | | | X |
| Pima College | | | X |
| **CALIFORNIA** | | | |
| O'Connor Hospital | | | X |
| Grossmont College | X | X | |
| Golden West College | | X | |
| Los Angeles City College | | X | |
| Los Angeles Valley College | X | X | |
| College of the Desert | | X | |
| San Bernardino Valley College | | X | |
| Santa Barbara City College | | | X |
| Ventura College | | | X |
| **CONNECTICUT** | | | |
| Quinnipiac College | | | X |
| **COLORADO** | | | |
| Colorado Electronics Technical Institute | | X | |
| Community College of Denver | | | X |
| **FLORIDA** | | | |
| Santa Fe Junior College | | X | |
| Miami-Dade Junior College | | | X |
| Brevard Community College | | X | |
| **GEORGIA** | | | |
| Augusta Area Technical School | | | X |
| **ILLINOIS** | | | |
| Evanston Hospital | | | X |
| Parkland College | | | X |
| Illinois State University | | | X |
| Triton College | | | X |
| Belleville Area College | | | X |
| Coyne American Institute | | | X |
| **KANSAS** | | | |
| Kansas Technical Institute | | | X |

*Note: This list does not include 32 additional schools which have expressed interest in the BMET Project and which have requested information about it.

| | Pilot Testing | Using Project Materials In Operating Programs | In Planned Programs |
|---|---|---|---|
| **KENTUCKY** | | | |
| Richmond Community College | | | X |
| **MARYLAND** | | | |
| Catonsville Community College | | X | |
| Howard Community College | | | X |
| Montgomery Junior College | | | X |
| **MASSACHUSETTS** | | | |
| Lincoln College | | X | |
| Springfield Technical Community College | X | X | |
| Mass. Bay Community College | | | X |
| **MICHIGAN** | | | |
| Schoolcraft College | X | X | |
| Washtenaw Community College | | | X |
| Kellogg Community College | | | X |
| **MINNESOTA** | | | |
| Brown Institute | | X | |
| Technical Education Center | | | X |
| Suburban Hennepin County Area Voc-Tech School | | | X |
| University of Minnesota | | | X |
| **MISSOURI** | | | |
| Forest Park Community College | | | X |
| **NEW JERSEY** | | | |
| Middlesex County College | | | X |
| County College of Morris | | | X |
| **NEW MEXICO** | | | |
| University of New Mexico | | X | |
| **NEW YORK** | | | |
| Monroe Community College | X | X | |
| New York City Community College | | | X |
| Queensborough Community College | | | X |
| Ulster Community College | | | X |
| Suffolk County Community College | | | X |

| | Pilot Testing | Using Project Materials In Operating Programs | Using Project Materials In Planned Programs |
|---|---|---|---|
| **NORTH CAROLINA** | | | |
| Durham Technical Institute | | | X |
| McDowell Technical Institute | | | X |
| **OHIO** | | | |
| Lima Technical Center | | X | X |
| M.J.Owens Technical Institute | | | |
| [illegible] Community College | | | X |
| Kettering College of Medical Arts | | | X |
| **OKLAHOMA** | | | |
| Oklahoma State University--The Technical Institute | | X | |
| Tulsa Junior College | | X | |
| U. of Oklahoma Medical Center | | | X |
| **OREGON** | | | |
| Portland Community College | | | X |
| **TENNESSEE** | | | |
| Chattanooga State Technical Institute | | X | |
| **TEXAS** | | | |
| Amarillo College | | X | |
| Texas State Technical Institute | X | X | |
| Texas Technical University | | | X |
| Bexar County Hospital Dist. | | | X |
| Dallas County Junior College | | | X |
| **UTAH** | | | |
| Utah Technical College at Salt Lake | X | X | |
| **VIRGINIA** | | | |
| U. of Virginia School of Engineering and Applied Science | | | X |
| **WASHINGTON** | | | |
| Spokane Community College | | X | |
| **WISCONSIN** | | | |
| Western Wisconsin Technical Institute | X | X | |
| Milwaukee School of Engineering | | | X |

# DISSEMINATION OF PROJECT PRODUCTS

DISSEMINATION OF PRODUCTS *

Total Number of BMET Interactive Network Participants

The 2,059 BMET Interactive Network Participants included on the attached chart represent individuals categorized by region and by affiliation. There is minimal overlap in number of institutions. Of these 2,059 individuals, each has received at least one TERC BMET document (product). These people include only those individuals who have received official publications. The list of publications printed and disseminated (plus inventory awaiting dissemination) is attached.

*This report was prepared in May, 1973. It therefore does not reflect some dissemination activities in 1973 and 1974.

Dissemination of Products

Number of Individuals Receiving BMET Products by Type of Institution and Region

| TYPE OF INSTITUTION | HEW REGION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | Other | Total |
| hospital or hosp. admin. | 33 | 99 | 38 | 44 | 146 | 27 | 37 | 32 | 33 | 9 | 12 | 510 |
| med school or M.D. | 8 | 13 | 5 | 7 | 6 | 2 | 11 | 1 | 5 | 4 | | 62 |
| health planners or educators | 13 | 14 | 38 | 17 | 18 | 17 | 16 | 6 | 15 | 5 | | 159 |
| equipment mfg. or pot. employers | 18 | 64 | 17 | 12 | 52 | 16 | 29 | 2 | 35 | 12 | 3 | 260 |
| BMET's | 12 | 50 | 17 | 15 | 30 | 33 | 26 | 10 | 36 | 8 | 5 | 242 |
| four year colleges | 19 | 23 | 7 | 11 | 26 | 13 | 20 | 12 | 20 | 4 | 2 | 157 |
| two year colleges | 9 | 22 | 4 | 13 | 22 | 10 | 19 | 9 | 16 | 4 | 3 | 131 |
| technical institutes | 12 | 15 | 10 | 7 | 16 | 10 | 6 | 6 | 4 | | 12 | 98 |
| other educators | 12 | 75 | 5 | 8 | 10 | 13 | 6 | 9 | 15 | 2 | 5 | 160 |
| other or unknown | 18 | 34 | 32 | 7 | 40 | 7 | 9 | 9 | 34 | 5 | 14 | 209 |
| societies | 9 | 16 | 14 | 3 | 15 | 3 | 5 | 1 | 1 | 4 | | 71 |
| TOTAL | 163 | 425 | 187 | 144 | 381 | 151 | 184 | 97 | 214 | 57 | 56 | 2059 |

## DISSEMINATION OF PRODUCTS
List of Products and Number Disseminated

| | Total Printed | Total Disseminated | Existing or Anticipated Inventory |
|---|---|---|---|
| PROGRAM PLANNING MATERIALS | | | |
| <u>Surveys of Needs and Resources</u> | | | |
| *Interim I Report: Development and Evaluation of BMET Educational Programs | 1000 | 1000 | |
| *Interim II Report: Survey of Job Characteristics, Manpower Needs and Training Resources. | 1500 | 1500 | |
| *Compendium of Educational Programs: Biomedical Equipment Technology (June, 1971) | 500 | 500 | |
| Digest of Educational Programs: Biomedical Equipment Technology (1971-72) | | | 500** |
| <u>Administrator Materials</u> | | | |
| *Springfield Technical Community College Model Curriculum | | | |
| *Springfield Technical Community College, Case Study | 150 | 90 | 60 |
| *BMET Task Lists | 500 | 450 | 50 |
| *BMET Task Key Sort Cards | | | |
| *Task Analysis by Selected Criteria: A Manual | 750 | 400 | 350 |

| | Total Printed | Total Disseminated | Existing or Anticipated Inventory |
|---|---|---|---|
| *BMET Sourcebook of Working Papers | 500 | 360 | 140 |
| Survey of Instructional Materials | | | |
| Monroe Community College: Case Study | | | |
| British Columbia Institute of Technology: Case Study | | | |
| Curriculum Lists | | | |
| What Does the BMET Need to Know: Instructional Resources Workshop Report | | | |
| Status Report on Certification | | | |
| *The BMET in the Hospital: the Hospital Administrator's Workshop Report | 300 | 27 | 273 |
| Curricula Compilation | | | 250** |
| BMET Curriculum Guide | | | 2000** |
| Report on Workshop for Hospital Administrators | | | 500** |
| Report on Workshop for 1974 BMET Program Planners | | | 250** |
| Career Ladder Workshop Report | | | 700** |
| Student/Personnel Materials | | | |
| *BMET Recruitment Brochures | 4000 | 4000 | |
| *A Description of the BMET's Day | 2000 | 1800 | 200 |
| *"Frontiers of Technology -- The Biomedical Equipment Technician" (16 mm) | | | |

*Completed

**Estimated number printed when product is complete

INSTRUCTIONAL MATERIALS

Experimental Instructional Modules in Biomedical Equipment Technology (Draft 1)

| | | Total Printed | Total Disseminated | Existing or Anticipated Inventory |
|---|---|---|---|---|
| *CM-1.1 | Introductory Cardiovascular Measurement | 100 | 100 | |
| *CM-1.2 | Lab for CM-1.1 | 100 | 100 | |
| *CM-2.2 | Intermediate Cardiovascular Measurement Featuring the Cardioverter | 100 | 100 | |
| *CM-2.3 | Intermediate Lab for CM 2.2 | 100 | 100 | |
| *CM-3.2 | Advanced Cardiovascular Measurement Featuring the Cardioverter | 100 | 100 | |
| *CM-3.3 | Advanced Lab for CM-3.2 | 100 | 100 | |
| *TR-1 | Specialized Amplifiers; Introductory Solid State Theory | 100 | 100 | |
| *TR-2 | Specialized Amplifiers: Equivalent Circuits | 100 | 100 | |
| *TR-3 | Specialized Amplifiers: R-C Coupling | 100 | 100 | |
| *TR-4 | Specialized Amplifiers: Chopper Amplifiers | 100 | 100 | |
| *TR-5 | Specialized Amplifiers: Operational Amplifiers | 100 | 100 | |

*Completed

| | | Total Printed | Total Disseminated | Existing or Anticipated Inventory |
|---|---|---|---|---|
| *ICU-1.1 | Intensive Care Units: Introductory and Featuring Hewlett-Packard | 100 | 100 | |
| *ICU-1.1A | ICU featuring the Remore installation | 100 | 100 | |
| *ICU-1.1B | ICU featuring the Pacemaker | 100 | 100 | |
| *ICU-1.1C | ICU featuring the Viso-Scope | 100 | 100 | |
| *ICU-1.1D | ICU Safety | 100 | 100 | |
| *Kenneth Dupont, Topics In Biomedical Measurements | | 50 | 50 | |
| *Dean DeMarre, Topics In Bio-Technology | | 50 | 50 | |
| | Transducers | | | |
| | Optics | | | |
| | Chromatography | | | |
| | pH Measurement | | | |
| | Spectrophotometers | | | |
| | Radiation | | | |
| | Power Supplies | | | |
| | Specialized Amplifiers | | | |
| | Cardiovascular Measurement | | | |
| *Digest of Educational Materials: An Annotated Bibliography | | 250 | 20 | 230 |
| Instructor's Guide for Biomedical Equipment Technology | | | | 250** |

*Completed

**Estimated number printed when product is complete

| | Total Printed | Total Disseminated | Existing or Anticipated Inventory |
|---|---|---|---|
| Operation and Measurement Series (4 Modules) | | | |
| *Electrocardiography | 200 | 187 | 13 |
| *Blood Pressure Measurement | 200 | | |
| Respiration and Temperature Measurement | | | 200** |
| Spectrophotometry | | | 200** |
| Component Analysis Series (8 Modules) | | | |
| *Linear Operational Amplifiers | 400 | 360 | 40 |
| *Power Amplifier | 200 | 155 | 45 |
| *Voltage Level Detector | 200 | 77 | 123 |
| *Monostable Multivibrator | 200 | 81 | 119 |
| *Low-Pass Filter | 200 | 70 | 130 |
| Audio Oscillator | | | 200** |
| *Wheatstone Bridge | 100 | 30 | 70 |
| Differential Amplifier | | | 200** |
| System Analysis Series (7 Modules) | | | |
| *ECG Monitor | 200 | 110 | 90 |
| *Electrocardiograph | 200 | 118 | 82 |
| *Cardiotachometer | 200 | 142 | 58 |
| Blood Pressure Recorder | | | 200** |
| Respiration Rate Recorder | | | 200** |
| *Electronic Clinical Thermometer | 200 | 40 | 160 |

*Completed
**Estimated number printed when product is complete

# DISSEMINATION CHART

## PROGRAM PLANNING MATERIALS

| Total Disseminated to Date | Total Inventory and Anticipated | By End of Project |
|---|---|---|
| 10,177 | 5,298 | 15,475 |

## INSTRUCTIONAL MATERIALS

| Total Disseminated to Date | Total Inventory and Anticipated | By End of Project |
|---|---|---|
| 3,090 | 2,810 | 5,900 |

## GRAND TOTAL

| Total Disseminated to Date | Total Inventory and Anticipated | By End of Project |
|---|---|---|
| 13,267 | 8,108 | 21,375 |

UNIVERSITIES, COLLEGES, HOSPITALS,

BUSINESSES AND OTHERS

INVOLVED IN BMET PROJECT

UNIVERSITIES, COLLEGES, HOSPITALS, BUSINESS, INDUSTRIES AND OTHERS INVOLVED IN THE DEVELOPMENT OF BMET PROJECT PRODUCTS

Community Colleges, Technical Institutes & Military Programs Involved in <u>Development</u> of Products

Springfield Technical Commurity College; Massachusetts
Texas State Technical Institute; Waco, Tx.
Schoolcraft College; Livonia, Mich.
Algonquin Community College; Ontario, Canada
British Columbia Institute of Technology; Burnaby, B.C.
Colorado Electronics Technical Institute; Manitou Sp., Colo.
San Bernadino Valley College; San Bernadino, Calif.
Crossmont College; El Cajon, Calif.
Monroe Community College; Rochester, NY
U.S. Air Force Medical Service School; Wichita Falls, Tx.
U.S. Army Optical & Maintenance Agency; Denver, Colo.
Brown Institute; Minneapolic, Minn.
Los Angeles Valley College; Van Nuys, Calif.
Utah Technical College at Salt Lake; Salt Lake City, Utah
Amarillo College; Amarillo, Tx.
Los Angeles City College; Los Angeles, Calif.
The Technical Institute: Oklahoma State University; Oklahoma City, Ok.
Regional Technical Institute; Birmingham, Ala.
Tulsa Junior College; Tulsa, Ok.
Western Wisconsin Technical Institute; La Crosse, Wisc.
Central Research Instrument Program; Little Rock, Ark.
Golden West College; Huntington Beach, Calif.
Michael J. Oweris Technical Institute; Punysburg, Oh.

Universities involved in <u>Development</u> of Products

Tulsa University
Texas A & M
University of Illinois
Oklahoma State University
University of Houston
University of Missouri
University of Maryland
Stanford University
Queens College
Northeastern University
University of New Mexico
Texas Tech University
University of Virginia
School of Engineering & Applied Sciences, Charlotte
Illinois State University
University of Minnesota
University of Cincinnati
University of Dayton
Amherst College, Amherst, Mass.
Tulane University School of Medicine, New Orleans, La.
Tufts University, Medford, Mass.
Massachusetts Institute of Technology, Cambridge, Mass.

Community Colleges, Technical Institutes & Military Programs Involved in Development of Products

Lowell Technical Institute; Massachusetts
Montgomery Junior College; Maryland
Glendale Community College; Glendale, Arizona
Santa Barbara City College; Santa Barbara, Calif.
Ventura College; Ventura, Calif.
Quinnipiac College; Haniden, Conn.
Community College of Denver; Denver, Colo.
Santa Fe Community College; Gainesville, Fla.
Miami Dade Junior College; Miami, Fla.
Augusta Area Technical Institute; Augusta, Ga.
Maraine Valley Community College; Palos Hills, Ill.
College of DuPage; Glen Ellyn, Ill.
Parkland College; Champaign, Ill.
Richmond Community College; Richmond, Ky.
School of Allied Health, Louisiana State University; New Orleans, La.
Kellogg Community College; Battle Creek, Mich.
Wastitinaw Community College; Ann Arbor, Mich.
Technical Education Center; Aroba, Minn.
Middlesex County College; Edison, NJ
County College of Marris; Dover, NJ
Queensborough Community College; Bayside, NY
Suffolk County Community College; Seldon, L.I., NY
McDowell Technical Institute; Marian, NC
Kettering College of Medical Arts; Kettering, Oh.
Lima Technical Center; Lima, Oh.
Portland Community College; Portland, Or.
Chattanooga State Technical Institute; Chattanooga, Tenn.
San Antonio Junior College; San Antonio, Tx.
Spokane Community College; Spokane, Wash.
Milwaukee School of Engineering; Milwaukee, Wisc.
Pima College; Tuscon, Ariz.
Bakersfield College; Bakersfield, Calif.
College of the Desert; Palm Desert, Calif.
Coyne American Institute; Chicago, Ill.
Triton College; River Grave, Ill.
Belleville Area College; Belleville, Ill.
Kansas Technical Institute; Salinas, Kan.
Catonsville Community College; Catonsville, Md.
Howard Community College; Columbia, Md.
Massachusetts Bay Community College; Watertown, Mass.
Suburban Hennepin County Area Voc-Tech Schools; Minneapolis, Minn.
Forest Park Community College; St. Louis, Mo.
New York City Community College; Brooklyn, NY
Ulster County Community College; Stone Ridge, NY

Community Colleges, Technical Institutes, and Military Programs Involved in Development of Products

Durham Technical Institute; Durham, NC
Lakeland Community College; Mentar, Oh.
Delaware Technical and Community College; Wilmington, Del.
Community College of Baltimore; Baltimore, Md.
Lincoln Technical College; Lincoln, Neb.
S. Oklahoma City Junior College; Oklahoma City, Ok.
State Technical Institute at Memphis, Tenn.
Centennial College of Applied Arts & Technology; Ontario
Fullerton Junior College; Fullerton, Calif.
Laney College; Oakland, Calif.
Ward Technical Institute; Hartford, Conn.
Broward Community College; Ft. Lauderdale, Fla.
Debalk Area Technical School; Clarboton, Ga.
Central YMCA Community College; Chicago, Ill.
DeUry Institute of Technology; Chicago, Ill.
Middlesex Community College; Bedford, Mass.
Ferris State College; Big Rapids, Mich.
Michigan Technological University; Houghton, Mich.
Burlington County College; Pemberton, NJ
Union County Technical Institute; Scotch Plains, NJ
Hudson Valley Community College; Troy, NY
Mohawk Valley Community College; Utica, NY
Cincinnati Technological College; Cincinnati, Oh.
Murray State College; Tishomingo, Ok.
Connaro State College; Warner, Ok.
Fox Valley Technical Institute; Appleton, Wisc.
Sasketchewan Technical Institite; Moose Jaw, Canada

BUSINESSES AND INDUSTRIES INVOLVED IN <u>DEVELOPMENT</u> OF PRODUCTS

American Optical Co.
Radiometer Co.
Hewlett-Packard
Mennan-Greatbach
Advanced Instruments
Instrumentation Laboratory
International Equipment Co.
Scientific Products
David Kopt Instruments
Dallons Inst uments
Medi-Call Service
General Electric
Picker X-Ray
Dundas Anesthesia
Bendix Commercial Service Corp.
Instra Service, L.A.
Burdick
Aldi Electronics, Inc., San Francisco
Cirbon-Farnsworth, Palo Alto
Varian Company, Palo Alto
Gentec Hospital Supply Co., San Francisco
Cobe Laboratories, Inc., Denver
Rocky Mountain Surgical, Denver
Technical Equipment Co., Denver
Muckle Equipment, Denver
Applied Technical Products, Denver
George Burberts and Sons, Denver
Johnnie Walker Medical Electronics, Inc., Denver
American Hospital Supply, Washington, D. C.
Picker Medical Products, Hialeah, Florida
Cambridge Instrument Co.
Technicon, Inc.
Curtin Scientific Co., Atlanta
Akron Surgical Co., Indianapolis
Seller Instruments, Indianapolis
Curtis & French Co., Indianapolis
Medical Electronics, Chicago
Caltronics, Inc., Metairie, Louisiana
Medical Devices, Inc., Kenner, LA
Control Fabrication and Service Corp., New Orleans
Murray Baumgartner, Baltimore
Technical Associates of New Orleans
Alpha, Medica, Inc., Boston
Detroit X-Ray
G. A. Ingram, Detroit
Evan-Sharrat, Detroit
Electro-Medical Co., Detroit
Harold Medical Equipment Service, St. Paul
Joseph Dahl Surgical Co., Minneapolis
Universal Hospital Services, Minneapolis
Minnesota Medical Research Foundation, Minneapolis
Physicians and Hospitals Supply Co., Minneapolis
Puritan-Bennett Corp., Kansas City
Kansas City Calibration and Repair
Electrodyne, Hazelwood, Missouri
Sherwood Medical Industries, Inc., St. Louis
ABC Medical Services, Inc., Overland, Mo.
Instrumentation Lab., St. Louis
Siener Corp., Union, N. J.
Harris Calorific Co., Cleveland
Brush Instruments, Cleveland
E. G. Baldwin and Assoc., Cleveland
Shuemann-Jones, Co., Cleveland
H. P. Gardner Repair Co., Cleveland
Air-Shields, Inc., Harboro, PA.
Medesco, Philadelphia
Smith, Kline & French Lab., Philadelphia

Fisher Scientific Co., Pittsburgh

Impac Instrument Service, Pittsburgh

Terrell Supply Co., Ft. Worth

Dallas Surgical Supply Co.

Honeywell Corporation

Medirent, Houston

Beckman Instrument Co.

Narco Bio-Systems, Houston

W. A. Kyle Co., Houston

Physio-Control, Seattle

Van Waters & Rogers, Inc., Seattle

Ohio Medical Products

Profex-Ray, Seattle

Pengelly X-Ray Corp., Milwaukee

Waters Instruments, Rochester, Minn.

Raycomm Industries, Freehold, N. J.

Medi-Tech, Watertown, Mass.

Bausch and Lomb Corp. NY

Lab-Line Instruments, Inc., Ill.

Esterline Angus Corp., Ind.

Perkin Elmer Corp., Conn.

International Equipment Corp, Mass.

Leeds & Northrup Co., Pa.

Sigmamotor, Inc., NY

HOSPTIALS INVOLVED IN DEVELOPMENT OF PRODUCTS

St. Vincent's Hospital, L.A.
Good Samaritan Hospital, L.A.
Queen of Angels Hospital, L.A.
White Memorial Medical Center, L.A.
Childrens Hospital of Los Angeles
Veterans Administration Hospital, L.A
Kaiser Foundation Hospital, L.A.
U.S.C. Medical Center, L.A.
University Hospital of San Diego
Veterans Administration Hospital, Palo Alto
Mills Memorial Hospital, San Mateo
San Francisco General Hospital
U.S. Public Health Service Hospital, San Francisco
Children's Hospital of San Francisco
St. Luke's Hospital, San Francisco
Mt. Zion Hospital and Medical Center, San Francisco
Veterans Administration Hospital, San Francisco
Letterman General Hospital, San Francisco
Franklin Hospital, San Francisco
Stanford Medical Center, Palo Alto
University of California Medical Center, San Francisco
Veterans Administration Hospital, Denver
Children's Hospital, Denver
St. Joseph's Hospital, Denver
General Rose Memorial Hospital, Denver
Rocky Mountain Osteopathic Hospital, Denver
Colorado General Hospital, Denver
Veterans Administration Hospital, Washington, D. C.
Providence Hospital, Washington, D.C.
Washington Hospital Center, Washington, D.C.
Walter Reed Army Medical Center, Washington, D. C.
Georgetown University Hospital, Washington, D. C.
National Institutes of Health, Bethesda, MD.
National Naval Medical Center, Bethesda, M D.
Baptist Hospital of Miami
Mt. Sinai Hospital, Miami
Veterans Administration Hospital, Miami
Jackson Memorial Hospital, Miami
Miami Heart Institute
Doctor's Hospital, San Diego
Highland Hospital of Rochester, N.Y.
University of Oklahoma Medical Center, Oklahoma City, OK
DeKalb County General Hospital, Decatur, Ga.
Veterans Administration Hospital, Atlanta
St. Joseph's Infirmary, Atlanta
National Communicable Disease Center, Atlanta
Emory University Medical School, Atlanta
Community Hospital, Indianapolis
Methodist Hospital, Indianapolis
Winona Memorial Hospital, Indianapolis
Marion County General, Indianapolis
Indiana University Medical Center, Indianapolis
Louis A. Weiss Memorial Hospital, Chicago
Presbyterian - St. Luke's, Chicago
Children's Memorial Hospital, Chicago
University of Illinois Hospital, Chicago
Charity Hospital of New Orleans
L.S.U. Medical School, New Orleans
Tulane University School of Medicine, New Orleans
Baltimore City Hospital
Children's Hospital, Baltimore
Mt. Sinai Hospital, Baltimore
University of Maryland Hospital, Baltimore

Children's Hospital, Boston
Veterans Administration Hospital, W. Roxbury, Mass.
Beth Israel Hospital, Boston
Mass. General Hospital, Boston
New England Deaconess Hospital, Boston
Faulkner Hospital, Boston
Kennedy Memorial Hospital for Children, Boston
University Hospital, Boston
New England Medical Center, Boston
Hutzel Hospital, Detroit
St. John Hospital, Detroit
Henry Ford Hospital, Detroit
Mt. Carmel Hospital, Detroit
Children's Hospital of Michigan, Detroit
Lafayette Clinic, Detroit
Northwestern Hospital of Minneapolis
Mt. Sinai Hospital, Minneapolis
Hennipen County General Hospital, Minneapolis
Lutheran Deaconess Hospital, Minneapolis
St. Mary's Hospital, Minneapolis
Veterans Administration Hospital, Minneapolis
St. Paul-Ramsey Hospital, St. Paul
Charles T. Miller Hospital, St. Paul
St. Joseph's Hospital, St. Paul
University of Minnesota Hospital, Minneapolis
St. Mary's Hospital, Kansas City
St. Luke's Hospital, Kansas City
Minorah Medical Center, Kansas City
Veterans Administration Hospital, Kansas City
University of Kansas Medical Center, Kansas City
Research Hospital and Medical Center, Kansas City

Barnes Hospital, St. Louis
St. Luke's Hospital, St. Louis
St. Mary's Hospital, Richmond Heights, Mo.
Veterans Administration Hospital, St. Louis
St. John's Mercy Hospital, St. Louis
St. Louis University Hospital
Lutheran Hospital, St. Louis
St. Anthony's Hospital of St. Louis
DePaul Hospital, St. Louis
Jewish Hospital and Rehabilitation Center, Jersey Hospital
Beth Israel Hospital, Newark
St. Barnabas Hospital, Livingston, N.J.
Cherry Hill Hospital, Cherry Hill, N.J.
Jersey City Medical Center
New York Medical College Hospital, New York City
Montefiore Hospital and Medical Center, Bronx
Veterans Administration Hospital, Bronx
Mt. Sinai Hospital, New York City
Morrisania City Hospital, Bronx
Hebrew Hospital for the Chronic Sick, Bronx
New York University Hospital, New York City
Baby's and Children's Hospital, Cleveland
Lutheran Hospital, Cleveland
Albert Einstein Medical Center, Philadelphia
U.S. Naval Hospital, Philadelphia
Institute of Pennsylvania Hospital, Philadelphia
Temple University Health & Science Center, Philadelphia
Hahneman Medical College, Philadelphia
Thomas Jefferson University Hospital, Philadelphia
Children's Hospital of Pittsburgh
Shadyside Hospital, Pittsburgh

Suburban General Hospital, Pittsburgh
Allegheny General Hospital, Pittsburgh
Veterans Administration Hospital, Pittsburgh
Presbyterian University Hospital, Pittsburgh
Methodist Hospital, Dallas
Chilren's Medical Center, Dallas
U. S. Air Force Hospital, Ft. Worth
Baylor University Medical Center, Dallas
University of Texas (SW) Medical School, Dallas
Ben Taub Hospital, Houston
Texas Children's Hospital, Houston
Veterans Administration Hospital, Houston
Baylor College of Medicine and Research, Houston
Texas Institute for Rehabilitation and Research, Houston
Texas Heart Institute, Houston
Providence Hospital, Seattle
Burien General Hospital, Seattle
Veterans Administration Hospital, Seattle
University of Washington, Seattle
Madigan General Hospital, Tacoma
Veterans Administration Hospital, Milwaukee
Lutheran Hospital, Milwaukee
West Allis Memorial Hospital, Milwaukee
St. Francis Hospital, Milwaukee
St. Luke's Hospital, Milwaukee
Mt. Sinai Hospital, Milwaukee
Evangelical Deaconess, Milwaukee
Milwaukee County General Hospital, Milwaukee
Elm Brook Hospital, Milwaukee
O'Connor Hospital, San Jose, California
Evanston Hospital, Evanston, Ill.
Fitzsimmons General Hospital, Denver
Peter Bent Brigham Hospital, Boston
Riverside Hospital, Trenton, MI
University of Colorado Medical Center, Denver

St. John's Hospital, Tulsa, Oklahoma
St. Paul's Hospital, Burnaby, B.C.
Springfield Hospital Medical Center, Springfield, Mass.
University of Alabama Hospitals & Clinics, Birmingham
University of Utah, Medical Center., Salt Lake City
Charles Miller Hospital, St. Paul
Holy Cross Hospital, Salt Lake City
Hillcrest Baptist Hospital, Waco, Texas
High Plains Hospital, Amarillo, Texas
Baptist Hospital Medical Center, Birmingham, Ala.
Baptist Memorial Hospital, Oklahoma City
Hollywood Presbyterian Hospital, L.A.
Mercy Hospital, Springfield, Mass.
Memorial Hospital, Colorado Springs
Wilson Memorial Hospital, Johnson City, N. Y.
St. Mary's Hospital, Madison, Wisconsin
Downstate Medical Center, Bronx, NY
Riverside Hospital, Trenton, Mich.

Others Involved in Product Development

Health Careers Council; Birmingham, Ala.
Health Careers Program, Arkansas Hospital Assoc.; Little Rock, Ark.
Health Manpower Council of CA; Orinda, CA
Health Professions Council of San Fransisco; San Fransisco, Ca.
The Connecticut Hospital Assoc.; New Haven, Conn.
Georgian Higher Education Authority, State Scholarships Commission; Atlanta, Ge.
Hospital Association of Hawaii; Honolulu, Haw.
Maryland Hospital Education and Research Foundation; Lutherville, Md.
Massachusetts Hospital Assoc.; Burlington, Ma.
Missouri Health Careers, Missouri Hospital Assoc.; Jefferson City, Mo.
Montana Hospital Assoc.; Helena, Mo.
Medical Careers Information, Nevada Hospital Assoc.; Reno, Nev.
New Mexico Hospital Assoc.; Alburquerque, NM
National Health Council, Inc.; New York, NY
North Dakota Health Careers Council, ND State University; Fargo, ND
Health Policy Planning Council; Greenville, SC
Hospital Council of the National Capital Area, Inc.; Washington, D.C.
Maryland Hospital Education and Research Foundation; Lutherville, Md.
Woman's Auxiliary California Medical Assoc.; Fullerton, Ca.
V.A. Hospital Personnel; Boston, Ma.
Arizona Hospital Assoc.; Phoenix, Ar.
Colorado Health Careers Council; Denver, Colo.
Association of Delaware Hospitals; Wilmington, Del.
Hospital-Health Careers; Miami, Fla.
Operation MEDIHC; Tampa, Fla.
Georgia Hospital Assn.; Atlanta, Ge.
Idaho Hospital Assoc.; Boise, Id.
Health Careers Council of Illinois; Chicago, Ill.
Indiana Health Careers, Inc.; Indianapolis, Ind.
Manpower Development & Public Affairs, Iowa Hospital Assoc.; Des Moines, Ia.
Kansas Hospital Association Educational Foundation; Topeka, Kan.
Health Careers in Kentucky; Louisville, Ky.
Health Careers Program, Louisana Hospital Assoc.; New Orleans, La.
Health Council, Inc.; Augusta, Me.

Others Involved in Product Development

Horizons Unlimited, Mass. Medical Society Auxiliary; Boston, Mass.
Michigan Health Council; East Lansing, Mich.
Minnesota Health Careers Council; Minneapolis, Minn.
New Hampshire Health Careers Council; Concord, NH
New Jersey Hospital Assn; Princeton, NJ
N.Y.S. Department of Health; Albany, NY
Regional Health Council of Eastern Appalachia; Morganton, NC
North Carolina Hospital Assn.; Raleigh, NC
Greater Cleveland Hosp. Assn.; Cleveland, Oh.
Health Careers of Ohio; Columbus, Oh.
Oklahoma Council for Health Careers; Oklahoma City, Ok.
Health Manpower Program, HCWP: Pittsburgh, Pa.
R.I. Council of Community Services; Providence, R.I.
Tennessee Health Careers Program; Nashville, Tenn.
Health Careers Council of Vermont; Randolph, Vt.
Virginia Health Careers; Richmond, Va.
Coordinating Council for Occupational Education; Olympia, Wash.
North Seattle Community College; Seattle, Wash.
Wisconsin Health Careers Program; Madison, Wisc.
Hospital Council of Greater Milwaukee Area; Milwaukee, Wisc.
American Medical Assoc. (Horizons Unlimited Project); Chicago, Ill.
Division of Careers and Recruitment, American Hospital Assoc.; Chicago, Ill.
National Health Council, Inc.; New York, NY
Connecticut Institute for Health Manpower Resources, Inc.; Hartford, Conn.
Alliance for Engineering in Medicine and Biology; Washington, DC
Biomedical Engineering & Instrumentation Branch, NIH, Division of Research Services; Bethesda, Md.
Biomedical Engineering Society; Evanston, Ill.
Engineers Joint Council; New York, NY
Foundation for Medical Technology, Mount Sinai Medical Ctr.; New York, NY
Emergency Care Research Institute, Philadelphia, Pa.
Medical Material Field Office, U.S. Air Force, Phoenixville, Pa.
Association for Advancement of Medical Instrumentation

PROJECT CONFERENCES AND WORKSHOPS

## Conferences and Workshops

First TERC Conference on BMET Education, Atlantic City, New Jersey (April, 1969)

Denver Conference on BMET Education (August, 1970)

Report of the Denver Conference

Hospital Administrator's Workshop (July, 1971)

Instructional Resources Workshop (September, 1971)

Career/Guidance Workshop for BMET/NMT (December, 1971)

First Tech Square Workshop (May, 1971)

First Tech Square Field Trial Workshop (February, 1973)

Second Tech Square Field Trial Workshop (April, 1973)

Third Tech Square Field Trial Workshop (April, 1973)

Field Coordinators Workshop (Feb. 1974)

ARTICLES AND PRESENTATIONS

Articles, Presentations


*Abele, John. "Administration of Medical Electronics," Hospitals (Journal of the American Hospital Association), December, 1969, pp. 53-56.

*________. "Cost Effectiveness in Medical Instrumentation," presented at the American Hospital Association Meeting, New Jersey, September, 1968.

*________. "The Role of Industry in an Accelerated National Program of Biomedical Instrumentation," presented to the Association for the Advancement of Medical Instrumentation at seminar sponsored by U.S. Senate Subcommittee on Government Research, Oklahoma City, October, 1966.

________. "The Role of the Biomedical Equipment Technician in Medical Instrumentation," presented at the annual meeting of the American Hospital Association, Chicago, September, 1968.

Angus, Robert. "Initiating and Operating a BMET program," presented as a member of the panel at the New England regional meeting of the American Technical Education Association, Northeastern University, Boston, March, 1973.

*Cadle, P. J. and Cohn, A. "Career Opportunities for Biomedical Equipment Technicians," Medical Electronics and Data (September-October, 1972), pp. 81-85.

________. Summary of "Survey of Job Characteristics, Manpower Needs and Training Resources for Biomedical Equipment Technicians," TERC's Interim II Report. Medical Electronics and Data (January-February, 1971) pp. 63-69.

Cadle, P. J. "Task Analysis of Training Programs in Emerging Technologies," presented to the International Meeting of the Institute of Manpower Sciences (Washington, D.C., 1971.

DeMarre, Dean. "The Biomedical Equipment Technician," presented to the Biomedical Technology and Manpower Conference, Grossmont College, El Cajon, Calif., March, 1970.

________. "Biomedical Electronics Education," Medical Electronics and Data (January-February, 1971) pp. 71-75.

________. "BMET-Biomedical Equipment Technician Training Update, 1972," Medical Electronics and Data (May-June, 1972) pp. 72-75.

Articles, Presen,ations

__________. "Role of the Audio Engineer in Medicine," Audio Engineering Society Journal (November, 1971) pp. 899-900.

*Frank, N. H. "Lab-Centered Physics Courses are in the Wings," Industrial Education (March, 1973) pp. 133-134.

*__________. "Tinkering with Hardware during Lessons in Physics," Industrial Education (April, 1973) pp. 73-75.

*Hubbard, W. D. "Development of Generalizable Educational Programs in Biomedical Equipment Technology," presented at annual meeting of Association for Advancement of Medical Instrumentation, Houston, July, 1968.

__________. "The Development of Educational Programs in Biomedical Equipment Technology." Journal of the Association for the Advancement of Medical Instrumentation (July, 1969) pp. 135-138.

McWane, John. "Biomedical Engineering: A Struggling Technology," presented to the engineering and medical faculty of Thayer School of Engineering, Dartmouth College, Dartmouth, N.H March, 1972.

__________. "Curriculum Materials Being Developed for Biomedical Equipment Technology," presented at regional meeting of American Technical Education Association, Springfield, Mass. June, 1972.

*Nelson, Arthur. "A Coordinated Research Effort," presented at annual meeting of the American Technical Education Association, Denver, December, 1966.

*__________. "Development of Educational Programs for the Emerging Technologies," presented at annual meeting of the American Vocational Association, Dallas, December, 1968.

*Rogers, John. "The Biomedical Equipment Technician," Industrial Education (January, 1971) pp. 1-8.

*Tompkins, Jack. "The BMET Program at Texas State Technical Institute," presented at annual meeting of the Association for the Advancement of Medical Instrumentation, Washington, D.C. March, 1973.

Articles, Presentations

__________. "Biomedical Equipment Technicians--a Need and a Solution," presented at the annual Meeting, Association for the Advancement of Medical Instrumentation (1971).

Wilkins, Margaret. "Summary of TERC's Instructional Resources Workshop," presented at annual meeting Association for the Advancement of Medical Instrumentation, Las Vegas, April, 1972.

Nelson, Arthur H. and Parker, Allen. "Program Development for for New and Emerging Technical Occupations." Journal of Research and Development in Education. (Spring, 1974) pp. 65-79.

__________. "Coordinated Program Development for Emerging Occupations." Technical Education Reporter (July-August, 1974) pp. 88-98.

Reporter Staff. "The Development of an Emerging Field." Technical Education Reporter (July-August, 1974) pp. 27-32.

Bauck, F. and Ridgway, A. "Better Health Through Hospital Equipment." Technical Education Reporter (July-August, 1974) pp. 33-38.

REPRINTS OF PUBLISHED ARTICLES

"Program Development for New and Emerging Occupations"

"Development of an Emerging Field"

"Better Health Through Hospital Equipment"

# PROGRAM DEVELOPMENT FOR NEW AND EMERGING TECHNICAL OCCUPATIONS

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Technical Education Research Centers, Inc.
Cambridge, Mass.

Technological advances have created new educational needs in our society. Large and growing numbers of support personnel are now demanded for doing highly skilled tasks, supervising less skilled workers and gathering data -- often without direct supervision from managers and professionals. These personnel are frequently called "technicians" in engineering, agriculture, and medicine; "professionals" or "specialists" in office, business, marketing, and community service fields; and "technicians" or "noncommissioned officers" in the military services.

As these career opportunities emerged, a new kind of education became necessary. On-the-job training, union apprenticeship, vocational education, and the liberal arts proved to be inadequate. In their place, a new type of postsecondary education involving an integrated balance of theory and practice are required. This preparation, frequently called "technical education," includes classroom instruction and laboratory, clinical, or field experiences. It is offered by a great variety of public, private non-profit, proprietary, business, labor, and military institutions. It usually – but not necessarily -- involves one to three years of higher education and leads to either a certificate or an associate degree.

Technical education has grown rapidly during the last two decades, but it does not yet adequately serve the 35% to 55% of our youths and adults who could benefit from it. To help address this inadequacy, Technical Education Centers was established in 1965 as an independent, non-profit corporation. TERC is dedicated to the expansion and improvement of technical and occupational education.

TERC's founders placed high priority on curriculum development for new and emerging technical occupations. There are at least a dozen of these important occupations, such as biomedical equipment technician, electromechanical technician, marine technician, and urban development technician. In an emerging occupation, there typically exists an unmet demand for thousands of well-prepared technicians. Because few, if any, educational institutions have high quality programs for preparing such technicians when an occupation first emerges, 50 to 500 schools should establish programs for each new occupation during a decade.

These programs are needed to increase the productivity of public and private employers and to provide students with paths to meaningful careers. Emerging occupations offer students from disadvantaged groups and other parts of the U.S. population realistic career opportunities for individual growth, rapid promotion, and a foundation for continuing education in an expanding technological field. Career education programs in new occupations are thus particularly attractive to community and junior colleges, technical institutes, and increasingly to divisions of four-year colleges and universities.

Between 1966 and 1974, the U.S. Office of Education awarded TERC a series of project grants to develop programs for four emerging occupations. One project has now been completed and the other three are nearing completion. This article describes the program development in the four projects and suggests some procedures and products for program development not only in technical education, but in other kinds of education as well.

*A New Kind of Curriculum Development*

Typical curriculum development projects create new instructional materials for a single well-established subject such as physics. These materials are designed with stated educational objectives and are tested and refined. In many cases, such projects devote little attention to making certain that educational institutions are actually going to use the materials. It is assumed that a project needs only to develop high quality products and can leave dissemination to commercial publishers who will be attracted by large potential markets.

By contrast, the development of an educational program for a new technical occupation usually presents a more complex research and development problem. The specifications of the occupation typically require that a school initiate a full-time, two-year program with several new technical courses, rather than improve a single existing course. Furthermore, because an emerging field usually is diffuse and rapidly changing, employers do not offer schools a consensus on objectives for program development. New fields also frequently lack instructional materials and experienced instructors and a school or community seldom can afford to develop the materials and to train instructors. Consequently, more than ten years generally elapse between the time employers seek new kinds of technicians and the time educational institutions first graduate such specialists.

TERC concluded that the reduction of this lag required a new kind of curriculum development project, which might be called a program development and demonstration project. Because of the diffuse and rapidly changing nature of emerging occupations, such a project could most effectively and economically facilitate the development of 50 to 500 programs by means of a nationally coordinated research an dissemination effort. The components of this effort are portrayed in Figure 1, the "TERC Model for Designing, Developing and Establishing a New Educational Program." (See pages 68-69.)

The steps that an educational institution takes to establish a program are shown across the top of the model. These include awareness/interest, feasibility study, program design, program start-up, ongoing program operation, and ongoing evaluation and revision. To assist schools with these steps, TERC implements a program development process including the five major kinds of activities shown across the bottom of the model.

A project begins with a national survey of occupational needs and educational resources. Based upon survey results and the ongoing guidance of employers, a project then develops program planning materials, instructional (system) materials, and guidelines for student personnel services. Throughout these activities, employers and professional associations are intensively involved to assure career relevance. School administrators, instructors and students are similarly included to assure educational relevance. This involvement, in turn, encourages the widespread implementation of the project's products, shown across the middle of the model and described in more detail below.

Specific tactics employed in each of TERC's program development projects varied according to the technology of the emerging occupation, its labor market, and the educational institutions with which the TERC staff members were working. Since program development of this sort was new, no detailed model was initially posited for the four projects. The model shown here emerged as TERC responded to the common requirements of technical education in electromechanical technology (EMT), biomedical equipment technology (BMET), laser electro-optics technology (LEOT), and nuclear medicine technology (NMT). Since the techniques employed by TERC for many aspects of program development are in widespread use, these will not be elaborated in this article. However, some unique features of each project deserve further comment.

*The Electromechanical Technology Project*

Electromechanical technicians deal with a broader scope of technology than do traditional specialists trained in either electronic or mechanical technology. They install, maintain, and repair complex industrial machinery incorporating mechanical, hydraulic, pneumatic, electronic, optical, and thermal devices. After an occupational survey in 1966, the U.S. Office of Education awarded a series of grants to TERC for a program development effort in this new occupational field.

According to the occupational survey, the traditional lines separating electronics and mechanics needed to be eliminated so the electromechanical technician could be equally at home in both of the technologies. The challenge was to teach both technologies in only two years. Since many principles that appear in one technology are also found in the other, the EMT Project staff chose to use a series of ten "Unified Concepts" as the conceptual framework for curriculum development. The resulting curriculum permits mutual support among the several courses and thereby facilitates learning. Such a system focused attention on technical concepts as contrasted with special applications of these concepts.

The materials for teaching the unified concepts were developed as a series of semester-length courses, so that they could be easily incorporated into existing school schedules. The organization of these courses during the first year provided the coordination required to present and integrate the unified concepts. In the second year of the curriculum, the student's technical comprehension and skills were strengthened through application of the basic concepts already learned.

The staff tested the materials with students at Oklahoma State University and then had them tried in several other schools. The materials were also critiqued by more than 40 technical experts. To further evaluate curriculum effectiveness, the project staff consciously established open – mainly formal – lines of communication between students and faculty at Oklahoma State. This effort resulted in much valuable information.

The EMT instructional materials, including 33 laboratory texts and instructors guides have now been published by the Delmar Publishing Company. A series of workshops and conferences were held throughout the country to familiarize users with the EMT materials. Influenced by these dissemination techniques, seventy educational institutions had established EMT programs by June of 1973 and were using some or all of the materials developed by TERC.

### *The Biomedical Equipment Technology Project*

Complex biomedical equipment, such as electrocardiograms and artificial kidneys, is increasingly being used to improve medical research and the diagnosis and treatment of patients. A serious need consequently developed for a new type of technician who could maintain, calibrate, repair, and operate this sophisticated equipment. Human life frequently depends on the knowledge and skill of these technicians. Yet in 1966, only two civilian schools and two of the U.S. military services were preparing biomedical equipment technicians. To rectify this shortage, the U.S. Office of Education awarded a series of grants during the period 1966-1974 to TERC for BMET program development.

Based on an occupational survey, the BMET Project staff envisioned a curriculum that would prepare a technician who combined knowledge of biomedical equipment and an understanding of anatomy, physiology, biochemistry, and patient care. The preparation of such a technician would have required an integrated curriculum similar to that developed by the EMT Project. After program development began at Springfield (Massachusetts) Technical Community College (STCC), however, some staff members began to question the need for an interdisciplinary technician. Although hospitals provided a huge *potential* job market for these technicians, the *current* BMET jobs were to be found mainly with manufacturing firms and repair service companies requiring electronic technicians with a specialized knowledge of biomedical equipment.

The staff had further reservations when a second pilot school, Texas State Technical Institute, decided not to transplant the STCC program, but instead to develop its own curriculum. These reservations were strengthened at a conference of representatives from ten American and Canadian educational institutions with BMET programs underway or being planned in 1969. Each institution intended to develop a program somewhat different from the others in response to its own unique constraints.

The BMET Project staff then shifted its strategy to developing products for flexible assistance to every educational institution seeking to initiate or improve a BMET program. These products included:

1. A collection of BMET laboratory modules,
2. A program planning and curriculum guide,

3. A compendium of both existing and planned BMET programs,
4. An annotated bibliography of BMET educational materials produced by TERC and other organizations,
5. An analysis of BMET tasks by selected criteria,
6. Recruitment brochures for potential BMET students, and
7. A "Sourcebook of Working Papers" concerning problems and possibilities in BMET education.

The project's staff also created an information clearinghouse to assist the network of institutions and individuals interested in BMET education. By facilitating the exchange of information and materials, the clearinghouse encourages interaction among the individuals in the network. An "interactive network" results. Because the clearinghouse periodically revises the compendium describing all BMET educational programs, it also obtains up-to-date information from those concerned with BMET education throughout the nation.

The BMET Project staff monitors the information flows to and from the clearinghouse in order to identify both problems and successes in BMET education. The staff then initiates workshops to explore these problems, and prepares case studies to document several successful programs.

Forty schools have already implemented BMET programs with TERC's assistance, and about twenty more are considering initiating programs within the next two years. More than 2,000 individuals throughout the country have contributed to or benefited from the BMET project at last count in May, 1973.

*The Laser Electro-Optics Technology Project*

The first laser was made operational in 1960 and applications grew rapidly after that. Once employers were able to purchase laser equipment at a reasonable price, they required well-prepared technicians to use this complex and potentially dangerous equipment. A few employers sought technicians who would work mainly with lasers but most wanted personnel who could perform a variety of fabrication, calibration, and testing tasks with optical and electro-optical equipment as well. To meet the urgent need for program development in this field, the U.S. Office of Education awarded TERC a series of grants during the period 1968-1974.

After an occupational survey, the LEOT Project staff decided to develop materials which could be used in optical and electro-optical programs as well as for laser technician education. The Project's staff also concluded that the materials available were either too academic or too simplistic for use in technician training. With the assistance of an advisory committee comprised largely of employers, the staff then designed a series of instructional modules which were further developed and tested with the help of Texas State Technical Institute faculty and students.

Each of the more than 100 instructional modules developed includes measurable objectives and a laboratory exercise supportive of these objectives. A modular format was adopted so each module could be used either autonomously or in combination with others. This allows educational institutions to choose from among the modules so each school can select a mix appropriate to its local manpower needs and institutional constraints. It also has made the materials attractive to instructors in other technologies and in physics. With the series of modules nearing completion. 45 schools have indicated an interest in the entire series and an additional 400 schools in portions of the series.

*The Nuclear Medicine Technology Project*

Since World War II, radioactive isotopes have been increasingly used for medical diagnosis and, to a lesser extent, for therapy. As the practice of nuclear medicine expanded, physicians and physicists involved began to need well-prepared technicians to measure radionuclide doses, position patients, operate sophisticated apparatus, and maintain records of radioisotope use. To respond to the technician needs in this critical health field, the U.S. Office of Education awarded TERC a series of grants for an occupational survey and program development, demonstration, and dissemination during 1968-1974.

The occupational survey identified fifty programs conducted by one or more hospitals, each program training one to three NMTs per year. Only three programs were discovered which included affiliations with education institutions, even though most of the physicians and physicists surveyed indicated a strong preference for such programs. Affiliation with schools both improved the quality of programs and reduced their costs.

The 53 then-existing programs for training NMTs varied greatly in length and content. Although part of this variation was due to the special constraints upon each program, substantial variation resulted from the fact that six different professional societies were seeking to regulate the NMT occupation. In addition, the Council on Medical Education of the American Medical Association wished to coordinate the process of accrediting NMT educational programs. The coordination of efforts among the societies had to be agreed upon before effective program development could take place.

After the NMT Project staff, based in Cambridge, Massachusetts, completed the occupational survey, it used the contacts acquired during the survey to begin acting as a facilitator of cooperation among the societies. The staff asked the AMA Council on Medical Education to obtain cooperation among the societies in sending representatives to a TERC-financed workshop to develop an instructor's guide. Five of the six societies agreed to assist. The sixth society initially refused, but later joined the development effort to make certain that its viewpoint was not eliminated from the field.

Meeting in a workshop, the representatives agreed on the content for an instructor's guide. They then obtained formal approval of the guide from each of their societies. The AMA Joint Review Committee completed the process by agreeing that this document be recommended for use by educational programs seeking information supplementary to that available from the AMA for program approval.

The NMT Project staff acted as facilitators in other ways as well. During the 1969 occupational survey, the staff discovered that the University of Colorado Medical School was developing an associate-degree program with the Denver Community College and fourteen hospitals. Although TERC had had no role in the development of this program, the staff decided to publicize it in a case study. As the only program of its size in existence, it automatically became a model. When other educational institutions developed associate-degree programs, TERC wrote case studies about some of them as well.

The NMT Project staff also organized a clearinghouse and developed products similar to those created by the BMET Project. This clearinghouse has provided information and services to educational institutions and hospitals planning to establish affiliations for NMT programs as well as to hospitals seeking to improve their existing programs. By May of 1973, the clearinghouse had grown to approximately 1000 users, of whom 30% were affiliated with community colleges, 27% with universities, 32% with medical schools, and 65% with hospitals.

*General Insights About Program Development*

During the four projects in new and emerging occupations, TERC's staff observed certain patterns in program development. Research into other kinds of educational innovations indicated that these patterns were widespread. Thus, some of the following observations are relevant to any development project which intends to have an impact on educational institutions throughout the nation.

1. *Responding to Field Constraints.* To develop effective programs in many educational institutions, each of TERC's four projects had to employ different tactics. The differences reflected variations in the technology, labor market demands, professional associations, and educational institutions concerned with each occupation. The EMT Project had to unify several technologies; the BMT Project had to assist many institutions to adapt electronics curricula for incorporating biomedical equipment; the LEOT Project had to offer a wide range of modules in response to variations in local occupational specifications; and the NMT Project had to facilitate cooperation among several strong professional societies.
2. *Accepting Local Autonomy.* The independence of individual educational institutions and the professional autonomy of the instructors within them results in evident differences among the educational programs for the same occupation. In most cases, a school will not introduce a comprehensive two-year program which is "not invented here." This unwillingness may be due to provincialism or to genuine and unique local needs. No matter how much a technical education curriculum is praised by professional experts, it frequently is rejected by local administrators and instructors. Therefore, if a curriculum development project expects to impact upon many educational institutions, it must accept the conditions set by each school. These often result in only partial implementation of an "ideal" educational program.
3. *Assisting Local Innovators.* To have the most impact on the development and improvement of many educational programs, a project must seek out and work with local innovators. As documented by L. Allen Parker (1971), innovations in educational institutions, business firms, and other kinds of organizations are most likely to succeed when at least one individual is highly dedicated to the change effort and also has general management capabilities. The best strategy for capitalizing on the energy and talents of such individuals is to expect them anywhere in the nation and to focus on them whenever and wherever they are identified by surveys and clearinghouse operations. These operations alone are all the support many local innovators need to develop or improve their programs. An active clearinghouse can provide local innovators the moral support of knowing that they are part of a national movement with a place to turn to for assistance.
4. *Developing Modular Materials.* Since local innovators will generally not adopt an entire two-year curriculum, or even all the materials for a course developed elsewhere, a project serves the field best by developing materials in modules which can be used flexibly by many educational institutions. The development of modular materials also

facilitiates the updating of those parts of a curriculum which become obsolescent each year as a result of technological change. Modular materials permit each school to build its own curriculum using quality building blocks. This approach has the added advantage that some instructors in programs outside the field of a particular curriculum development project will use individual modules from the project, thus expanding the usefulness of the project's output.

5. *Involving Both Teachers and Developers.* Two of TERC's projects initially employed technical educators who both wrote the materials and taught the courses in which their materials were used. It was assumed that developers who taught using their own materials would develop more effective materials. At the end of the first year in each of these projects, however, there was concern that the successes being achieved might be due to the personal characteristics of the developer-teachers rather than the content of the materials. Each project then decided to confine its staff to developing and revising instructional materials and had other technical educators test the materials. Development of materials was often subcontracted to individuals outside of TERC, or to the staff of other TERC projects with specialized expertise.
6. *Recognizing the Limits of Evaluation.* The evaluation of individual modules was successfully executed using performance objectives, criterion reference tests, and validation with a sample from the target population. The *formal* evaluation of entire course or entire programs, however, proved to be impossible. Three of the projects did attempt such evaluations by means of confidential case studies and student questionnaries. But these mechanisms were frequently so threatening to technical educators and students that further cooperation with educational institutions would have been unlikely if TERC had persisted in their use.

   In contrast, the projects discovered that *informal* evaluations which occurred during confidential case studies, workshops, and consultations did result in significant revisions of courses and programs. (Henry M. Brickell (1964) obtained similar findings during his survey of the innovative efforts by developers and educators at the elementary and secondary levels in New York State.) The involvement of employers and students in the workshops and confidential case studies proved a good method for prodding educators to keep their programs up to date, especially if job placement opportunities were threatened. Placement in a decent job with multiple career options is *the* pragmatic criterion for effectiveness in occupational education.
7. *Encouraging the Interaction of All Concerned with a Field.* Informal interactions were found to be vital only to effective evaluation but also to effective dissemination. Brickell found the same to be true for New York educators and the National Center for Educational Research and Development (1969) corroborated this finding during a national survey of superintendents. Most educators of all sorts appear to distrust published research reports and speeches at conventions. To learn about innovations, they instead rely upon informal conversations. In the case of TERC's projects, informal interactions during the surveys, workshops, and clearinghouse operations were also important in identifying local innovators and obtaining assistance from employers.

The vital role of informal interactions in the development and diffusion of innovations is elaborated by L. Allen Parker (1971). This doctoral thesis also explores the foundations and implementation of TERC's strategy for facilitating such interaction as a means to change in America's decentralized educational system.

*Suggested Products of Program Development*

Twelve products are suggested for a development, demonstration, and dissemination project which intends to impact upon educational institutions throughout the nation. The priority to be placed on each product is determined by a field's technology, labor market demands, professional associations, and the educational institutions concerned. Available time and financial resources might also limit a project from developing all of the following products.

1. *Survey of Needs and Resources.* A national survey is recommended to determine what needs to be done in a field and to discover the materials and people available in the nation as resources for program development. In the case of occupational education, the *needs* include the estimated number of graduates required by the nation's employers each year, occupational specifications, any programs and materials which must be developed for instructional purposes, and qualifications of appropriate faculty and staff. The *resources* are the network of programs, materials, faculty, staff, professional associations and employers involved in the given field. To encourage later contributions for employers and experts in the field, the survey report concludes with a section containing signed critiques of the report from leading employers and experts.
2. *Information Clearinghouse.* Having identified the needs and resources of the network, the project can begin matching some of the resources with some of the needs through a clearinghouse. As new needs and resources appear, these are also included in the clearinghouse, which becomes the basic information center for both the project and the nation. An effective clearinghouse operation involves more than passive collection and dissemination of information. Requests and information inputs must be monitored to identify emerging patterns of needs and resources. When a pattern emerges, the project's staff and appropriate members of the network in the field must be alerted so that decisions can be made regarding necessary changes in the project.
3. *Compendium of Educational Programs.* The resources survey and the clearinghouse operations can identify educational programs which are in operation or are being planned. Descriptions of these are then compiled into a compendium which anyone interested can use to discover who is doing something about the given field of education. Because every program in the nation is included, no educator feels unrecognized. After learning about other programs through the compendium and discussions at workshops, some educators will begin to improve their programs. For the compendium to be effective as an informal prod to improvement, it must be updated periodically.
4. *Case Studies.* From the resources survey and data collection for the compendium, a project's staff can identify unusual educational programs if any exist. Case studies are then undertaken to ascertain the steps used for planning these programs, the kinds of obstacles encountered, the methods of overcoming obstacles, and the reasons for unresolved issues. If a study unearths important facts which are confidential, the case can be presented with other case studies as an anonymous example. A thorough study of an existing program also assists the

project's staff in developing formal and informal administrative guidelines for new program implementation.

5. *Program Planning and Curriculum Guides.* Based on information gained during the survey, the clearinghouse operations, and preparation of case studies, a project can develop a program planning and curriculum guide. This document, or collection of documents, alerts administrators to factors which must be considered when deciding whether to implement a program. It also provides information on such considerations as student and faculty selection, formation of an advisory committee, facilities necessary for conducting a program, and procedures for obtaining the ongoing involvement of employers. An extensive section of the guide includes one or more suggested course sequences, detailed course outlines, laboratory activities, and a description of facilities, equipment, and costs. As with the survey report, this guide can conclude with a section of signed critiques from employers and experts in the field.
6. *Instructional Modules.* The needs survey usually exposes a lack of quality instructional materials for some or all aspects of a field. A project then undertakes or subcontracts the development of these materials. Employers need to be intensively involved in the development process and students in the testing and validation of its products. Because few educational programs will adopt all of the products, modular materials which can be adopted as autonomous units best serve potential users.
7. *Bibliography of Instructional Materials.* For those planning or improving educational programs, the project also develops a bibliography of instructional materials developed by any and all organizations. The bibliography includes annoted descriptions – not evaluations – of the materials. It can also describe laboratory equipment of various manufa .urers.
8. *Workshops.* National and regional workshops are vital for training instructors and administrators who are implementing or improving a program. Guides and clearinghouse operations alone are frequently not sufficient. At these workshops, no single activity is more important to educators developing new programs than the chance for informal conversations. To enhance the informal interactions, the project's staff purposely invites educators from operating programs and those planning programs, as well as concerned employers. When a project encounters a serious problem in program development, it can also organize a workshop for participants in the field, including employers, to seek solutions.
9. *Recruitment and Career Materials.* Among other problems a workshop can address is the definition of career options for an occupation. When an occupation is emerging, it is likely to be fluid in its characteristics and generally unknown to educators, students, parents, and even employers. If the occupation can be placed in a cluster with similar occupations, guidelines and objectives can be provided for designing educational programs which offer many career options. Recruitment materials and articles in journals and trade magazines can then publicize the occupation's existence and the kind of education it requires.
10. *Counseling and Student Assessment Guidelines.* In conjunction with the development of career options, a project can formulate guidelines for counselors and mechanisms for student assessment of educational programs. Unless a curriculum development project activity encourages the involvement of counselors in program development, TERC has found

that such involvement is likely to occur only as an afterthought – if at all. The conspicuous inclusion of counseling guidelines in planning materials helps to focus attention on this area. Among other things, the guidelines can include sample questionnaires and other communications mechanisms for obtaining student assessments of the program. Similarly, sample follow-up surveys of graduates can encourage the faculty to seek feedback from former students who are discovering the applicability of their formal education to on-the-job practices.

11. *Sourcebooks.* As those concerned about a field grope for solutions to its problems, the problems and proposed solutions can be documented in a "Sourcebook of Working Papers on Problems and Possibilities." Disseminated in a loose-leaf format, sections of a sourcebook can be inserted, updated, or deleted as the field develops. Another kind of sourcebook combines elements of the compendium, the bibliography, and the program planning guide into one reference.
12. *Follow-up Questionnaries and Materials.* As a field of education continues to develop, it frequently changes so that survey data and some materials become obsolete. Although a project's staff monitors clearinghouse requests and inputs to identify some of these changes, the staff can also make periodic investigations to discover other changes. Follow-up surveys of educators, employers, and *program graduates* can be used to complement clearinghouse operations.

*Need to Maintain Program Relevance*

New trends identified by follow-up surveys often require changes in programs to maintain their relevance to the field. Whereas other components of a program development project for new occupations can be created and implemented during five to seven years, the maintenance of relevant programs requires development and follow-up mechanisms which must continue after termination of research funding for the project. As TERC's four research and demonstration projects draw to a close, educators, employers, and professionals are expressing concern about the continuation of these services needed to maintain relevance and growth.

They stress the fact that technical education programs must be updated periodically if they are to remain relevant to student's and employers' needs. In the case of emerging technical occupations, such changes may be necessary every year or two for many years until an occupation becomes well-defined. New occupations are also likely to have manpower needs which increase for decades before becoming stabilized; consequently, additional educational programs must be established each year for some length of time.

If the nation can afford nothing else, the concerned participants in the interactive network for the projects have stressed that ways must be found to continue *active* clearinghouse operations. This would include collection of new data and materials and dissemination of information and documents. More important to *active* operation, however, would be the organization of workshops on serious problems in the field and the initiation of proposals or projects for the development of new instructional modules to replace those which have become obsolescent. Workshops might also be needed to train instructors in the use of new materials. Depending on the field involved, such clearinghouse operations might be continued either by the organization which executed the original development project or by some other research and development organization.

TERC has been exploring possible ways to continue clearinghouse operations. Some possible solutions have been proposed and two are being tentatively implemented, but this is the remaining major challenge of program development projects for new technical occupations.

When this challenge is met, a proven model will exist for develping and improving quality educational programs for emerging technical occupations. These quality programs will prepare youths and adults for careers as technicians and comparable specialists who work with professionals, business managers, government employers, and labor executives to improve the nation's goods and services. These educational programs will satisfy many students because they provide skill in performing practical tasks and insights into why things happen. Moreover, quality programs will offer many disadvantaged youths a realistic path to remunerative and respectable careers.

The development and improvement of these quality programs thus is critical in a society experiencing rapid technological change. We have the functional model within our reach. The availability of financial resources for further program development is and will be the controlling factor in meeting urgent present and future needs of new and emerging technical occupations.

## ACKNOWLEDGEMENTS

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TECHNICAL
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# The Development of an Emerging Field

**THE DEVELOPMENT OF AN EMERGING FIELD**
***Hospitals need technicians to maintain increasingly complex health care systems. Filling a need first addressed by the military, the education of Biomedical Equipment Technicians is now a growing civilian field.***

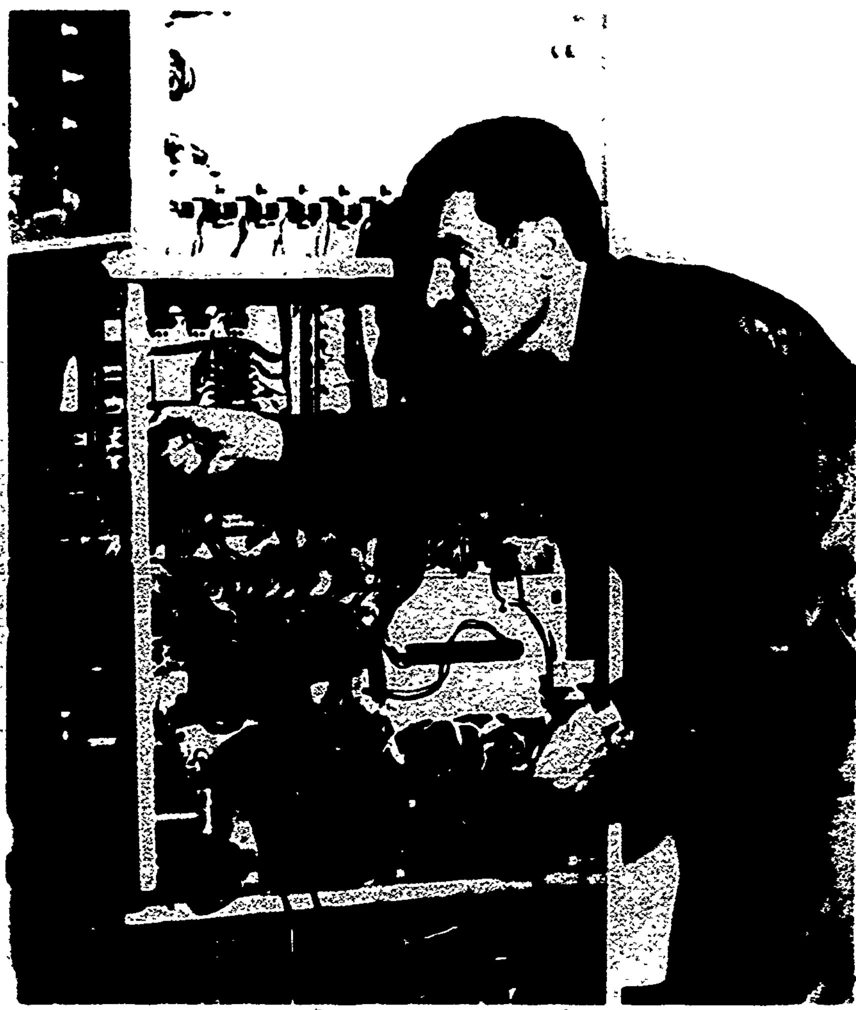
Although the field of biomedical equipment maintenance has only recently gained independent status as an occupation, its history dates back to World War II. At that time, the U.S. Army saw a crucial need for technicians to repair medical equipment in its many hospital stations around the globe. Lacking the maintenance expertise within its own ranks, the Army recruited some employees of biomedical equipment manufacturers to train biomedical equipment maintenance personnel. A small equipment repair shop in St. Louis, Missouri, provided a working base for the Army's initial training program. After the shop was greatly expanded, it became the principal repair station in a worldwide system of shops.

**AIR FORCE FROM ARMY**

The Army's Medical Equipment Maintenance training program began in 1942 with a sixteen-week course. In 1946, it was expanded to a 26-week course including both Army and Navy personnel. With the subsequent emergence of the Air Force as a separate service, the program took on a tri-service configuration. However, in 1957, the Air Force established its own training program at Gunter Air Force Base in Alabama.

The Air Force training was initially modeled closely after the Army program. But, the Air Force soon found that it did not have the number of instructors or on-the-job training sites necessary for an Army type program. When the Air Force program then relocated at Sheppard Air Force Base in Texas, a major restructuring was initiated. Programmed instruction was developed to compensate for the small number of Air Force instructors. Furthermore, a laboratory was constructed which included all the kinds of biomedical equipment used by the Air Force, so that on-the-job training situations could be thoroughly simulated.

The Sheppard program gradually expanded to its present size of 120 students and 23 instructors. Meanwhile, the Army program relocated to Fitzsimmons Hospital in Denver, Colorado, where its operations were extended to include 100 instructors and some 600 students.



*Although the Army and Air Force programs differ in the respect that the former emphasizes classroom and on-the-job training and the latter relies on programmed instruction and job simulation, the two programs share the same dedication to the "hands on" approach. Both schools stress specialized knowledge of equipment in the field rather than a theoretical approach.* In addition, both schools address the specific needs of their services, and instructors have a clear idea of the job responsibilities their students will need to meet. Because the military programs operate within a standardized system, they are not subject to as many variables as confront civilian BMET programs.

**NEED FOR CIVILIAN BMETs**

While the military was developing its Biomedical Equipment Maintenance programs to train BMETs, civilian hospitals were still dependent on manufacturers for repair services. However, as hospitals began to acquire more complex biomedical equipment systems, this dependence presented substantial difficulties. Most of the companies producing biomedical equipment were small concerns which could afford to employ only a few maintenance persons. These service personnel were trained on the job to function something like BMETs, but were too few in number to always efficiently meet the service needs of the hospitals using their companies' equipment. Hospitals often would have to wait a month or more before repairs, which frequently proved to be trivial, could be made on their systems. Given the lifesaving function of the systems, such long delays had profound and sometimes dire implications.

Moreover, this equipment had been developed and placed in use without due consideration for supportive maintenance programs and personnel. Many hospitals purchased biomedical equipment without being able to assure its safe operation. Sometimes the equipment was inadequately designed from the start. In other cases, equipment which originally was safe gradually became uncalibrated to the point where it was unsafe to use with patients.

### RELUCTANT HOSPITAL ADMINISTRATORS

Although hospital administrators desired to provide the best possible patient care, they frequently did not see the necessity of setting up in-house equipment maintenance programs. These programs tended to be first eliminated during hospital budget cuts, and last to be considered during times of budget expansion. Even when the need for such programs was acknowledged, hospital administrators were slow to establish the programs because of the shortage of well-prepared BMETs and uncertainty about how the BMET could be placed in the hospital's organizational structure.

***Skeptical administrators needed to be convinced that they would actually save money by having their own BMETs, or by sharing repair services with other institutions. The need for BMETs had to be recognized and their role better defined before BMET training programs could gain a footing in the civilian sector.***

### OPENING UP THE FIELD

When the Association for the Advancement of Medical Instrumentation (AAMI) was launched in 1965, the BMET field entered a new historical phase. AAMI represented the first formal attempt to bring physicians, equipment manufacturers, and biomedical engineers together to work toward the solution of their common problems. AAMI assumed responsibility for developing badly needed standards for the manufacture of medical equipment, and greatly facilitated communication between doctors and the equipment manufacturers.

At the time of AAMI's founding, only two civilian schools in North America offered programs for training BMETs. Consequently, the U.S. Office of Education awarded a series of grants to Technical Education Research Centers (TERC) for BMET program development. Advised by some of AAMI's members, TERC initially documented the need for BMETs and then set out to develop civilian educational programs. After an initial attempt to formulate an "ideal" curriculum for a systems-oriented technician, TERC began to assist schools seeking to initiate BMET programs. In most cases such initiation involved adding a biomedical equipment component to an established electronics program.

AAMI and TERC then jointly sponsored several conferences to assist schools and to further define the BMET's role in hospitals. Following these conferences, an important hospital administrators' workshop was held to explore intensely the considerable cost benefits hospitals could expect from hiring their own BMETs. ***It was found that BMETs could reduce the equipment maintenance costs in some hospitals by a factor of five.***

As a result of these and other efforts made by concerned individuals and organizations, civilian BMET education has expanded greatly during the last decade. Today, there are at least 40 two-year educational programs for BMETs in community colleges, technical institutes, and state colleges or universities throughout North America. [One of the first of these programs, that of the British Columbia Institute of Technology, is described in the following article.]

## THREE KINDS OF BMET PROGRAMS

After three decades of development, the field of biomedical equipment technology now contains three broad categories of educational programs. a) military, b) technical institute; and c) community college or state university. As already described, the military programs emphasize a specialized knowledge of specific pieces of biomedical equipment and deemphasize theory. In contrast to the military programs, both technical institute and community college programs offer less "hands on" experience. This is the case not so much by design as by financial limitation. Biomedical equipment is very expensive, and civilian programs simply do not have the resources necessary to assemble the full range of equipment that can be found in the military programs.

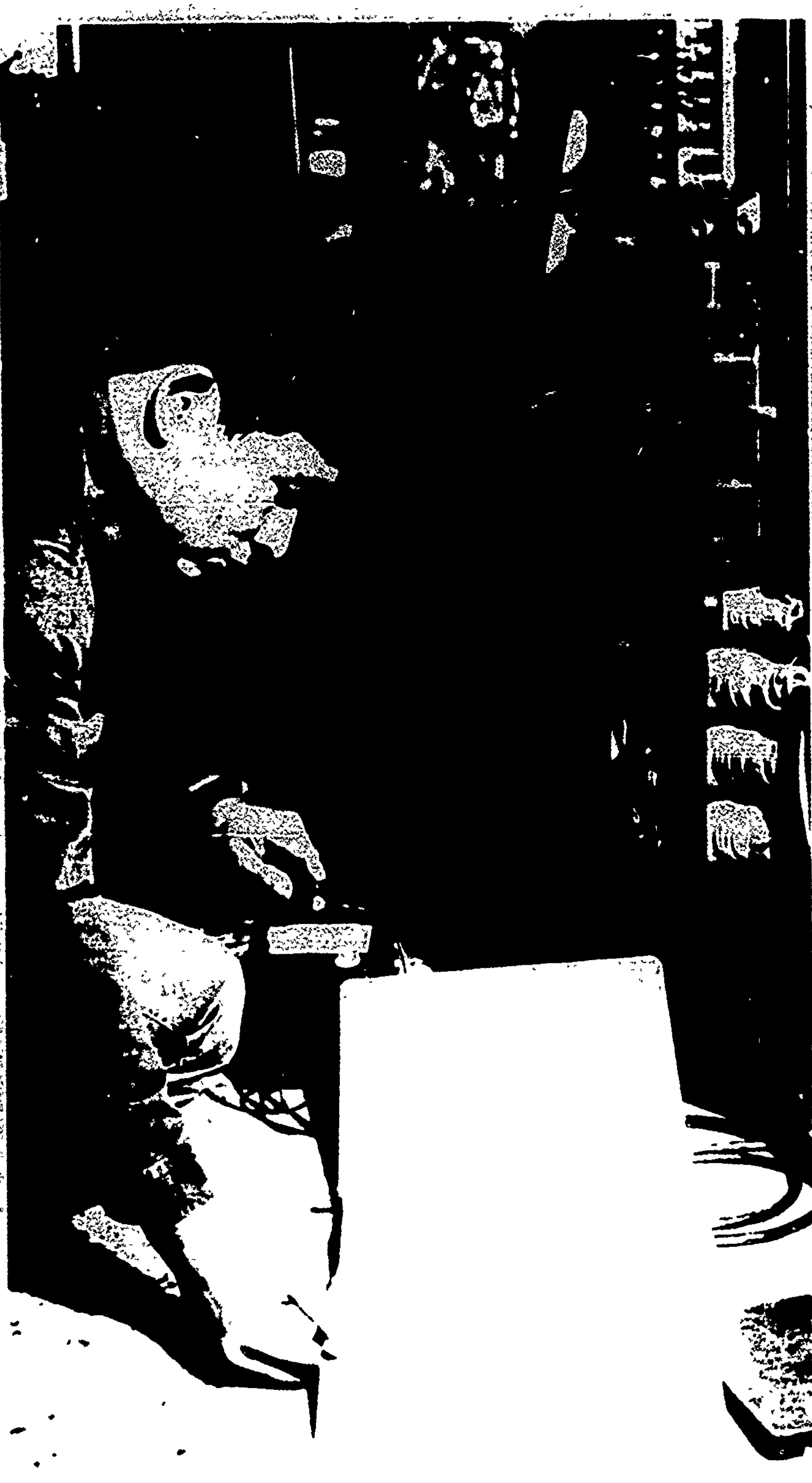
While still stressing "hands on" experience, technical institutes usually provide more theoretical orientation in electronics than either military or community college BMET programs. On the other hand, community colleges and state universities ordinarily provide their BMET students with some general education, as well as with theory courses designed to provide transfer credit for baccalaureate degrees. In general, the programs designed for transfer offer less "hands on" experience with biomedical equipment than do technical institute or military programs.

Each approach has its strengths and weaknesses from the differing perspectives of students, teachers, manufacturers, biomedical equipment engineers, hospital administrators, and physicians. No single perspective is likely to dominate the field since each type of program is capable of satisfying the specific needs of its clientele.

## AAMI DEVELOPMENTS

Given the great diversity of BMET programs, the field needed a method for assuring the competence of program graduates. After much discussion, AAMI's Board of Examiners for Biomedical Equipment Technicians developed a 150-question exam, which was administered for the first time in the spring of 1972. Since that time over 200 individuals (80% of those tested) have passed the exam to become certified BMETs. A similar exam has since been developed by the Veterans Administration.

These exams have been a catalyst for opening up communication between practicing BMETs. Recently, a BMET association was formed within AAMI by a group of certified BMETs, and it is expected that one or more representatives from this association will be elected to the AAMI Board of Examiners some time in the future. Another concern of AAMI's is the need for a BMET-program accreditation mechanism. Although opinion within AAMI is practically unanimous concerning the need for such a mechanism, consideration of this is still in the discussion stage.



**HOSPITALS NEED ALTERNATIVES**

***Because many hospitals are too small to afford their own BMETs, they need alternative maintenance options. In some cases, a small private company of BMETs has been formed to service several hospitals. Another option is "shared services."*** By linking together with other institutions, the small hospital is able to purchase a range of expertise it would not otherwise be able to afford.

One shared service firm, the *Carolinas Hospital and Health Services, Inc.*, provides a comprehensive biomedical equipment service package to 27 hospitals in North and South Carolina. In addition to installation, calibration, maintenance and repair services, this nonprofit corporation offers its clientele such extras as environmental testing and In-Service Training to hospital staff. Approximately eight to ten shared service operations are now in existence around the nation, with another fifteen currently being developed. As shared services becomes more popular, it will open up a significant source of employment for BMETs. This approach may also challenge larger hospitals to develop their own high-quality preventive maintenance systems, or be held liable for not purchasing available expertise.

Hospital associations can take a leadership role in fostering cooperation among their member institutions and nearby programs preparing BMETs. For instance, the Texas Hospital Association and Texas State Technical Institute (TSTI) have jointly undertaken comprehensive electrical

safety surveys in many Texas hospitals. Such surveys have resulted in cooperative BMET training ventures involving TSTI and several hospitals. In turn, these joint ventures have greatly extended employment opportunities for BMET graduates from TSTI.

Several two-day workshops in Hospital Electrical Safety have also been conducted by the TSTI instructional staff. These workshops, which have been enthusiastically received by hospital administrators, maintenance personnel, and plant engineers, have helped to increase the awareness in Texas hospitals of the need for competent BMETs. In addition, the workshops have assisted administrators to define a viable role for BMETs within their individual hospitals.

**THE BMET FUTURE**

According to a *Barron's* article on November 5, 1973, medical equipment and supplies sales for 1973 were expected to reach $5 billion. Furthermore, equipment sales were expected to continue to grow at a rate of 7% to 11% annually. The risk of huge damage suits has impressed hospitals with the need for the best possible diagnostic equipment. Moreover, the safety regulations imposed by the U.S. Department of Health, Education and Welfare have made it necessary for hospitals to update and maintain the efficient operation of electronic devices. These pressures will ensure a greater availability of jobs for BMETs.

The nature of future BMETs who will be educated to satisfy this expanding demand has yet to emerge. As industry continues to develop more complex biomedical equipment, a greater degree of specialization will be called for within the BMET field. Many programs preparing BMETs will no doubt respond by educating one or more specialized kinds of technicians. On the other hand, many programs will probably continue to stress a more generalized BMET because the fully competent hospital BMET must possess not only the expertise necessary to efficiently maintain a diversity of equipment, but also the skills and knowledge that enable him or her to interact meaningfully with a variety of hospital personnel.

Thus, both specialist and generalist BMET programs will most likely be found in the future. In any case, it is certain that improved delivery of health care will require increased numbers of well-prepared technicians in biomedical equipment technology.

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*by REPORTER Staff*

# Better Health Through Hospital Equipment

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## BETTER HEALTH THROUGH HOSPITAL EQUIPMENT

***The electronic devices used in the diagnosis and treatment of disease must be maintained.***

The introduction of complex electronic equipment in hospitals has made possible some major improvements in health care. Sophisticated devices such as cardiac monitors, automatic blood analyzers, and heart-lung machines can substantially increase the effectiveness of doctors and the efficiency of hospitals. On the other hand, these devices have also created problems; improperly maintained instrumentation can produce an electric shock or a misdiagnosis fatal to a patient. Furthermore, equipment breakdowns can cause havoc in hospital practices.

***The use of biomedical equipment has consequently created an expanding field for biomedical equipment technicians or technologists. BMETs must know how to install, operate, and troubleshoot a wide range of diagnostic and therapeutic equipment.*** Some serve as support personnel to physicians involved in patient care and to hospital researchers developing new equipment. Others work with manufacturers to develop, produce and service new devices. The remaining BMETs own or work for firms which contract to maintain equipment in smaller hospitals which cannot afford full-time, electronic technologists.

In the early 1960's only the armed forces in the U.S. and Canada were preparing BMETs. As civilian use of biomedical instrumentation expanded, a demand for civilian BMET educational programs emerged. One of the first schools in North America to respond was the British Columbia Institute of Technology (BCIT) in Burnaby, British Columbia.

### BCIT INITIATES A PROGRAM

Since its founding in 1964, BCIT has been educating technicians to fill job vacancies mainly within British Columbia. In response to the Province's need for a well-trained health work force, BCIT's health division has grown from two programs in 1964 to the eight that now service the 120 or so hospitals of the Province. British Columbia also has six equipment manufacturers—all potential employers of BMETs.

In 1964, Mr. S.T. Richards, full-time director of the Institute's health division, contacted Province administrators and physicians to determine the health technician needs. Technologists trained in biomedical electronic technology were among those proposed. Planning for the program began officially in 1966, with the establishment of an advisory committee.

The BMET program was established in 1967 with a curriculum drawn mainly from the Institute's existing courses. A large portion of the student's time was spent in courses designed primarily for electronics technicians rather than for the BMET's special concerns. A more effective program could not be implemented until the BMET job content was more clearly defined and faculty were prepared to teach the new technology.

Gradually new courses, such as biophysics, were added and existing ones adapted to better suit the BMET's needs. The mathematics course began to stress the application of mathematical principles to biomedical electronics. Furthermore, laboratory experiences related to biomedical instrumentation were implemented for the BMET students taking the electronics course.

### THE PRESENT CURRICULUM

***In keeping with the basic philosophy of most technical institutes in North America, the student spends about half of his or her time in the laboratory, and half in lectures.*** Course materials and sequence are similar to those of many BMET programs in the United States. During the first 75% of the program there is a strong emphasis on basic electronics and related science courses in chemistry, anatomy, and physiology, as shown in Table 1, while the last 25% emphasizes biomedical electronics technology. About 35% of the courses attended are given by BMET program staff; the other 65% are given by other departments, but provide BMET applications.

The BCIT curriculum differs from most BMET programs in two respects. One is the *medical materials* course, which concentrates on the comparative properties of all classes of engineering materials with biomedical applications. This course is of special value to the student planning to work in research. The other is the biophysics course, which covers mechanics, electricity, magnetics, waves, and heat with emphasis on the applications of physics to biological systems. Although some BMET programs have specialized courses emphasizing those physiological systems measurable by electronic equipment, most BMET programs include only a standard physiology course.

**TABLE 1. Biomedical Electronics Technology**

**Year 1**

**Quarter A**

| Subject | Classroom Hours per Week |
|---|---|
| General Chemistry for Health Technologists | 6 |
| Technical Writing | 3 |
| Mathematics (Biomedical Electronics) | 8 |
| Electronics Principles and Practice | 9 |
| Human Anatomy and Physiology for Biomedical Electronics Students | 4 |
| Library and Research | 5 |
| | 35 |

**Quarter B**

| Subject | Classroom Hours per Week |
|---|---|
| General Chemistry for Health Technologists | 6 |
| Technical Writing | 3 |
| Mathematics (Biomedical Electronics) | 4 |
| Numerical Methods and Computing | 4 |
| Electronics Principles and Practice | 9 |
| Human Anatomy and Physiology for Biomedical Electronics Students | 4 |
| Library and Research | 5 |
| | 35 |

**Quarter C**

| Subject | Classroom Hours per Week |
|---|---|
| General Chemistry for Health Technologists | 6 |
| Technical Writing | 3 |
| Mathematics (Biomedical Electronics) | 9 |
| Electronics Principles and Practice | 9 |
| Introductory Microbiology | 2 |
| Tutorial | 1 |
| Library and Research | 5 |
| | 35 |

**Year 2**

**Quarter D** (No classes)

**Quarter E**

| Subject | Classroom Hours per Week |
|---|---|
| Mathematics (Biomedical Electronics) | 5 |
| Biophysics | 3* |
| Medical Materials | 4 |
| Electronics Principles and Practice | 6 |
| Methods of Electrical Measurement | 4 |
| Medical Instrumentation | 3 |
| Biomedical Electronics | 5 |
| Physiology for Biomedical Electronics Students | 3* |
| Library and Research | 5 |
| | 35 |

**Quarter F**

| Subject | Classroom Hours per Week |
|---|---|
| Biophysics | 3* |
| Workshop Practice | 4 |
| Electronics Principles and Practice | 4 |
| Digital Principles and Techniques I | 6 |
| Medical Instrumentation | 3 |
| Biomedical Electronics | 5 |
| Practical Experience in Biomedical Electronics | 5 |
| Physiology for Biomedical Electronics Students | 3* |
| Library and Research | 5 |
| | 35 |

**Quarter G**

| Subject | Classroom Hours per Week |
|---|---|
| Biophysics | 3* |
| Digital Principles and Techniques II | 6 |
| Medical Instrumentation | 3 |
| Biomedical Electronics | 11 |
| Practical Experience in Biomedical Electronics | 7 |
| Physiology for Biomedical Electronics Students | 3* |
| Library and Research | 5 |
| | 35 |

*Alternate weeks.

## EQUIPMENT NEEDED

Before the program began, the department head and senior instructor drew up a list of equipment needed by the program. Funds for the equipment were secured through the British Columbia Department of Education, of which BCIT is a part. A 1,000 square foot laboratory at BCIT houses the equipment which includes devices used in various parts of hospitals such as operating rooms, coronary care units, pulmonary function laboratories, and clinical laboratories.

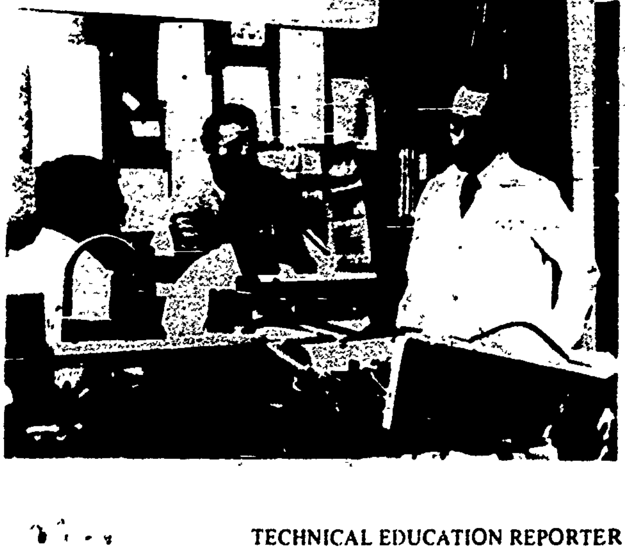
Although BCIT funding for its BMET program has been more than adequate in comparison to the typical program in North America, it has not been sufficient to purchase all the equipment desirable for an ideal program. Securing sufficient equipment can be a serious problem, especially for new programs. There must be one or more devices employing each principle of operation the BMET is likely to encounter.

## PRACTICAL EXPERIENCE

All BCIT technology programs are designed to provide training in a realistic work setting. The BMET student is given practical work experiences one day per week during twenty weeks of the fifth and sixth quarters. To compensate for a lack of costly laboratory equipment, many BMET programs in North America require more on-the-job experience of their students. However, BCIT has structured its BMET laboratory so that many work experiences can be simulated effectively.

The faculty of the BMET program at BCIT maintains close contact with the work supervisors, one of whom is also a member of the program's advisory committee. These supervisors and the BMET senior instructor insure that the practical experience reinforces the theoretical studies pursued by the student.

***Each BMET student is placed consecutively with two differing agencies among five local hospitals, six research institutes, and three equipment manufacturers.*** This placement program is unusual, as most BMET programs offer only one practical experience—usually in a hospital. BCIT students thus have the opportunity to compare two kinds of potential employers.

### GRADUATE PLACEMENT

The practical experience also aids in graduate placement because potential employers have the opportunity to meet the students. If placement does not result directly from the work experience, BMET graduates can seek assistance from the Canada Manpower Office. This federal agency provides placement information and is often instrumental in setting up appointments between students and prospective employers. Over 95% of the fifteen to twenty BCIT graduates from the BMET program have been placed each year.

### PROGRAM RECRUITMENT

In February or March, BCIT publishes an annual catalogue which is sent to all high schools in the Province. Any Institute programs that are still underenrolled before they start in the autumn are advertised in the local paper. The applicants responding to such recruitment devices must have a high school diploma and a background in math, physics, and chemistry if they are to be admitted to the program.

The program has always attracted more than enough applicants. At one time, however, the program had a high dropout rate, which was traced to faulty recruitment techniques. Many of the students enrolling had little interest in electronics and were better suited to be equipment operators. Now all recruitment materials stress the electronics emphasis of the program; BMETs are presented as being concerned mainly with the "insides" of the equipment. Students who now enroll have a better understanding of the program's nature, so that the dropout rate has declined to a low level.

### GROWTH OF THE ADVISORY COMMITTEE

The original advisory committee served until 1972, when it was expanded to more accurately represent the potential BMET employers. Insight into the hospital setting is now provided by a physician, a representative of the British Columbia Hospital Association, and a representative of the British Columbia Hospital Insurance Service. A member of the National Research Council represents the needs of the research and development area, and an equipment manufacturer provides feedback from that sector of the field. A student representative has also been added, and an alumnus will soon join.

Since its inception, the advisory committee has met semi-annually to make recommendations on curriculum matters. It also advises on the number of BMETs to be trained in the future.

### PROGRAM TRENDS

The BMET curriculum has evolved with the refinement of the BMET job description and will continue to change as a result of new developments in the technology. The department is planning to increase the number of courses in the curriculum specifically for BMETs by designing a first year electronics course more closely integrated with second year materials. The BMET program is emerging as an area of study increasingly distinct from traditional electronics.

The BMET program is also likely to change as a result of the shifting employment situation in the Province. The British Columbia Hospital Insurance Service has acknowledged the need for an equipment repair system encompassing all Province hospitals. A government post for a coordinator of such a system has been established, and as soon as a clinical engineer is hired for the post, implementation of the system should begin. The institute will work closely with the coordinator to keep the BCIT program responsive to the Province's hospital needs.

The systematizing of hospital equipment repair will probably increase the BMET demand, which already exceeds BCIT supply capabilities. Laboratory space currently is the major constraint on the size of the BMET program, but in 1976 this limit will be lifted with completion of a new BCIT academic building. The BMET laboratory size will then be increased to 3,000 square feet and the student intake to about 30 per year.

In general the future is bright for BMET graduates. According to a *Barron's* article, medical equipment sales in North America have been increasing at the rate of 7% to 11% annually. Furthermore, hospitals are constantly refining old equipment to increase their effectiveness in the diagnosis and treatment of disease. Wherever there is biomedical equipment, there will be a need for biomedical electronics technologists.

### FOR FURTHER INFORMATION:

*Biomedical Equipment Technology: A Suggested 2-Year Post-High School Curriculum* Cambridge, Massachusetts: Technical Education Research Centers. 1974.

Loehwing, David A., "Biomedical Technology–All Systems Are Go." Barron's National Business and Finance Weekly, November 5 and 12, 1973.

*M.B. Wilkins made significant contributions to the composition and content of this article.*

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