DOCUMENT RESUME

ED 056 220 VT 014 171

AUTHOR	Welch, William G., Sr.
TITLE	The Determination of a Technical Core Curriculum for a Two Year Technical Program in Bio-Medical Electronics.
INSTITUTION	Western Wisconsin Technical Inst., La Crosse.
PUB DATE	Jun 70
NOTE	116p.
AVAILABLE FROM	Bookstore, Western Wisconsin Technical Institute, 6th and Vine Street, La Crosse, Wisconsin 54601 ($2.50; please pay by check)
EDRS PRICE	MF-$0.65 HC-$6.58
DESCRIPTORS	Advisory Committees; *Biomedical Equipment; Comparative Analysis; *Core Curriculum; Curriculum Planning; *Educational Needs; Educational Research; *Electronic Technicians; Equipment Maintenance; Occupational Information; Surveys; *Technical Education

ABSTRACT

The major concerns of this study were to determine the extent of need for bio-medical electronic technicians and to determine what would constitute a functional technical core curriculum for training to fill that need. Following a review of medical and electronic literature, a survey instrument was developed and sent to hospitals, manufacturers, clinics, and research centers in the bio-medical field. The data were analyzed and presented to an advisory committee which assisted in the determination of the areas of concentration and curriculum. The greatest need for Bio-Medical Electronic Technicians was in the area of maintaining and servicing, and a lessee need was for engineering aids and technicians capable of modifying and adapting equipment. It was concluded that to meet these demands the technician needs an in-depth knowledge of basic electronics with abilities to read and interpret schematic diagrams. Suggestions for the curriculum included emphasis on the service and maintenance of equipment, but not neglecting modification, adaption, and operation. A proposed 2-year (six quarters) program would culminate in an Associate of Science degree in bio-medical electronic technology. (Author/GEE)

ED056220

THE DETERMINATION OF A TECHNICAL CORE CURRICULUM FOR A TWO YEAR TECHNICAL PROGRAM IN BIO-MEDICAL ELECTRONICS

by

William G. Welch, Sr.

INDUSTRIAL DIVISION

WESTERN WISCONSIN TECHNICAL INSTITUTE
LA CROSSE, WISCONSIN

ABSTRACT

Title:

The Determination of a Technical Core Curriculum for a Two Year Technical Program In Bio-Medical Electronics

Author:

William G. Welch
Chairman, Industrial Division
Western Wisconsin Technical Institute
La Crosse, Wisconsin 54601

Statement of the Problem:

The problem is two fold--first to determine in which areas of assistance there is a need for bio-medical electronic technicians. Possible areas of assistance are in the development, manufacture, testing, sales, service, operation and maintance of electronic devices and systems used in bio-medical work. The second step in the problem is to determine what would constitute a functional technical core curriculum, a curriculum to train technicians in the most needed areas of assistance as determined in the first step of the problem

Research Design:

The author used a search of the literature, in medical and electronic journals, to establish a basis for the paper and a survey that was sent to hospitals, manufacturers, clinics and research centers in the bio-medical field. The data of the survey was analyzed and presented to an advisory committee which assisted in the determination of the areas of concentration and the determination of a technical core curriculum.

Findings:

The greatest need for Bio-Medical Electronic Technicians was in the area of maintaining and servicing, and a some what lesser need for engineering aids and technicians capable of modifying and adapting equipment. To meet these demands and n-depth knowledge of basic electronics would be necessary with abilities to read and interpret schematic diagrams. Some knowledge of patient relationships would be necessary and a clinical experience of internship for the student should be considered.

Price:

$2.50 hardcopy 109 pages July, 1970

Address Request To:

Bookstore
Western Wisconsin Technical Institute
6th and Vine Streets
La Crosse, Wisconsin 54601

WGW:kh

ACKNOWLEDGMENTS

The author of this study wishes to express his appreciation to Dr. Robert J. Spinti for his genuine help and interest in the completion of this paper, and to my wife Mary F. and daughter Mary M. for their efforts and patience during the writing of this study. Also to Fritz Wenzel for his valuable help with the bio-medical curriculum.

June 1970 William G. Welch

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

STATEMENT OF THE PROBLEM

The problem is twofold. The first step is to determine in which areas of assistance there is a need for bio-medical electronic technicians. Possible areas of assistance are in developing, manufacturing, testing, selling, servicing, operating and maintaining electronic devices and systems used in bio-medical work. The second step in the problem is to determine what would constitute a functional technical core curriculum, a curriculum to train technicians in the most needed areas of assistance as determined in the first step of the problem.

PURPOSE OF THE STUDY

The purpose of the study is to provide a curriculum that could be offered by the Western Wisconsin Technical Institute to fill the needs of clinics, research centers, hospitals, distributors and manufacturers of bio-medical equipment for bio-medical electronic technicians.

For a better understanding of the inference of some terms used in this paper, the following definitions are given:

1. Technical core refers to that portion of an associate degree curriculum consisting of all subjects that directly and immediately pertain to the specialized occupational education of technicians.[1] Generally, the technical core constitutes 45 per cent to 57 per cent of the curriculum.

2. Areas of assistance means those particular services the technician might be performing in working with, or as an assistant to engineers, researchers, doctors and other medical personnel.

3. Technical program is used synonymously with associate degree program. Technical is used to describe a broad middle level of occupations, not necessarily professions, but more rigorous and theoretical than the trades or more specialized and applied than most professions. Program refers to the whole group or sequence of courses which make up the curriculum for an occupational education, designed to provide a balance of general, theoretical and technical information. Hence a technical program is an occupational education

[1]American Society for Engineering Education, Characteristics of Excellence in Engineering Technology Education, Final Report of the Evaluation of Technical Institute Education, (Urbana, Illinois: The American Society for Engineering Education, 1962), p. 32.

for middle level occupations between the trades and professions, specialized and applied yet theoretical in nature.[2]

4. Electronic is defined as follows:

> Involving the flow of electrons in a vacuum or through semiconductors. Of or pertaining to electronics i.e. to that branch of physics that treats of the emission, transmission, behavior, and effect of electrons, especially as applied by means of vacuum tubes, cathode-ray tubes, photoelectric cells, and the like, together with the associated electrical devices.[3]

5. Bio-medical is a contraction of biology and medicine. The term is generally combined with some field of engineering, such as mechanical, chemical or electronic. In this paper, the combination is with electronics or instrumentation; hence, its ultimate use infers a technician from an engineering field related to electronics or instrumentation who would be working with a medical doctor or biologist. It will also be used to identify electronic equipment or instrumentation that is to have a medical or biological use.

---

[2] Wisconsin Board of Vocational, Technical and Adult Education, Guidelines for Program Development and Evaluation, (Madison, Wisconsin: Wisconsin Board of Vocational, Technical and Adult Education, 1969), p. 10.

[3] Allen, William H. (ed). Dictionary of Technical Terms for Aerospace Use. National Aeronautics and Space Administration, Washington, D.C., 1965. p. 96.

ORGANIZATION OF THE PAPER

The idea for this paper came to the author first through observations of the increased use of electronic equipment and instruments by the medical professions. As early as 1964, through visits to hospitals and the reading of literature, the need for technicians in the medical fields was becoming obvious. The idea was reinforced strongly after reading a paper presented by Arthur I. Nelson, President of The Technical Education Research Center, in which he mentioned the development of a post-high school technical program in Bio-Medical Equipment Technology. Nelson cited the rapid growth of bio-medical engineering. In his discussions with industrial and medical leaders, there was indicated a need for technicians in this expanding field. He also commented that there were no programs in the bio-medical equipment technology in the United States.[4]

In a letter, dated April 6, 1967, to Mr. Charles G. Richardson, Director, School of Vocational, Technical and Adult Education, La Crosse, Wisconsin, from Mr. C. L. Greiber, Director of the Wisconsin State Board of Vocational, Technical and Adult Education,

[4]Nelson, Arthur H., "A Coordinated Research Effort -- Developing Technical Education Programs in Emerging Technologies", Denver, Colorado: December 5, 1966.

it was stated that in planning the new Health Science facility, bio-medical electronic technology should be studied. With this encouragement, the author began gathering information pertaining to the bio-medical field.

While on a trip to the Western part of the United States during the summer of 1967, a number of inte .ews were held with personnel from manufacturers, educational institutions and medical facilities concerning the need for bio-medical equipment technicians. The consensus was very strongly expressed that there was a need for technicians. One manufacturer was in the process of training its own personnel because no qualified technicians were available.

The information presented in this paper consists of a search of medical and electronic journals for supportive material and the results of a survey sent to manufacturers, distributors, hospitals, clinics and research centers. The results of the survey along with collected information will be reviewed by a steering committee, to determine the content for the "technical core" of the curriculum.

LIMITATIONS OF THE STUDY

Research of literature was limited to the Stout State University Library, La Crosse State University Library, Western Wisconsin Technical Institute Library, and literature available in the author's

files of collected studies and documents. The study does not intend to produce course outlines, only the topical material and equipment that should be contained in the courses. The technical core content here presented should not be construed to be ideal, but accepted as a guide only to be proved by putting this material into operation.

CHAPTER II

REVIEW OF THE LITERATURE

SIMILAR STUDIES

Medical electronics may date back to the year 1895, when Roentgen discovered X-ray, a date which preceded the development of the triode vacuum tube by ten years. Yet in the years since, the use of electronics in medicine has not kept pace with the use and development of electronics in other fields. Only in the last decade has medical electronics tended to close this gap between electronic instrumentation in medicine and electronic instrumentation applications in general.[1] It would seem reasonable, then, that there should have been a need created for electronic technicians in this emerging field of medical electronics. In a field where specific programs in medical engineering have been established in a number of universities, it should follow that there would be a need for technicians in this field as there has been in other engineering fields.

The author's search revealed only one study having been made on bio-medical electronics programs for technicians. This study was conducted by the Technical Education Research Center, Inc. of

---

[1] Joseph H. Wujek, Jr., "Medical Instrumentation Systems," Electronics World, Volume 78, No. 1 (January, 1968), p. 30.

Cambridge, Massachusetts[2], and performed pursuant to a grant with the Office of Education, United States Department of Health, Education and Welfare. The author did not try to duplicate this work, but has utilized the information contained therein as a basis for this study. The Technical Education Research Center Study will henceforth be referred to as the TERC Study.

The introduction to the TERC Study reads:

> Recent advances in the fields of electronics and instrumentation have resulted both in the acceleration of medical technology in terms of equipment and procedures, and the creation of a need for people able to understand and effectively utilize these new gains. The proliferation of increasingly more complete and sophisticated instruments and methods in this area has created, among other things, a need for technicians capable of servicing and maintaining the bio-medical equipment used in hospitals and medical research institutes. The development of this technology has opened up a new area of employment -- one which requires its personnel to be trained specifically to meet its needs.[3]

Bio-medical equipment manufacturing has been a rapidly growing industry in the past few years as is indicated in the TERC Study, and as further indicated by very recent data found in Investor's Spotlight which states:

---

[2] Development and Evaluation of Educational Programs in Bio-Medical Equipment Technology, Phase I, Technical Education Research Center Inc., Cambridge, Massachusetts, (Bethesda, Maryland: ERIC Document Reproduction Service, ED 016845, 1967). 160 pages.

[3] Ibid., p. 1.

> Available statistics indicate that the bio-medical electronics industry is preparing for a period of sharply accelerating growth in the years ahead. Total industry sales not including X-ray and EDP equipment were about $260 million in 1967. Last year volume rose to approximately $300 million and should reach $500 million by 1970 and top $1 billion by 1975 for a projected growth rate of over 20 per cent per year!
>
> To these figures must be added X-ray equipment sales which run around $150 million and are growing about 10 per cent a year. More importantly, electronic data processing volume, believed to be approximately $125 million, is expected to increase nearly 300 per cent by 1975 as the computer gains acceptance for physiological data handling.[4]

The preceding should be a good indicator of the rapid growth in the use of new bio-medical systems and instruments.

The TERC Study goes on to indicate the lack of training programs:

> At present there are few educational programs in existence to prepare men specifically as Bio-Medical Equipment Technicians (BMET's). This lack of training opportunities has created an occupational vacuum; there is a lack of individuals able to fill the roles fostered by technological advances. There is evidence that the lack of educational programs for BMET's is adversely affecting many national health programs now underway, and, unless corrected, may impair the quality and efficiency of our nation's health services.[5]

---

[4] The Marshall Company, Inc., "Investor's Spotlight," Bio-Medical Electronics 8 Stocks to Gain, A Report Prepared by Research Correspondent - Spear and Staff, Inc. (Babson Park, Massachusetts, April, 1969) p. 1.

[5] TERC Study, loc. cit., p. 1.

The TERC Study had a three-fold purpose. Going on the assumption that there was a need for BMET's, the first step was to find the extent of the need. Once the need had been verified, the specification for the technician had to be established. These might be job functions, characteristics, employment opportunities and location of the employment opportunities.

The third step was to develop a preliminary framework for the curriculum, a curriculum which would properly prepare technicians to meet the specifications for a BMET.[6]

The TERC Study was started in April, 1966, and completed in June, 1967. Much of the survey work was done by unstructured interviews. Those interviewed included medical schools, medical research institutes, hospitals, and bio-medical equipment manufacturers.

One result showed that there was little formal training taking place for BMET's, and that those technicians that could be identified in the field had electrical, electronic or instrumentation backgrounds. Their training seemed to lack, in varying degrees, basic education in the various disciplines thought necessary for this technology. It was also observed that the on-the-job training these technicians received was rather restricted to specific pieces of equipment.

---

[6]Ibid. p. 1

As someone familiar with the concepts of technical education might suspect, the lack of a formalized educational program for the technician left the technician lacking in the ability to develop and grow in this rapidly changing technology. This would indicate primarily a lack of basic knowledge in mathematics, science and even electronics itself. There was also an indication that professionals were performing tasks that could have been handled by technicians who had the proper training. The result would have been better use of professional time. Employment opportunities were indicated in three major categories of employers -- hospitals, equipment manufacturers and medical research institutes.[7]

Because of the lack of funds and the lack of information in this field, the TERC Study was confined to obtaining factual occupational information related to the development of employment opportunities, functions, and other characteristics of BMET's. This did provide information for a preliminary outline of a curriculum for BMET's. The curriculum outline that was developed by the TERC Study is shown in Table I (table follows on next page). As a result of these limitations, it was recommended that at a later date a carefully designed curriculum be developed and evaluated, and that the necessary instructional materials be tested. The basic study then did not do what this study proposed to do, but it is a good foundation.

---

[7]TERC Study, op. cit., p. 3.

TABLE I

PRELIMINARY BMET CURRICULUM

First Semester	Class	Lab	Credit
Bio-Medical Techniques I	2	3	3
Electrical Fundementals	2	3	3
Principles of Electronics	2	3	3
Physics I (Mechanics)	3	3	4
Mathematics I	3	0	3
English I	3	0	3
	15	12	19
Second Semester			
Bio-Medical Techniques II	2	3	3
AC and DC Circuits	2	3	3
Basic Electronic Circuits	2	3	3
Physics II (Heat, Light, Sound)	3	3	4
Mathematics II	3	0	3
English II	3	0	3
	15	12	19
Third Semester			
Bio-Medical Techniques III	3	3	4
Bio-Medical Electronics Systems I	2	3	3
Basic Pulse Circuits	2	3	3
Mathematics III	3	0	3
Psychology I	3	0	3
Report Writing	2	0	2
	15	9	18
Fourth Semester			
Bio-Medical Techniques IV	3	3	4
Bio-Medical Electronic Systems II	3	3	4
Bio-Medical Equipment Construction and Design	1	3	2
Basic Computers	2	3	3
Psychology II	3	0	3
Speech	2	0	2
	14	12	18
Total			
Bio-Medical Component	16	21	23
Electrical/Electronic Component	10	15	15
Physics/Mathematics Component	17	9	20
General Education Component	16	0	16
	54	45	74

Source: TERC Study, p. 90

On the basis of the data gathered the following conclusions were drawn:

1. There is a current need for between 1,350 and 1,450 technicians to service and maintain bio-medical equipment in the New England and Mid-Atlantic regions;

2. This need, projected to 1970, increases to between 3,200 and 3,700 BMET's;

3. The greatest opportunity for employment is with manufacturers of bio-medical equipment, although the more sophisticated jobs are found in hospitals and research institutions;

4. There are four general job types that a BMET will fill:

    a. Rudimentary service and maintenance under close supervision by the production manager in the manufacturer setting or the chief engineer in the hospital setting, and providing and average salary of $6,800;

    b. General service and maintenance requiring greater competencies not only with respect to the quality of his work, but also with respect to the number of tasks expected of him, and supervised to a greater degree by professional people and providing an average salary of $7,400;

    c. Sophisticated service and maintenance that so would involve design and modification of equipment almost exclusively under the supervision of professional people and providing an average salary of $8,400;

d. Sales oriented service under the supervision of the sales manager, and providing an average salary of $9,000;[8]

Further conclusions emphasized the lack of training programs for BMET's and the inadequate preparation of many of the technicians employed. The TERC Study was confined to the Eastern part of the United States; however the conclusions contained a definite statement projecting the study beyond the Eastern Regions of the United States. It was stated:

> Although the Field Study was specifically focused on the New England and Middle Atlantic regions, it is believed that the need for and basic characteristics for BMET's throughout the United States will not vary greatly from those in the regions studied.
>
> Very conservatively there is estimated to be a national need for educational programs to provide at least 2,000 BMET's per year in the United States utilizing a curriculum such as outlined preliminarily in this report. Although this number will not fill all of the employment opportunities for BMET's, it will provide a hard core of well-trained technicians. Since the need for BMET's is distributed throughout the United States, this requirement implies a need for at least fifty geographically distributed educational institutions such as technical institutes and community/junior colleges to establish educational programs for BMET's as quickly as possible.[9]

---

[8]TERC Study, loc. cit., pp. 99 - 100.

[9]TERC Study, op. cit. pp. 100 - 101.

It would appear that a whole new approach might have to be taken in developing a technical core for the curriculum to train BMET's. The conclusions state further:

> The technician capable of filling the existing and developing employment opportunities for BMET's identified by this Field Study will be a new type of technician. His preparation will require a new type of interdisciplinary curriculum.[10]

A very general projection of a curricula for bio-medical technicians was made in an editorial in Medical Research Engineering.[11] The curricula list was part of the separate material made available to the preliminary advisory committee.[12]

Berkley emphasized that the technicians should not be narrowly trained in one field such as physics, zoology, or physiology, but should have a more divergent background consisting of a combination of these specialities.[13]

He also noted the effects in institutions that lack trained technicians:

> There are a number of effects (all adverse) which predictably

---

[10] TERC Study, *op. cit.*, p. 100.

[11] Berkley, Carl, "Training Technical Assistants", *Medical Research Engineering*, 6:7-9, 2nd Quarter 1967.

[12] See Appendix A.

[13] *Ibid.*, p. 8.

> occur in an institution or a laboratory lacking competent bio-medical engineering technical assistants. (a) The equipment "appears" to work and gives entirely erroneous or irreproducible results. (b) The equipment may work sporadically between visits of the manufacturers' maintenance and service men. (c) Equipment intended for other purposes is modified resulting in locomotives being used as wheelbarrows, or (d) Ph. D.'s in bio-medical engineering are impressed into service as technicians.[14]

Berkley makes a final recommendation that the training for the bio-medical field might start in the high school continuing on through all post high school levels, with some persons stopping off at different levels along the way, and with the outstanding students going on to become the bio-medical engineers of the future.[15]

To understand the relationship between Electronic Technology, Health Occupations and Bio-Medical Electronics one should review the general curricula being offered in Electronic Technology and the Health Occupations.

ELECTRONIC TECHNOLOGY

The first suggested curriculum guide for a two-year full-time program to educate highly skilled electronic technicians was published by the U.S. Office of Education in 1960. Rapid technological developments in electronics caused the guide to be revised in 1966. The

---

[14] Ibid., p. 9.

[15] Ibid., p. 9

original 1960 guide was used extensively in the development of the first Electronic Technology Program established at Western Wisconsin Technical Institute, in September of 1961. The program began as a broad, two-year vocational program for electronic servicing technicians. During the school year of 1962-63 the program received NEDA Title VIII approval, resulting in additional financial aids, which allowed for expansion and improvement of the program. The emphasis of the curriculum was shifted from servicing to industrial technology during the 1964-65 school year. The program was evaluated by the Wisconsin State Board of Vocational, Technical and Adult Education, and in April, 1966, the school was given authority to grant the Associate of Science Degree in Industrial Electronics to students meeting the requirements of the program. A constant effort has been made to keep course content, equipment and the instructional staff up to date.

Western Wisconsin Technical Institute was designated by the State Board as the pilot school for Quarter System operation for the school year of 1969-70. This resulted in the electronics program being revised from four semesters to six quarters. This did not alter the basic content of the curriculum, but has caused reconsideration of the structure of many of the courses. The six quarter system does, however, provide greater degrees of freedom and flexibility over the four semester program.

The purpose of the Electronic Technology Program, as set forth in the program monograph, reads:

> The purpose of the course is to fulfill the philosophy of vocational-technical education.
>
> This program will do more than prepare the student in his technical specialty. On completion of his schooling the technician must be ready to take his place in industry. Therefore, the training the technician will get under the technology program must be acceptable to industry in all aspects.
>
> To meet industry's criteria, the school's program will produce a technician who is well spoken, who ca relate to others and who can communicate with others. The technician will not only speak the language of the engineer, but he will be able to interpret the engineer in his plans to solve engineering problems on his level, as they arise. Therefore, he will be versed in mathematics and the related sciences. He will know and understand the history and economics of the world in which we live.
>
> The scope of the training in this technology will train a complete technician, which involves more than technical proficiency.[16]

The curriculum, listed in Table II, is divided into three parts according to the Guidelines for Associate Degree Programs set forth by the Wisconsin State Board of Vocational, Technical and Adult Education. The first part, general education, has a minimum of 23 quarter credits including communications skills and social studies. The second

---

[16] Electronic Technology Monograph, Board For Vocational, Technical and Adult Education, La Crosse, Wisconsin, 1965. p. 6.

TABLE II

ELECTRONIC TECHNOLOGY

	Credit	Class	Lab
First Quarter			
Communications Skills 1	3	3	0
Technical Mathematics 1	5	5	0
Electronic Methods 1	3	1	4
DC Circuits	4	2	4
Technical Drawing	3	1	4
	18		
Second Quarter			
Communications Skills 2	3	3	0
Technical Mathematics 2	5	5	0
Technical Physics 1	3	2	2
Electronic Methods 2	2	1	2
AC Circuits	4	2	4
	17		
Third Quarter			
Social Science	3	3	0
Technical Mathematics 3	4	4	0
Technical Physics 2	3	2	2
Active Devices	4	2	4
Electric Machinery	3	2	2
	17		
Fourth Quarter			
Social Science	3	3	0
Technical Physics 3	3	2	2
Introduction to Computer Science	3	2	2
Linear Electronic Circuits	5	3	4
Pulse Circuits	3	2	2
	17		
Fifth Quarter			
Social Science	3	3	0
Social Science Elective	2	2	0
Non-linear Electronic Circuits	4	2	4
Electronic Computer Concepts	3	2	2
Industrial Electronics 1	3	2	2
Elective (any area)	3	--	-
	18		
Sixth Quarter			
Communications Skills 3	3	3	0
Social Science Elective	3	3	0
Industrial Electronics 2	4	2	4
Electronic Problem	3	1	4
Technical Elective	4	-	-
	17		

part, the basic supportive core, has a requirement of 14 quarter credits of mathematics and nine quarter credits of physical science. The mathematics sequence progresses through an introduction to calculus. The physical science involves measurement, mechanisms, fluids, gases, heat, optics and sound. The third part, the technical core, has 57 quarter credits devoted to electronic and related subjects to give a total of 103 quarter credits.

The technical core, the heart of the program, has been developed to accept entering students with no previous experience in electronics. In the two electronic methods, courses the student receives instruction in the use of electronic instruments, tools, techniques of soldering and handleing components. These courses also give an overview of the field of electronics. The AC and DC courses are traditional, but they are mathematically based and the latest concepts are used in these foundation courses. Solid state devices are emphasized throughout the program, in the active devices, pulse circuits, linear and non-linear circuits, and industrial electronics courses. Several important features of the program are the electronic computer concepts course which deals with number systems; boolean algebra and logic circuitry; and the electronic problem course where independent work toward the solution of a practical problem, involving materials, processes, specifications and results of the problem, are made in a written and oral report.

An important addition to the program has been the Introduction to Computer Science Course which introduces the technical student to computer use and computer language.

The relationship of the Electronic Program can be shown in the Flow Chart, Figure I. The chart shows the flow of the basic supportive core into the technical specialty portion of the program and how the technical speciality itself is interrelated. The chart shows the relevancy of each course. It should also be noted that six quarter credits can be elected in some area the student might desire, adding a degree of flexibility. These electives may be in areas such as hydraulics, mechanisms, mathematics, business or marketing.

HEALTH PROGRAMS

Western Wisconsin Technical Institute has been offering programs in the field for several years. The first programs were in Practical Nursing and Dental Assisting, and, later, programs in Medical Assistant, Nursing Assistant, and Operating Room Assistant have been offered. These are conducted in well-equipped laboratories and classrooms in the institute, and clinical experience is offered in area hospitals and clinics. An associate degree program to train Medical Laboratory Technicians will begin with the fall term of 1970. This program will add depth to the existing medical technology staff and expand the laboratory equipment available in the school.

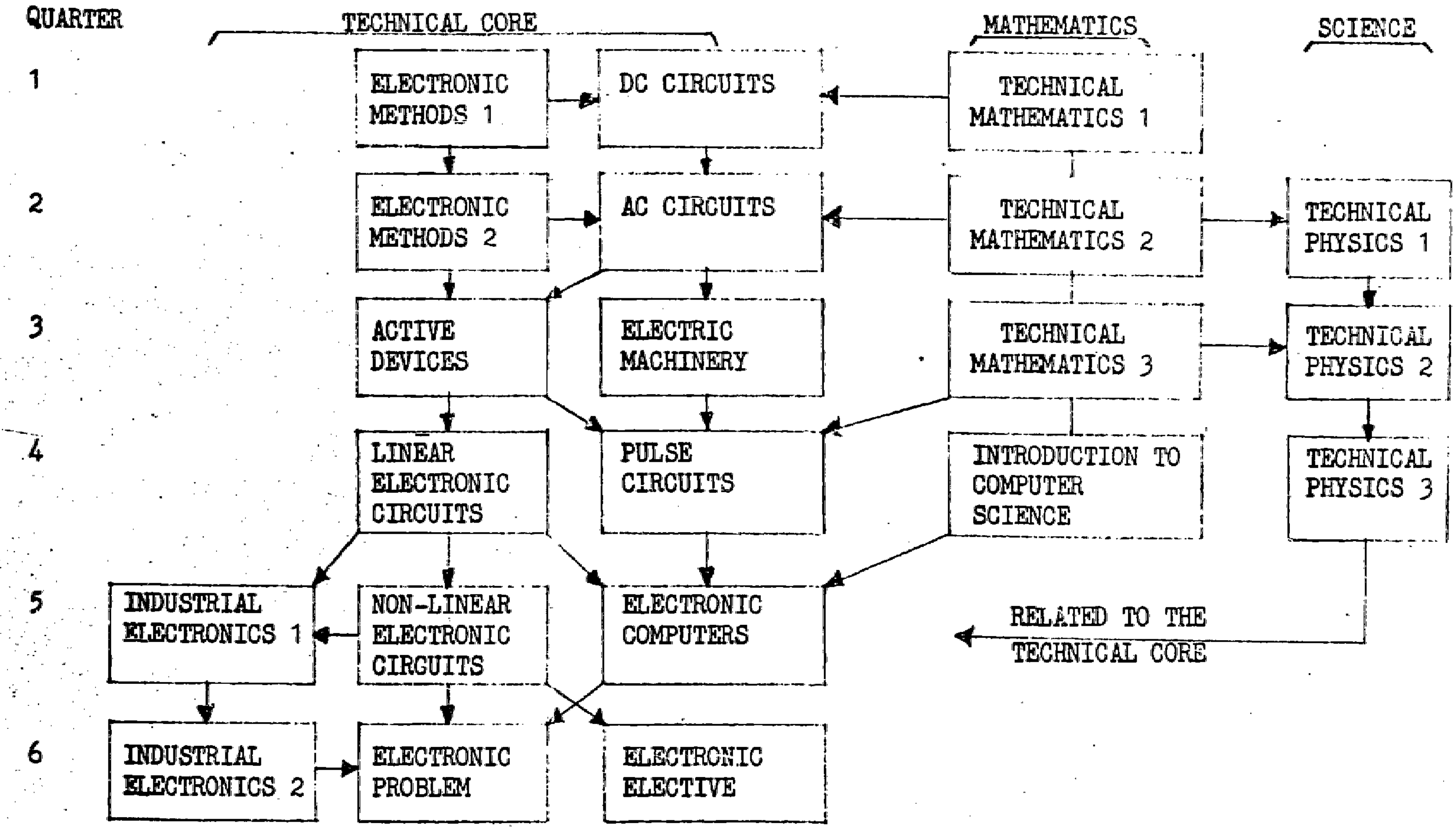


FIGURE 2

ELECTRONIC TECHNOLOGY PROGRAM FLOW CHART

The proposed curriculum for the Medical Laboratory Technician program is shown in Appendix B. Future programs in Radiological Technician, Medical Records Technology and Electroencphologram Technology have been planned.

BIO-MEDICAL ELECTRONICS

Having examined the current offerings in the two-year Electronic Associate Degree Program at Western Wisconsin Technical Institute, one should examine the possible program offerings in the field of Bio-Medical Electronics.

> The science of electronics is the "liaison officer" responsible for converging the life sciences and the physical sciences into a single society. The organization of widely divergent fields that seemed to stay apart until the science of electronics was put to work in the life sciences, resulted in man-made disciplines with titles such as "bio-medical electronics", "biophysics" and "bio-medical engineering".[17]

It has taken a great deal of understanding on both sides for these disciplines to get together. A competent investigator in one field cannot just "read up" in another and enter into it. One solution was group work, well organized and properly directed, by members of each field. This cooperation has resulted in the rapid advances in the bio-medical

[17] Herrick, J. F., "History of Bio-Medical Electronics Art," Proceedings of the IRE, 50:1173-77, May, 1962.

electronics field in the last decade. Instrumentation has been fundamentally important in the development of this interzonal field, and it is in the area of instrumentation that the technician will find he is very much needed.[18]

In writing about electronics in clinical research, Mackay states:

> By electronics, we may mean circuits containing components in which the mean path of the current carriers is comparable with the physical dimensions of the elements. These can amplify (e.g., thyratrons, transistors, tubes) and give rapid responses. Thus, they are useful components of systems for monitoring electrical signals accompanying various bodily processes. Also, many physiological variables are best measured using electronic techniques in conjunction with transducers of pressure, blood velocity, temperature, gas concentration, etc. Clinical procedures can often be considered either diagnostic or therapeutic, and there are also therapeutic methods which depend upon the effect of electricity, radiation, or ultrasonics on the human body.[19]

The body of Mackay's article elaborated on a number of topics: pressure measurement, radiology, instantaneous frequency determination, radio telemetering to and from within the body, sound and ultrasound and gas analysis. He concluded by stating that these are only a few involvements of electronics in clinical research; he then recommends the reader refer to the "Bibliography on Bio-Medical Electronics".[20]

---

[18] Ibid., pp. 1174-75.

[19] Mackay, R. Stuart, "Electronics in Clinical Research," Proceedings of the IRE, 50:1177-89, May, 1962.

[20] "Bibliography of Bio-Medical Electronics" prepared by The Medical Electronics Center of the Rockefeller Institute, and published by the Professional Group on Bio-Medical Electronics of the Institute of Radio Engineers.

A great deal has been written recently in the field of bio-medical engineering and many universities have begun programs in bio-medical engineering. Some schools are using existing courses from the different disciplines; others are producing courses specifically for this combination field. The questions often arise, of what and how much biological education should be undertaken. The suggested solution is a collaborative responsibility. The engineering scientist must know biological science in general, but in his field he must be an expert. Talbot says, "Even Helmholtz today could not be equally a biological and physical scientist... Then how much? Enough to have perspective, to be able to communicate and be responsive to the bio-scientist.[21]

Talbot concludes by stating that even though some are not convinced, the fact remains that these complex programs are now widely being organized and that by cooperation they involve interdisciplinary knowledge.[22]

The November, 1959, issue of the Proceedings of the IRE was specially devoted to bio-medical electronics. It contained 27 articles on bio-medical application of electronics. Many other publications such as, "Chemical and Engineering News," "Instrument Technology,"

---

[21] Talbott, Samuel A., "Education for Engineers in Bio-Medical Research," Proceedings of the IRE, 50:1195, May 1962.

[22] Ibid., p. 1198.

"Instrument Technology," "Product Engineering," "Science," "Electronics," and "Medical Research Engineering" have had articles on bio-medical electronics most all of these on the engineering level. Medical Research Engineering, which was formerly the "American Journal of Medical Electronics," editorialized on Medical Engineering Program Planning. It told of public awareness of medical engineering because of Medicare and Federal grants through the National Institute of Health to further research. Point eight of a ten-point statement was, "A study should be made of a medical engineering applicants training program for para-medical personnel."[23] It should be noted that this did not come about and resulted in the TERC Study.

Medical instrumentation systems have been classified into three general categories. diagnostic/patient monitoring systems, therapeutic systems, biomedical research systems.

The diagnostic/patient monitoring systems involve ECG or EKG for heart-signal measurement, and the EEG for brain-signal measurement. These instruments involve high gain amplifiers with strip-chart recorders or oscilloscopes as read out devices, and electrodes for signal pickup from the patient. For intensive care centers or during surgery various

[23]Editorial, "Medical Engineering Program Planning and System Analysis," Medical Research Engineering, 7:6-7, First Quarter 1968.

forms of transducers are used to monitor blood pressure, pulse, respiration, and temperature. This information may be sent to one central monitor station where several patients may be monitored at one time. Many advances in monitoring were advanced or developed by the government's space programs. X-ray has been a diagnostic tool for many years, as well as a therapeutic device for the treatment of malignancies. Diathermy, radio frequency energy has been used for many years to produce deep heat within the body. Ultrasonic machines have been developed for rapid massage for muscle treatment. Various types of stimulators applying electrical impulses to the body have been developed. The implantable heart pacer is a good example of this.

A great variety of devices are used in biomedical research systems. Current flow in materials produce indication of pH level. Photelectric devices are used to count blood samples, usually by comparing a sample with a known cell concentration. A variety of electrical control systems are used to control pressures, flow rates, temperatures and other parameters in artificial organs or in complex research problems. The use of servo systems in artificial limbs has been increasing.

Computer applications in both research and diagnostic practice have been on the increase. The future seems to be great for the laser, implantable transmitters and receivers along with other microelectronic circuits for monitoring and stimulation of body functions. All of these

things free hospital and laboratory personnel for other tasks, but require more technical personnel for their production, use and maintenance.[24]

A number of national meetings have been organized and held in the field of Bio-Medical Engineering. The third annual meeting of the Association for the Advancement of Medical Instrumentation, held in Houston, Texas, in July, 1968, had a section on "Technician Support for Medical Instrumentation", by John E. Abel, who is associated with TERC as the moderator.

---

[24] Wujek, Joseph H. Jr., "Medical Instrumentation Systems", Electronics World, 79:46-47, 86. January 1968.

CHAPTER III

THE METHOD OF INVESTIGATION

INTRODUCTION

This study proposed to obtain current and pertinent information primarily by the use of a survey directed to Hospitals, Medical Research Centers and Manufacturers of Bio-Medical Electronic equipment. In preparing this survey information from the TERC Study, Medical and Electronic Journals, and personal interviews with persons involved with bio-medical equipment were used. The writer has had some experience in this field of work.

The results of the survey were presented to a preliminary advisory committee for review, and further recommendations with respect to content and division of material in the Technical Core of the curriculum.

THE SURVEY

The survey was divided into ten sections, some having multiple responses. The first seven parts used a Likert scale for an opinion response to positive statements; the scale used was a 1, 2, 3, 4, 5, scale on which the respondent was asked to cross out the number which seemed most appropriate. The numbers progressively indicated whether

the respondent (1) disagreed, (2) tended to disagree, (3) could not say, (4) tended to agree, (5) agreed with the statement. The remaining three parts were questions asking for numbers or the checking of items. Along with the survey and a covering letter went a suggested preliminary curriculum projecting six quarters of a two-year associated degree program.[1] This is shown in Table III. The curriculum was based on the Guidelines for Associate Degree Programs, as set forth by the Wisconsin State Board of Vocational, Technical and Adult Education.

The guidelines divide the programs into three major parts: General Education, Basic Core and Technical Core. The General Education is made up of Communication Skills and Social Studies amounting to about 21 per cent of the total program. The Basic Core involves mathematics and physics, amounting to approximately 21 per cent of the program. Approximately 45 per cent to 57 per cent of the curriculum would be the technical core and three per cent to 12 per cent may be electives. Table IV displays the divisions along with subject title. Figure Two is a circle diagram showing courses, laboratory, and class work distribution by percentage.

That portion of the curriculum devoted to bio-medical subjects was not broken down, because this was the portion of the curriculum that was to be developed from information gathered in the survey.

---

[1]See appendix C.

TABLE III

PROPOSED CURRICULUM FOR

BIO-MEDICAL ELECTRONICS

FIRST YEAR

First Quarter	Credits
Bio-Med. Techniques	3
Electronic Methods	3
D. C. Circuits	4
Mathematics I	5
English Composition	3
	18

Second Quarter	
Bio-Med. Techniques	3
A. C. Circuits	4
Physics I	3
Mathematics 2	5
Speech	3
	18

Third Quarter	
Bio-Med. Techniques 3	3
Electronics	5
Physics 2	3
Mathematics 3	4
Social Science	3
	18

SECOND YEAR

Fourth Quarter	Credits
Bio-Med. Techniques	3
Electronics	3
Bio-Med. Group	3
Physics 3	3
Basics of Computers	3
Social Science	3
	18

Fifth Quarter	
Bio-Med. Techniques 5	3
Bio-Med. Subjects Group	10
Social Science	5
	18

Sixth Quarter	
Bio-Med. Techniques 6	3
Bio-Med. Subjects Group	9
Technical Report Writing	3
Social Science	3
	18

TABLE IV

DIVISION OF THE BIO-MEDICAL

ELECTRONICS CURRICULUM

GENERAL SUBJECTS 21%	MATHEMATICS 13%	PHYSICS 8%	ELECTRICITY ELECTRONICS 20%	BIO-MEDICAL SUBJECTS 38%
English Composition	Algebra	Mechanics	AC and DC Circuits	Techniques Courses
Speech	Trigonometry	Heat	Electronic Methods	Equipment
Tech Report Writing	Analytic Geometry	Optics	Amplifying Devices	Courses to be determined
Psychology	Introduction to Calculus	Sound		
Economics		Fluids and Gasses		
Other Social Sciences				

Prerequisites: High school graduation with adequate mathematics. Physics and two years of mathematics preferred.

% is in quarter hours

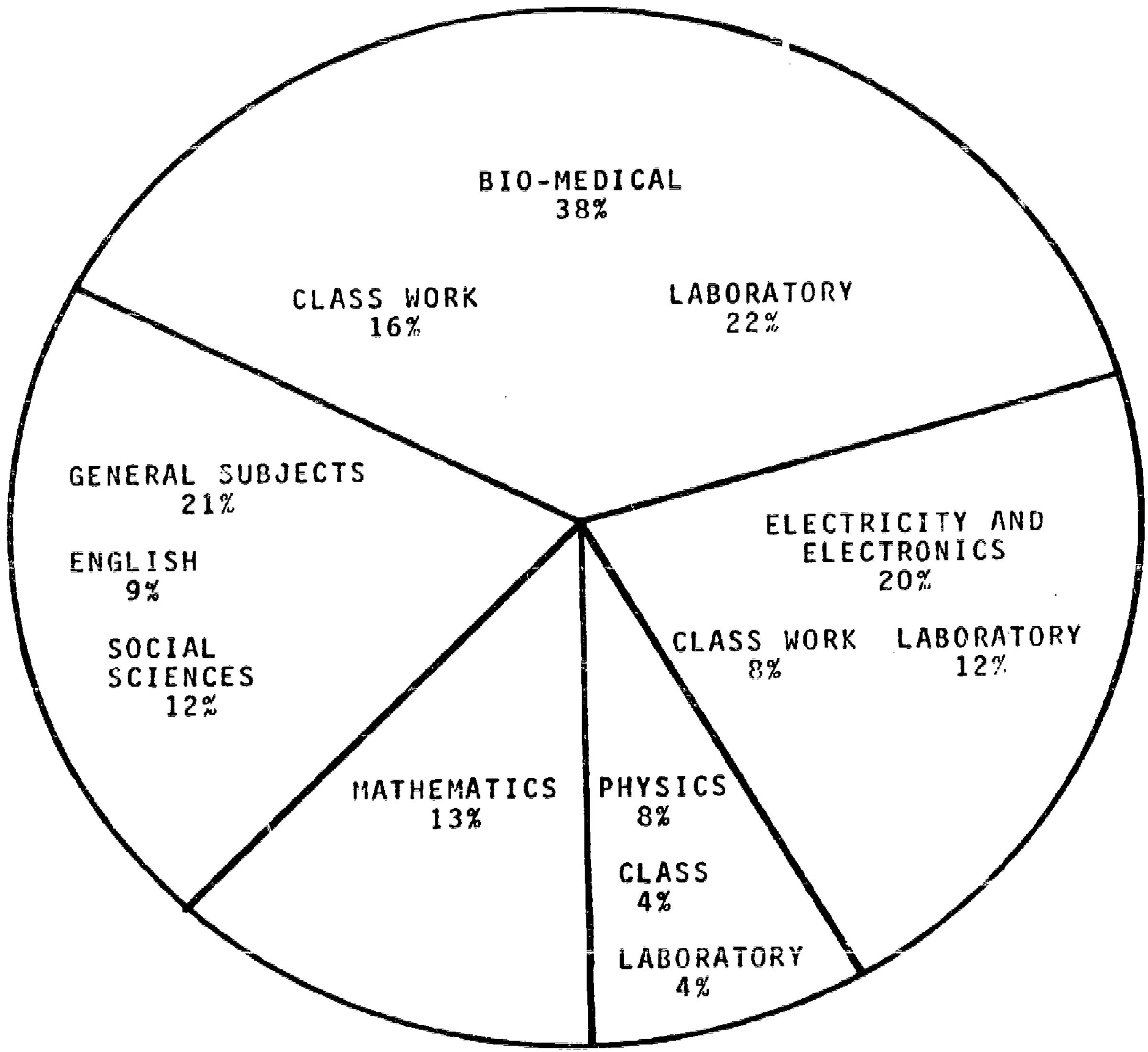


FIGURE 2

DIVISION OF CURRICULUM

BY CLASS WORK AND LABORATORY

The survey was mailed, along with a self-addressed stamped envelope, to 62 hospi s, clinics, medical centers and medical research institutions and to 19 manufacturers of bio-medical electronic equipment. The hospitals were institutions of 100 beds or larger from Wisconsin, Minnesota, Iowa and Illinois. The manufacturers were from various parts of the United States.

TABULATION OF THE SURVEY

A total of 81 survey forms were sent out, 36 of these were returned, giving a return of 44.5 per cent. The responses were divided into three sub-populations: Hospitals (H), Research and Medical Centers (R), and Manufacturers (M). The hospital sub-population was 21, the research and medical center 8, and the manufacturer 7.

The one through five Likert scale, used for responding to the first seven parts of the survey, was weighted for tabulation.

The (1) disagree with response was assigned a -2 value, the (2) tend to disagree with response was assigned -1, the (3) cannot say response was given a value of zero, the (4) tend to agree with, and (5) agree with were assigned values of +1 and +2 respectively. The responses of a sub-population to a given part were then added together. The response of the total population was also added together for each part. This, then, produced four totals for each response on the survey. Since the sub-populations were different in population number the totals of a

given part for that sub-population were normalized by dividing the total by the sub-population. For example, if a Hospital response to a part totaled 27, the 27 was divided by 21 (the Hospital sub-population) resulting in a normalized value of 1.3 when rounded to one decimal place. This normalization could then produce number values ranging from -2 to +2.

A significance of values was arbitrarily assumed. Values of +1.5 to +2 were considered to be a strong agreement with an item. Values from +0.5 through +1.4 as agreeing with an item but with some reservation. The range from -0.4 through +0.4 was an indication that there was an unfamiliarity with the response or an indication of not wanting to either approve or disapprove the response. The values between -1.4 and -0.5 indicated disagreement with the item, but with some reservation. Values from -2 through -1.5 were considered to be in total disagreement with the item.

Parts seven through ten asked about the areas of assistance, and employment information at the time of the survey and five years from the date of the survey. Part seven asked about jobs that might be performed in part of wholly by a BMET. The response method was by the described Likert scale plus an indication of how many persons were then employed in the listed jobs. The results are tabulated in Table V. The populations in the tables are identified as Total Population (T), Hospitals (H), Research Centers (R), and Manufacturers (M).

It should be noted that servicing and maintaining received the strongest emphasis by all respondents, and that at the time of the survey Manufacturers employed, by far, the greatest number of persons performing these tasks. As might be expected Hospitals employed the greatest number in equipment operation and equipment application.

TABLE V

JOBS THAT COULD BE PERFORMED BY BMET

The following might be jobs performed wholly or in part by a bio-medical electronic technician.

Population	T	H	R	M
Normalized Value For				
Servicing (repair of defects)	1.9	1.9	2.0	2.0
Maintaining (routine)	1.8	1.7	2.0	2.0
Equipment operation	0.9	0.9	1.0	1.0
Modification of equipment	1.6	0.8	1.4	1.1
Equipment application aid	0.9	1.1	0.6	0.7
Engineering aid	1.0	1.0	1.1	1.0

The number now employed.

Population	T	H	R	M
Number of persons				
Servicing (repair of defects)	176	8	5	163
Maintaining (routine)	68	7	5	56
Equipment operation	76	48	5	23
Modification of equipment	15	2	3	10
Equipment application aid	33	23	3	7
Engineering aid	12	2	0	10
Persons serving in a combination of above jobs	74	8	13	53
Total of all jobs employed by each population	454	98	34	322

The response to part 8, "How many trained technicians could you employ if they were available?" was asked for at two dates. The number at the time of the survey and in five years from the time of the survey. There were some question marks as responses; these were counted as zero need. The results are shown in Table VI.

TABLE VI

NUMBER OF TECHNICIANS THAT COULD BE EMPLOYED BY RESPONDENTS TO BIO-MEDICAL ELECTRONICS SURVEY

Population	T	H	R	M
Number of Technicians				
Now	99	26	15	58
By 1974	259	48	37	174

Part 9 asked "How is maintenance and service on your bio-medical equipment handled?". There were three responses that could be checked, your own staff, contracted for, and on call service. Some respondents checked more than one, indicating they were using a combination. These were counted as separate responses, and percentages of a population were calculated. These are given in Table VII.

TABLE VII

PERCENTAGE OF POPULATION INDICATING HOW MAINTENANCE AND SERVICE WAS HANDLED

Population	T	H	R	M
How Handled		Percentage		
Own staff	66	62	62	86
Contracted for	33	52	12	0
On call service	58	81	[illegible]8	14

The last part of the survey asked "Who installs your equipment?". There were two possible choices: your own staff or contracted for. Again, respondents checked both, indicating they use both. These were also counted as separate responses. The percentages are given in Table VIII.

TABLE VIII

PERCENTAGE OF POPULATION INDICATING WHO INSTALLED BIO-MEDICAL EQUIPMENT

Population	T	H	R	M
Who installs equipment		Percentage		
Own staff	53	43	50	100
Contracted for	58	86	38	0

In part one of the survey, all three subpopulations were in close agreement that two years of school would seem to be adequate. On the normalized scale, Hospitals responded 1.2, Research Centers 1.3, and Manufacturers 1.3. This tabulation would indicate a response which tends to agree, with only slight reservation. Part two indicated there

was agreement that an internship or clinical experience was relevant to the training of a BMET. However, the groups did not indicate this with equal strength. Hospitals indicated a strong agreement with, 1.6. The Research Centers the least agreement with, by a value of 0.6. Manufacturers had some reservation about the internship, by indicating 0.9.

Results of part three indicated that if an internship or clinical experience were to be included, it should follow the school work rather than being a part of the school program. Greater reservation was indicated, but the same ratio existed between groups as for the internship itself. Hospitals indicated 0.6, Research Centers 0.3, and Manufacturers 0.6.

The remainder of the survey, parts four, five and six, were intended to aid in the determination of a functional technical core curriculum.

In part four, "The following subjects should be included in the curriculum", the respondents all favored physiology and chemistry for inclusion. Hospitals and Manufacturers agreed on biology, while anatomy was suggested only by Hospitals. The tabulation is shown in Table IX.

TABLE IX

NORMALIZED VALUES FOR RESPONSES TO BIO-MEDICAL ELECTRONICS SURVEY, PART 4

The following subjects should be included in the curriculum:

Population	T	H	R	M
Normalized Value For				
Biology	0.7	1.0	-0.4	1.1
Physiology	1.1	1.0	0.9	1.9
Chemistry	1.1	1.3	1.0	0.7
Anatomy	0.4	0.9	0.0	-0.4

In addition to the evaluation of responses shown in Table X, part five of the survey respondents suggested instrument repair and maintenance, closed circuit TV and thermo dynamics as "knowledge of some skill in functions or systems" to be included in the curriculum. Of the items listed, only X-ray, lasers and ultra-violet processes received low responses. As additional responses to part five of the survey, instrument repair and maintenance, closed circuit TV and thermo dynamics were suggested.

TABLE X

NORMALIZED VALUES FOR RESPONSES TO BIO-MEDICAL ELECTRONICS SURVEY, PART 5

The bio-medical technician should have some knowledge of some skill in the following functions or systems:

Population	T	H	F	M
Normalized Value For				
Response stimulus devices	1.4	1.5	1.3	0.7
Monitoring devices	1.9	1.8	2.0	2.0
Gross electrical activity	1.6	1.6	1.3	1.7
Fine electrical activity	1.4	1.7	0.6	1.4
pH measurement	1.3	1.3	1.9	0.9
X-ray	0.4	0.5	0.9	-0.4
Ultra-sonics	1.0	1.1	0.6	0.9
Lasers	0.5	0.7	0.3	0.1
Electrode design	1.2	1.3	0.6	1.3
Fluid dynamics	0.8	0.8	0.8	0.9
Servo mechanisms	1.0	0.9	1.4	1.0
Transducers	1.5	1.3	2.0	2.0
Electrophoresis	0.8	0.9	0.9	0.6
Ultra-violet processes	0.4	0.8	0.3	-0.6
Thermography	0.8	0.9	1.0	0.3
Instrument testing	1.9	1.8	2.0	2.0
Instrument calibration	1.8	1.8	2.0	1.7

Finally, in part six the respondents indicated equipment that should have a high priority for inclusion in the class and laboratory work in the bio-medical courses. In addition to the equipment listed in the survey and shown in Table XI, dye injectors, coulter counters, autoanalyzers, cardio verting equipment and EMG devices were suggested. Only cameras and medical computers received low ratings.

TABLE XI

NORMALIZED VALUES FOR RESPONSES TO BIO-MEDICAL ELECTRONICS SURVEY, PART 6

The following equipment should have a high priority for inclusion in class and laboratory work in the bio-medical courses:

Population	T	H	R	M
Normalized Value For				
Oscilloscopes	2.0	2.0	2.0	1.9
Amplifiers	1.9	1.9	2.0	1.7
Carrier Amplifiers	1.6	1.6	1.9	1.3
Differential Amplifiers	1.7	1.5	1.9	2.0
Micro electronic transmitters and receivers	1.3	1.2	1.5	1.6
Cameras	0.8	1.0	0.6	0.1
Regulated power supplies	1.6	1.6	2.0	1.3
Closed circuit television	1.1	1.5	0.6	0.3
Audio monitors	1.3	1.6	1.1	0.6
Tape recorders	1.3	1.6	0.9	0.9
Oscillographs	1.8	1.8	1.8	1.9
Medical computers	0.8	0.8	1.6	-0.1
Spectrophotometers	1.4	1.5	1.9	0.7
Blood analyzers	1.3	1.3	1.6	0.7
pH meters	1.5	1.5	1.9	1.0
EEG and EKG devices	1.7	1.5	1.9	2.0
Chromatographs	1.3	1.3	1.6	1.0

SUMMARY

The greatest need shown for the Bio-Medical Electronic Technician (BMET) was in the area of maintaining and servicing, and this need was expressed almost equally by Hospitals, Research Centers and Manufacturers. These three categories of employers also indicated

they would need technicians who could qualify as Engineering Aids and Technicians who would be capable of modifying equipment. The survey revealed that the BMET needs a broad range of skills. To meet these demands the BMET will have to have an in-depth knowledge of basic electronics and be able to relate this knowledge to various instruments and systems used in the therapeutic, diagnostic and research aspects of medicine today. Other objectives in the training of BMETs would be: (1) familiarization with the operation of bio-medical instruments and systems; (2) experience in service and maintenance procedures; (3) development of an understanding of physiological responses; (4) familiarization with some chemical and biological processes; (5) comprehension of calibration procedures; and (6) development of the capability to modify and adapt equipment. Working in hospitals and clinics would require the technician to be versed in procedures, regulations and the organization of these institutions, as well as being conversant with some medical terminology.

CHAPTER IV

RESULTS OF THE STUDY

The purpose of this study, to determine a suitable curriculum for the training of Bio-Medical Electronics Technicians (BMETS), was to be met in two steps. The first step was the determination of the areas of assistance where BMETs are most needed. The second step was the development of a technical course curriculum to train technicians in the most needed categories.

AREAS OF ASSISTANCE

Using the strength of the responses to the question, "The following might be jobs performed wholly or in part by a BMET", servicing and maintaining equipment would be the areas of greatest need for technicians by all subpopulations. Servicing implies the repair of defective or malfunctioning pieces of equipment or systems; this contrasts with maintaining which would be routine checking of equipment, and would involve steps of preventive maintenance on functioning equipment, the testing of components, cleaning, lubricating, adjusting and calibrating of the equipment. Both of these areas received almost perfect agreement as jobs to be performed wholly or in part by BMETs.

Servicing and maintaining then should receive the strongest emphasis in the curriculum. Next in indicated strength of response, but with some reservation, was the modification of equipment and engineering aid. Modification of equipment and engineering aid would in general be higher level jobs than servicing and maintaining, and require a greater depth of knowledge as to how and why devices operate and a better understanding of the applications of these devices. An engineering aid is generally a person who works with an engineer. It may be some time before many institutions employ bio-medical engineers, and many smaller institutions may never have an engineer on their staff. The smaller number of respondents requiring modification of their equipment at this time and the smaller number of respondents employing an engineer may have lowered the need response in these two job titles. The need for both modifiers of equipment and engineering aids could be expected to increase.

The jobs receiving the lowest indication were equipment operation and equipment application aids; yet the response was 0.92, which is fairly strong. Both of these jobs are more medically oriented than electronically oriented.

At the time of the survey, the greatest number of employed servicing and maintaining technicians were with manufacturers, primarily because one manufacturer employed a large number of technicians in the field. Hospitals indicated very low numbers of servicing and

maintaining technicians of their own, but indicated a large number of BMETs were needed and would be needed by 1974. When this figure is multiplied by the greater number of hospitals in existence compared to the number of manufacturers, the total number needed in servicing and maintaining would be a rather large number. The number indicated by research institutions was nearly as great as for hospitals, but there are far fewer of these institutions. The number of technicians now employed in equipment operation and equipment application aid exceed those employed for modification of equipment and engineering aids in hospitals and research institutions. This contradicts the jobs performed responses, but might be justified by the unavailability of BMETs to perform these jobs. Respondents also indicated that many of their people performed in a combination of the six jobs.

Thus, the present and future needs for BMETs in all areas now and in the future look very favorable.

Manufacturers perform almost all of their own service and maintenance, while hospitals distributed their service and maintenance between their own staff, contract and on-call service. Hospitals did favor the on-call service. Again, this is most likely due to the indicated shortage of BMETs to perform in-house service. Research centers seemed to use their own staff to a greater extent than on-call or contracted-for service. Bio-medical equipment installation figures showed that manufacturers used their own staff to install their equipment;

or systems should then be incorporated at the proper place in the curriculum. X-ray, lasers, and ultra-violet devices received very low responses by all three groups. Manufacturers considered X-ray a separate field by itself, while research institutions did indicate some need. Hospitals were the only group indicating any need for lasers and ultra-violet knowledge. It might not be necessary for the latter three items to be included in the curriculum, or only in a very general form if they are included.

The choice of equipment to be used for training technicians is a very important step. The equipment needs to be relevant to the training, not just nice to have. Generally equipment cost becomes an important consideration in the starting of a program. In many programs similar to the BMET program, equipment investment has been sizable. Individual instruments may cost several thousand dollars each. Some pieces are very specialized and may become obsolete in a very short period of time. Consequently, much consideration must be given to the selection of the appropriate equipment to be used in both classroom instruction and laboratory work. Oscilloscopes and amplifiers received the strongest response by all groups. Oscilloscopes would be used as instruments not only by the technician in his work, but also as an instrument that is used in many of the medical processes. Other equipment receiving strong emphasis were carrier amplifiers, differential amplifiers, regulated power supplies, oscillographs, EEG, and

hospitals contracted for most of their installation, while research centers installed more of their own equipment than hospitals do.

THE TECHNICAL CORE CURRICULUM

Since physiology and chemistry both rated 1.1, tending to agree that they should be included in the curriculum. Biology rated 0.7 overall and anatomy 0.4. Anatomy seemed to be the least needed. The rating of biology was lowered by Research Institutions with a response of -0.4, while Hospitals and Manufacturers responded with a 1.0 and 1.1. This would indicate that the subpopulation with the highest employment potential tended to agree that biology should be included. Only Hospitals tended to agree on anatomy with 0.9, Research Institutes gave no response, and Manufacturers indicated a -0.4, which is almost a disagree response.

The order of importance of the sciences would be physiology, chemistry, and biology. The only subpopulation considering anatomy as a need subject was the hospital group.

The survey results indicated a strong need, by technicians, for knowledge of some skill in monitoring devices, gross electrical activity, fine electrical activity, response stimulus devices, pH measurement, transducers, instrument testing and instrument calibration. A moderate need was shown for ultra sonics, electrode design, fluid dynamics, electrophorisus, servo mechanisms and thermography. These functions

EKG devices. These alone give a good range of devices that could be used in the instruction of BMETs. Microelectronic transmitters and receivers, closed circuit TV, audio monitors, tape recorders, spectrophotometers, blood analyzers, pH meters and chromatographs also were given emphasis for inclusion. Cameras were recommended by hospitals but not by manufacturers. Research institutions showed a strong need for medical computers while manufacturers rejected them, and hospitals showed some interest in medical computers. At the rate new devices are entering the bio-medical instrumentation field, it was difficult to include all equipment in the survey. A number of important pieces of equipment, not included in the survey, but recommended by the respondents were listed in the previous chapter.

ADVISORY COMMITTEE

An advisory committee of experts representing hospitals, clinics, research centers, manufacturers, and BMETs was formed to review the findings of this study and make recommendations for the technical core curriculum.

The committee met at the Marshfield Clinic, Marshfield, Wisconsin.[1] Two BMETs explained their background and how they entered the field. Bo[illegible] electronic training and experience in the military

[1] March 24, 25, 1970, See Appendix D.

service, and one of them had been specifically trained in medical instrumentation repair. They related how they had made their transition to employment in their technician position.

Both emphasized the need for a good foundation in basic electronics with an adequate amount of time spent in reading schematics and developing trouble-shooting techniques. Experience was considered important, but it might not be practical for the school to provide any great amount of experience. This would have to come through actual employment or through an internship, if it could be arranged. There would be difficulty in establishing a clinical experience because of the limitations of available supervision in the job experience since only a few institutions now have competent technicians on their staffs. A summer work experience with cooperating institutions could also aid in giving experience to aspiring BMETs.

Close cooperation between the school and manufacturers of equipment would be very important, and many manufacturers conduct seminars that might be helpful. The group emphasized the need for BMETs and generally felt that institutions could no longer rely on outside service for most of their equipment repair needs. Equipment is becoming too widely used and there is too much dependence on it to have to wait for outside service.

Physiology and chemistry would be very helpful in the training of BMETs, while biology and anatomy would not be as important. These

sciences need not be taught as separate courses but should be taught as a part of the electronics or bio-medical courses, wherever they would relate to the topic being considered. Physiology should be the first to be offered, then chemistry, and finally biology.

BMETs should have some patient relationship, which would involve safety and a realization of patient concerns. Equipment may need service while it is being used: for example, the BMET may have to repair equipment in an emergency in the operating room, intensive care or in a patient's room.

A wide range of equipment would become the responsibility of the BMET. Some would be very simple devices, only electrical or mechanical in nature, but others would be very sophisticated devices requiring a wide range of knowledge. A need would also exist for some familiarity with mechanical and fluid principles in servicing bio-medical equipment. The concepts of electrodes and transducers are also very important.[2]

CONCLUSIONS

The courses necessary to provide the basic electronic knowledge exist in the Electronic Technology program. The content of the electronic program was shown in Chapter II. Those electronic subjects suitable for use in the bio-medical curriculum are as follows: Electronic Methods

[2]See Appendix D for more details.

1, DC Circuits, AC Circuits, Active Devices, Linear Electronic Circuits, Pulse Circuits, Non-linear Electronic Circuits, and Introduction to Computer Science.

These courses introduce electrical and electronic concepts without requiring any prior knowledge of electronics. This sequence of electronic courses runs through the fifth quarter and should provide all the electronic background necessary for the future growth of the technician and serve as a basis for the courses specifically devoted to medical instrumentation. The content of the particular bio-medical courses should be coordinated with and related to these electronic courses, in accordance with the concept of an interdisciplinary approach. The mathematics and science sequence would also be the same as those now available.

To meet the specific objectives of the bio-medical area, the first course should be an introduction to bio-medical electronics in which hospital and clinic organization and operation are presented along with regulations and procedures. Medical terminology and patient-instrument safety are also incorporated in this course. The laboratory portion is devoted to field trips of medical institutions and a non-technical introduction to basic electronic devices such as oscilloscopes, amplifiers, transducers, recorders, and power supplies. These devices are not necessarily medical instruments but are generally electronic in nature. The committee suggested that specific medical instruments not be introduced until the second quarter. For specific course titles, see Appendix E.

Physiological processes should be the central topic in the second quarter. It is here that physiology and anatomy would be introduced, not as separate disciplines, but as a basis for the introduction to physiological measurements and tests, gross electrical activity, monitoring devices and an introduction to instrument calibration. In this quarter the operation of specific instruments like the EKG, EEG, and EMG would be introduced along with various electrodes and audio monitors. This course would be largely a familiarization, and work with instruments would be restricted to the theory of operation that could be related to the electrical principles already studied and to connections and simple adjustments demonstrating application and operation.

Physiological processes should receive greater emphasis than anatomy, chemistry and biology. This would be accomplished by continuing the study of physiological processes into the third quarter. Chemical processes are also introduced in the third quarter as a part of Physiological Processes 2. Response stimulus, fine electrical activity, and basic chemical concepts such as chemical equilibriums, ionization, and redox would be studied. The measurement of pH as well as its concepts would be important at this point along with some material on fluid dynamics. The use of instruments should be in pH meters, blood analyzers, the automatic balance, and some basic chemical analysis. The use of instruments should be continued by investigating additional physiological measurements.

Biological processes would be the concentration in the fourth quarter which begins the second year of the program. Bio-Medical Techniques 1 would encompass a study of cell structure, biological measurements and tests, terminology, and electronic equipment related to biological measurements and the biology laboratory. Oscillographs, colorimeters, spectrophotometers and pH meters would be equipment which would be used in the laboratory work.

The bio-medical offerings become a greater part of the program in the fifth and sixth quarters. It is at this point in the program that the student should have enough basic knowledge to enable him to really understand the internal workings of the instruments and equipment he is to work with. Bio-Medical Techniques 2 would introduce more specialized techniques such as electrophoresis, ultra-violet processes, spectrophotometry, chromotography, fluorescence, gama counting, and closed circuit television. The related pieces of equipment to be considered would be electrophoretic apparatus, flame photometers, chromatographs, isotope equipment.

Medical Instrumentation 1 would investigate the theory and operation of basic measuring instruments along with calibration procedures and routine maintenance procedures. Additional pieces of equipment that could be considered would be blood analyzers, carrier amplifiers and differential amplifiers.

The final quarter has three courses devoted to bio-medical instrumentation. Bio-Medical Techniques 3 would consider research

techniques and requirements, new concepts just being introduced, and things predicted for the future. An overview of X-ray, ultrasonics and lasers might also be included. Instruments that could be involved in laboratory work would be recording devices, observation devices and medical computers. Medical Instrumentation 2, which is heavy in laboratory work, would continue the study of the theory and operation of bio-medical measuring instruments along with more depth in calibration, servicing and troubleshooting techniques. The design of electrodes, thermography and servo-mechanisms would also be studied. Instruments for laboratory work, along with troubleshooting problems, would be automatic analyzers, and micro-electronic transmitters and receivers.

Medical Instrument Construction and Applications, a problem course which should exercise most of the knowledge gained in the program, would center around an assigned or chosen problem in the construction, modification, or adaptation of fundamental components to meet special needs. Systems calibration, transducers, and electrodes would also be further contemplations. Other than the problem components themselves, analog to digital converters, and the adaptation of recording devices should be examined.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

SUMMARY

The greatest need for Bio-Medical Electronic Technicians (BMETs) was in the area of maintaining and servicing and this need was expressed almost equally by hospitals, research centers, and manufacturers. These three categories of employers also indicated they would need technicians who could qualify as engineering aids and technicians who would be capable of modifying equipment. The survey revealed that the BMET needed a broad range of skills. To meet these demands, the BMET will have to have an in-depth knowledge of basic electronics and be able to relate this knowledge to various instruments and systems used in the therapeutic, diagnostic, and research aspects of medicine today. Other objectives in the training of BMETs would be: a familiarization with the operation of bio-medical instruments and systems; experience in service and maintenance procedures; development of an understanding of physiological responses; familiarization with some chemical and bio-logical processes; comprehension of calibration procedures; and development of the capability to modify and adapt equipment. Working in hospitals and clinics would require the technician to be versed in

procedures, regulations, and the organization of these institutions, as well as being conversant with some medical terminology.

The preceding objectives were suggested to a committee of experts from the field. The committee added the following objectives: the BMET should have some knowledge of patient relationships; be able to do simple electronic construction; and understand instrument safety. They very strongly emphasized that the BMET have the ability to read and interpret electronic schematics and manuals.

These considerations were the basis for the technical core curriculum developed in this study. The curriculum emphasizes service and maintenance of bio-medical electronic equipment, but does not neglect modification, adaptation, and operation of this equipment. The total program would be six quarters in length, two academic years, and culminate in the attainment of an Associate of Science Degree in Bio-Medical Electronic Technology. Some consideration of a clinical experience or internship should be associated with or follow the program.

RECOMMENDATIONS

Further study will be required into methods and procedures of implementing a clinical experience or internship for the technician who is to be trained in the Bio-Medical Electronics Technology program.

It is recommended that the program be implemented and begin with the fall term of the 1971 school year at Western Wisconsin Technical Institute. The program and its graduates should be evaluated at two year intervals after the program has been started. This evaluation should be continual because of the rapid changes that are taking place in both the medical and the electronics fields.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Books

Allen, William H. (ed.). Dictionary of Technical Terms for Aerospace Use. Washington, D.C.: National Aeronautics and Space Administration, 1965.

Bukstein, Edward J. Medical Electronics. New York: Fredric Ungar Publishing Co., 1959.

Dewhurst, D. J. Physical Instrumentation In Medicine and Biology. New York: Pergamon Press, 1966.

Smith, Donald A. Medical Electronics Equipment Handbook. Indianapolis: Howard Sams and Co., 1962.

Yanof, Howard M. Bio-Medical Electronics. Philadelphia: F. A. Davis Co., 1965.

2. Periodicals

Berkley, Carl, "Training Technical Assistants," Medical Research Engineering, 6:7-9, Second Quarter, 1967.

Editorial, "Medical Engineering Program Planning and System Analysis," Medical Research Engineering, 7:6-7, First Quarter, 1968.

Herrick, J. F. "History of Bio-Medical Electronics Art," Proceedings of the IRE, 50:1173-77, May, 1962.

Mackay, R. Stuart. "Electronics in Clinical Research," Proceedings of the IRE, 50:1177-89, May, 1962.

Talbott, Samuel A. "Education for Engineers in Bio-Medical Research," Proceedings of the IRE, 50:1195, May 1962.

Wujek, Joseph H. Jr. "Medical Instrumentation Systems," Electronics World, 78:30, January, 1968.

3. Publications of the Government, Learned Societies, and Other Organizations

American Society for Engineering Education. Characteristics of Excellence in Engineering Technology Education. Final report of technical institute education. Urbana, Illinois: The American Society for Engineering Education, 1962.

Board of Vocational, Technical and Adult Education. Electronic Technology Monograph. La Crosse, Wisconsin: Board of Vocational, Technical and Adult Education, 1965.

First National Conference on Medical Electronics. Proceedings. New York: McGraw-Hill Inc., 1969.

Spear and Staff, Inc. Bio-Medical Electronics 8 Stocks To Gain, "Investor's Spotlight." Milwaukee, Wisconsin: The Marshal Company, Inc., 1969.

Technical Education Research Center, Inc. Development and Evaluation of Educational Programs In Bio-Medical Equipment Technology, Phase I. Cambridge, Massachusetts: Technical Education Research Center, Inc., 1967. (ERIC Document Reproduction Service, ED016845)

The Medical Electronics Center of the Rockefeller Institute. Bibliography of Bio-Medical Electronics. New York: Institute of Radio Engineers.

Wisconsin Board of Vocational, Technical and Adult Education. Guidelines for Program Development and Evaluation. Madison, Wisconsin: Wisconsin Board of Vocational, Technical and Adult Education, 1969.

4. Unpublished Materials

Nelson, Arthur H. "A Coordinated Effort -- Developing Technical Education Programs In Emerging Technologies." Delmar, New York: American Technical Education Association, Inc., 1966. (Mimeographed).

LIST OF APPENDICES

APPENDIX A.	Draft Curricula for Medical Engineering Technicians Or Laboratory Assistants.
APPENDIX B.	Health Program Curriculum Outlines.
APPENDIX C.	Survey Instrument Use in Bio-Medical Electronic Study.
APPENDIX D.	Advisory Committee.
APPENDIX E.	Bio-Medical Electronics Curriculum.
APPENDIX F.	List of Respondents to Bio-Medical Survey.
APPENDIX G.	Course Descriptions for Electronic Courses, Mathematics, Science, English and Social Science.
APPENDIX H.	Correspondence Received Pertaining To The Bio-Medical Electronics Study.

Appendix A

DRAFT CURRICULA FOR MEDICAL ENGINEERING TECHNICIANS OR LABORATORY ASSISTANTS

HIGH SCHOOL

Chemistry - Inorganic, Organic, some Biochemistry with lab
Physics - Heat, Light (optics) Mechanics, Electricity and Magnetism, Nucleonics, Lab
Biology - Botany, Zoology
Math - Algebra, Geometry, Trigonometry, beginning Calculus

Hand Tools and Machine Shop practice
Instrument Making, test, calibration & repair
Electrical Measurements and devices
Communications & Electronics
Drafting - Mechanical Drawing, Map Making, Freehand & Perspective Illustration, Photography, Report Preparation and Duplication
Laboratory Instruments & Techniques - Record keeping, Safety, Operation of lab equipment (Glassware, microscopes, cameras, photography, physical, chemical & biological measurements, solution preparation, pH, centrifuges, samples)

Library work

COLLEGE

Chemistry - General Chemistry - 1 year
Inorganic - Quantitative & Qualitative Analysis
Organic Chemistry with Lab
Biochemistry with Lab
Physiological Chemistry

Biology - Zoology - Vertebrate, Invertebrate (optional)
Microbiology
Botany (optional)
Physiology
Vertebrate Anatomy
Histology

Mechanical Drawing

Drafting - Engineering Drawing

Machine Shop Practice

Scientific Instrument Design, Test, Calibration and Repair

Library Science

COLLEGE (continued)

Medical Technology - Animal Care, Psychological Testing, Drug Administration, Specimen Preparation, Histology, Microscopy (light & Electron), Lab techniques - surgical procedures, record keeping, Culture-methods, photography, Chemical preparation & tests, Lab safety - Radiation measurements, radiography, electrophoresis, centrifugation, automation

Physics - General Survey
Heat
Light - Optics & Spectroscopy, Lasers
Acoustics
Mechanics
Electricity & Magnetism
Electronics
Nucleonics

Mathematics - Advanced Algebra
Logic & Scientific Method
Trigonometry & Surveying
Calculus
Differential Equations
Computer Operation & Programming

Engineering - Electronics Engineering
Standards & Measurements
D.C. & A.C. Theory
Communications
Properties of Materials
System design & Maintenance
Transducers, Input-output devices
Safety
Environmental Science
Patent Protection

Geology - Geodesy, Astronomy, Mineralogy, Astronautics

APPENDIX B

PRACTICAL NURSE

The practical nurse has become an essential part of the nursing team which is so important in patient care. They are trained to function effectively in many types of nursing situations under the supervision of a doctor or a registered nurse.

The full-year program offers classes and laboratory instruction in the school and affiliated hospitals. The student is thoroughly prepared to take the State Board examination to qualify as a licensed practical nurse (LPN).

The practical nurse may be employed by hospitals to do general care, by patients to give individual care, by nursing homes, doctors' offices and clinics. They may also work in industrial plants and government agencies under the supervision of a physician or registered nurse. With additional training they may specialize in the operating room, or as a surgical or obstetrical technician.

		Total Hours
FIRST QUARTER		
5-10-301	Nursing Foundations	140
5-10-302	Nursing Perceptions	24
5-10-303	Body Structure and Function	36
5-10-313	Personal and Vocational Development 1	36
5-10-310	Nursing Foundations (Clinical)	56
		292
SECOND QUARTER		
5-10-320	Development Through the Life Span 1	24
5-10-311	Mental Nursing	24
5-10-326	Medical-Surgical Nursing 1	60
5-10-323	Geriatrics Nursing (Clinical and P.C.D.)	120
5-10-324	Mental Nursing (Clinical and P.C.D.)	120
		348
THIRD QUARTER		
5-10-336	Medical-Surgical Nursing 2	60
5-10-337	Maternal-Newborn Nursing	24
5-10-333	Development Through the Life Span 2	24
5-10-339	Child Nursing	24
5-10-317	Maternal-Newborn Nursing (Clinical and P.C.D.)	60
5-10-319	Child Nursing (Clinical and P.C.D.)	60
5-10-332	Medical Nursing (Clinical and P.C.D.)	60
5-10-334	Surgical Nursing (Clinical and P.C.D.)	60
		372
FOURTH QUARTER		
5-10-346	Personal and Vocational Development 2	27
5-10-348	Medical-Surgical Nursing 3	36
5-10-340	Medical-Surgical Nursing (Clinical and P.C.D.)	180
5-10-349	Terminal Practice (Clinical)	120
		363

OPERATING ROOM ASSISTANT

The need for a specialized person to perform duties as an operating room assistant has been established to prevent the transfer of registered nurses and licensed practical nurses from the bedside duties.

The program includes theory and practice relative to operating room, emergency room, and recovery room procedures, and clinical experience in each area. The assistant is trained to prepare the room for surgery, function with surgeons during surgery, and care for the room and equipment after surgery. Training is also given in ordering and securing supplies and equipment, and in reporting and recording selected data associated with surgery.

The operating room assistant functions under the direct supervision of the surgeon or the registered professional nurse. Reassessment of the health field has shown that it is economically sound to train supporting people to release registered nurses from assisting types of duty.

FIRST QUARTER		*Hours*
8-09-316	Charm and Personality	3
5-12-311	Normal Body Structure and Function	3
5-12-312	Operating Room Theory	5
5-12-314	Operating Room Laboratory	10
5-12-318	Personal and Vocational Development	2
5-12-316	Operating Room Terminology	2
		25

SECOND QUARTER		
	(First six weeks)	
5-12-321	Abnormal Body Structure and Function	3
5-12-322	Operating Room Theory	5
5-12-324	Operating Room Laboratory	21
		29
	(Second six weeks)	
5-12-329	Clinical Experience	30
		30

THIRD QUARTER		
5-12-339	Clinical Experience	30
		30

MEDICAL ASSISTANT

There is an increasing need for trained medical assistants who can work with the doctors in offices, laboratories, clinics and hospitals.

The field of medical assisting demands flexibility and adaptability in a variety of situations. It requires training in basic medical skills, office procedures, terminology, and laboratory technics. The program involves classroom, laboratory and clinical practice in a medical office. It also includes practice in assisting the doctor in treating patients, care and setup of instruments, sterilization, preparation of medications, ordering supplies, and performing laboratory tests after training. Medical assistants develop an attitude of concern for the patient as well as the ability to communicate with the patient, doctor, and the general public.

Upon completion of the program, the graduate may be employed in doctors' offices, in clinics, laboratories, or hospitals.

FIRST QUARTER		*Hours*
8-09-316	Charm and Personality	3
8-01-333	Applied Communication Skills 3	3
1-06-300	Typewriting	3
5-09-311	Medical Skills 1	6
5-09-310	Hematology 1	3
5-09-315	Urinalysis 1	3
5-09-317	Body Structure and Function 1	3
5-09-318	Medical Terminology 1	2
		26

SECOND QUARTER		
8-09-330	Human Relations	2
8-01-334	Applied Communication Skills 4	3
1-02-302	Office Management	3
5-09-321	Medical Skills 2	6
5-09-319	Extended Lab 1	2
5-09-320	Hematology 2	3
5-09-325	Cardiography 1	3
5-09-327	Body Structure and Function 2	3
5-09-328	Medical Terminology 2	2
		27

THIRD QUARTER		
5-09-301	Medical Office Procedures	3
5-09-331	Medical Skills 3	4
5-09-329	Extended Lab 2	2
5-09-335	Microbiology	3
5-09-336	Special Procedures	3
5-09-337	Body Structure and Function 3	3
5-09-338	Medical Terminology 3	2
5-09-314	Professional and Vocational Adjustment	2
5-09-339	Extended Lab 3	8
		30

MEDICAL LABORATORY TECHNICIAN

PROPOSED CURRICULUM

First Quarter	Credit	Class	Lab
Communication Skills 1	3	3	0
Survey of Algebra	5	5	0
Anatomy Physiology	5	4	2
Medical Laboratory Science 1	4	2	4
	17	14	6

Second Quarter			
Communication Skills 2	3	3	0
Chemistry 1	4	3	2
Anatomy Physiology	5	4	2
Medical Laboratory Science 2	5	2	4
	17	12	8

Third Quarter			
Communication Skills 4	3	3	0
Chemistry 2	4	3	2
Microbiology	5	3	4
Medical Laboratory Science 3	6	2	4
	18	11	10

Fourth Quarter			
Communication Skills 5	3	3	0
Psychology	5	5	0
American Institutions	3	3	0
Medical Laboratory Science 4	7	2	4
	18	13	4

Fifth Quarter			
Sociology	5	5	0
Economics	3	3	0
Medical Laboratory Science 5	7	2	4
Elective	3	3	0
	18	13	4

Sixth Quarter			
Communication Skills Elective	3	3	0
Social Science Elective	3	3	0
Medical Laboratory Science 6	7	2	4
Elective	3	3	0
	16	11	4

APPENDIX C

Complete Survey Instrument

Cover Letter

Preliminary Curriculum Proposal for Bio-Medical Electronic Technology

Table I, Proposed Curriculum for Bio-Medical Electronics

Table II, Division of the Bio-Medical Electronics Curriculum

Figure I, Division of Curriculum by Class Work and Laboratory

Bio-Medical Electronic Technology Survey

WESTERN WISCONSIN TECHNICAL INSTITUTE
6th and Vine Streets
LA CROSSE, WISCONSIN
54601

CHARLES G. RICHARDSON
District Director

July 15, 1969

There has been an increasing need indicated for persons capable of adapting servicing and maintaining electronics and instrumentation in the medical field. Looking to the future, we are trying to anticipate technician employment needs in this field.

With a number of successful programs in both the Health and Electronics field, we now feel that we are capable of extending our educational services to the Bio-Medical Electronics field. We primarily train technicians in many fields with both vocational and associate degree competencies. We need your help in determining the Bio-Medical portion of the curriculum.

Enclosed you will find a survey and a preliminary course of study. Will you please complete the survey at your convenience -- but please do not delay too long. Enclosed is a self-addressed, stamped envelope for your convenience. You need only return the survey portion.

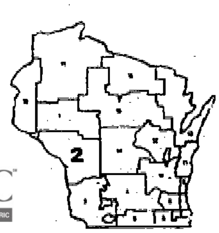
We appreciate your cooperation with this survey, and we will send you a report of the results. Replies will be kept confidential and reported only in summary totals.

Sincerely yours,

William Welch

William G. Welch
Supervisor of Trade and Industry

WGW:mb
Encl.



Center For Wisconsin Vocational, Technical and Adult Education District No. 2

PRELIMINARY CURRICULUM PROPOSAL FOR
BIO-MEDICAL ELECTRONIC TECHNOLOGY

The attached sheets represent our thoughts on a curriculum to train a technician for the Bio-Medical Electronics or Bio-Medical Instrumentation fields. The curriculum is so designed as to comply with the guidelines for associate degree programs in technical institutes in the State of Wisconsin, as set forth by the Wisconsin State Board of Vocational, Technical and Adult Education. It should also meet the recommendations of the American Society for Engineering Education and the very broad suggestions of the North Central Association of Colleges and Secondary Schools; hence the assignment of general subjects, mathematics and physics.

Table I shows the distribution of subjects by years and quarters, each quarter being twelve weeks in duration and the allotment of credit hours to each subject. The standard distribution of time for credit hours is used; that is, one credit hour for each hour of class and one credit hour for each two hours of laboratory.

Table II shows the assignment by percentage of credit hours to the particular divisions of the curriculum.

Figure I, the circle diagram, shows the distribution of each division of the curriculum to class work and laboratory by per cent of credit hours.

That portion of the curriculum devoted to bio-medical subjects has not been broken down, particularly in the second year, because this is the portion of the curriculum that is being developed through this survey.

We hope that you will take the short time necessary to complete the attached questionnaire. We believe that your time will be a valuable service to both the medical and educational fields.

TABLE I
PROPOSED CURRICULUM FOR BIO-MEDICAL ELECTRONICS

1st YEAR

1st Quarter	Credits
Bio-med Techniques	3
Electronic Methods	3
DC Circuits	4
Mathematics 1	5
English Composition	3
	18

2nd Quarter	
Bio-med Techniques	3
AC Circuits	4
Physics 1	3
Mathematics 2	5
Speech	3
	18

3rd Quarter	
Bio-med Techniques 3	3
Electronics	5
Physics 2	3
Mathematics 3	4
Social Science	3
	18

2nd YEAR

4th Quarter	Credits
Bio-med Techniques	3
Electronics	3
Bio-med Group	3
Physics 3	3
Basics of Computers	3
Social Science	3
	18

5th Quarter	
Bio-med Techniques 5	3
Bio-med Subjects Group	10
Social Science	5
	18

6th Quarter	
Bio-med Techniques 6	3
Bio-med Subjects Group	9
Technical Report Writing	3
Social Science	3
	18

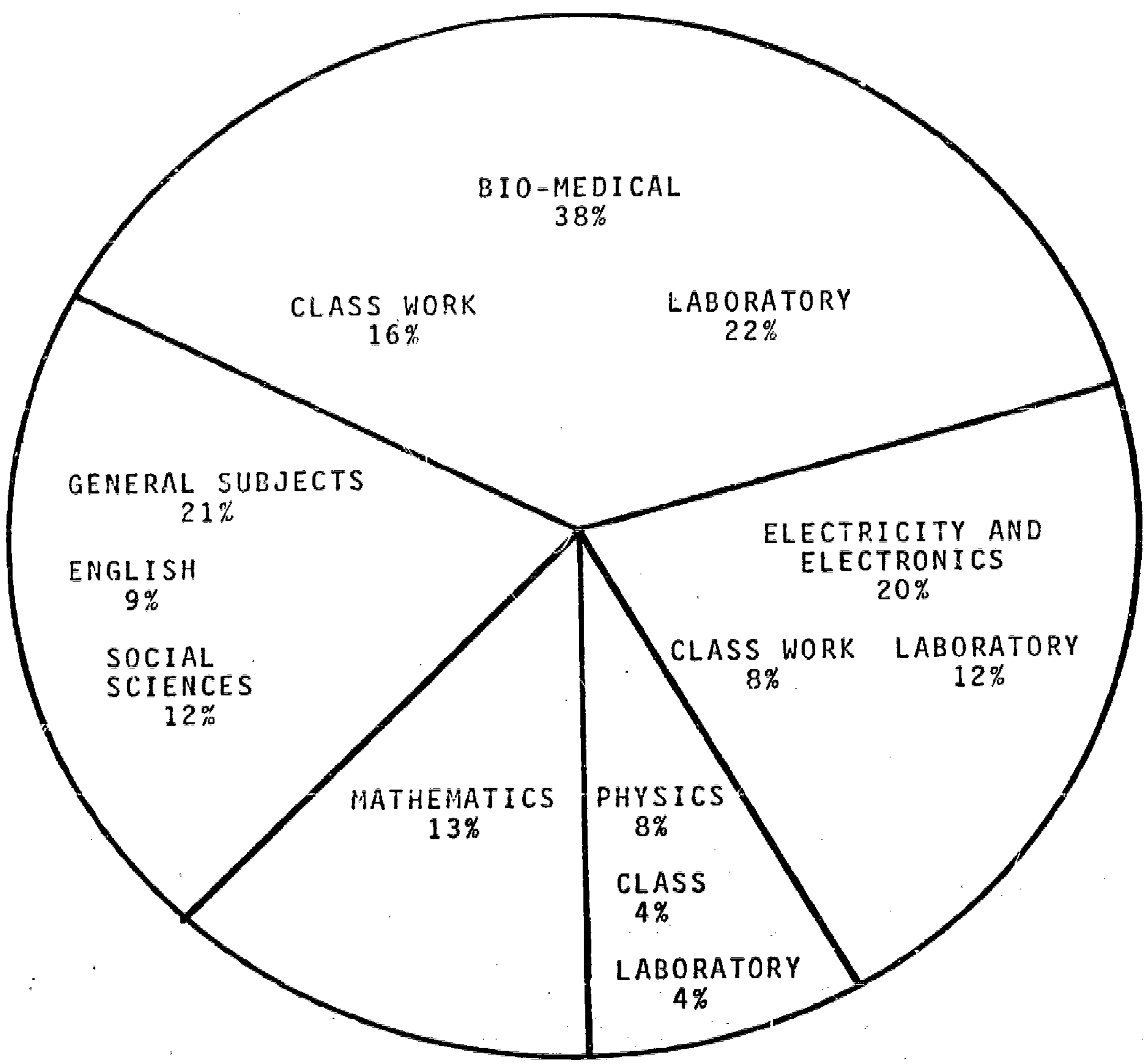
TABLE II
DIVISION OF THE BIO-MEDICAL ELECTRONICS CURRICULUM

GENERAL SUBJECTS 21%	MATHEMATICS 13%	PHYSICS 8%	ELECTRICITY ELECTRONICS 20%	BIO-MEDICAL SUBJECTS 38%
English Composition	Algebra	Mechanics	AC and DC Circuits	Techniques Courses
Speech	Trigonometry	Heat	Electronic Methods	Equipment
Tech report Writing	Analytic Geometry	Optics	Amplifying Devices	Courses to be determined
Psychology	Introduction to Calculus	Sound		
Economics		Fluids and Gasses		
Other Social Sciences				

Prerequisites: High school graduation with adequate mathematics. Physics and 2 years of mathematics preferred.

% is in quarter hours

FIGURE I
DIVISION OF CURRICULUM BY CLASS WORK AND LABORATORY



BIO-MEDICAL ELECTRONIC TECHNOLOGY SURVEY

After reviewing the preliminary curriculum for Bio-Medical Electronic Technology would you give us your recommendations for elaboration on the bio-medical, electronic and science portion of this curriculum by completing the following survey:

Directions: Circle or cross out the appropriate number. Progressively the numbers identify whether you (1) disagree, (2) tend to disagree, (3) cannot say, (4) tend to agree, (5) agree with the statement.

SPECIFICALLY:

1. Two school years seem to be an adequate amount of time for the program.

   1 2 3 4 5

2. An internship or clinical experience would be relevant to the training in this curriculum.

   1 2 3 4 5

3. If an internship or clinical experience were included, it should follow the two years of school work.

   1 2 3 4 5

4. The following subjects should be included in the curriculum:

Biology	1	2	3	4	5
Physiology	1	2	3	4	5
Chemistry	1	2	3	4	5
Anatomy	1	2	3	4	5

5. The bio-medical technician should have some knowledge of some skill in the following functions or systems:

Response stimulus devices	1	2	3	4	5
Monitoring devices	1	2	3	4	5
Gross electrical activity	1	2	3	4	5
Fine electrical activity	1	2	3	4	5
pH measurement	1	2	3	4	5
X-ray	1	2	3	4	5
Ultra-sonics	1	2	3	4	5
Lasers	1	2	3	4	5
Electrode design	1	2	3	4	5
Fluid dynamics	1	2	3	4	5

Servo mechanisms	1	2	3	4	5
Transducers	1	2	3	4	5
Electrophorisus	1	2	3	4	5
Ultra-violet processes	1	2	3	4	5
Thermography	1	2	3	4	5
Instrument testing	1	2	3	4	5
Instrument calibration	1	2	3	4	5

Others _______________________

____

6. The following equipment should have a high priority for inclusion in class and laboratory work in the bio-medical courses:

Oscilloscopes	1	2	3	4	5
Amplifiers	1	2	3	4	5
Carrier Amplifiers	1	2	3	4	5
Differential amplifiers	1	2	3	4	5
Micro electronic transmitters and receivers	1	2	3	4	5
Cameras	1	2	3	4	5
Regulated power supplies	1	2	3	4	5
Closed circuit television	1	2	3	4	5
Audio monitors	1	2	3	4	5
Tape recorders	1	2	3	4	5
Oscillographs	1	2	3	4	5
Medical computers	1	2	3	4	5
Spectrophotometers	1	2	3	4	5
Blood analyzers	1	2	3	4	5
pH meters	1	2	3	4	5
EEG and EKG devices	1	2	3	4	5
Chromatographs	1	2	3	4	5

Others _______________________

____

7. The following might be jobs performed wholly or in part by a bio-medical electronic technician:

						*Number now employed
Servicing (repair of defects)	1	2	3	4	5	( )
Maintaining (routine)	1	2	3	4	5	( )
Equipment operation	1	2	3	4	5	( )
Modification of equipment	1	2	3	4	5	( )
Equipment application aid	1	2	3	4	5	( )
Engineering aid	1	2	3	4	5	( )
Others ________________						( )

____

* Please enter the number of persons you now have that might be filling these jobs.

8. How many trained technicians could you employ if they were available?

Now ___ By 1974 ___

9. How is maintenance and service on your bio-medical equipment handled?

___ Your own staff ___ Contracted for ___ On call service

10. Who installs your equipment?

___ Your own staff ___ Contracted for

11. I would like a report of this survey upon its completion. ( )

Replies will be kept confidential and reported only in summary totals.

NAME ________________ DATE ________________

POSITION ________________

INSTITUTION ________________

CITY ________________ STATE ________________

APPENDIX D

Advisory Committee

Agenda for Meeting at Marshfield, Wisconsin

Report of Meeting of Committee

Supplementary Report to Committee Meeting

DISCUSSION OF MEDICAL ELECTRONICS

TUESDAY - MARCH 24 & 25, 1970

Visitors:	Miss Beatrice Palen, Mr. Arnold Potthast, Miss Anita Smith, Mr. William Welch, and Mr. John Biron
12:00 Noon:	Luncheon - St. Joseph's Hospital Conference Room No. 1. Visitors, Mr. David Jaye (Hospital Administrator), Dr. Norbert Koopman (Dean, University of Wisconsin Center) and Mr. Frederick Wenzel
1:30 p.m.:	Tour of Hospital, X-ray Department and Clinical Laboratory. Visitors, Mr. LeRoy Ferries and Mr. Frederick Wenzel
3:30 p.m.	Discussion session - Foundation Office. Visitors, Mr. LeRoy Ferries, Mr. James Kipp, Mr. Howard Scott, Dr. Dean A. Emanuel, Dr. Richard H. Ulmer, Dr. Richard D. Sautter, Mr. Frederick Wenzel and Mr. James Olson.
7:00 p.m.	Dinner - Knight Inn. Visitors, Mr. Frederick Wenzel and Mr. James Olson

WEDNESDAY - MARCH 25, 1970

9:00 a.m.	Tour of the Marshfield Clinic Laboratories and Computer Center. Visitors, Mr. LeRoy Ferries, Mr. William Matthews, and Mr. James Kipp
10:30 a.m.	Coronary Care Unit - St. Joseph's Hospital. Visitors, Mr. LeRoy Ferries, Mr. Howard Scott, Mr. James Kipp, and Dr. Dieter M. Voss.
12:00 Noon:	Luncheon - Knight Inn. Visitors, Mr. James Olson, Mr. LeRoy Ferries, and Mr. William Matthews

REPORT OF DISCUSSION OF MEDICAL ELECTRONICS MEETING

MARSHFIELD CLINIC, MARSHFIELD, WISCONSIN

MARCH 24-25, 1970

HOST: MARSHFIELD CLINIC, MARSHFIELD CLINIC FOUNDATION, ST. JOSEPH'S HOSPITAL

VISITORS: Miss Beatrice Palen, Mr. Arnold Potthast, Miss Anita Smith, Mr. William Welch, and Mr. John Biron

MARSHFIELD: Mr. David Jaye, Dr. Norbert Koopman, Mr. Frederick Wenzel, Mr. LeRoy Ferries, Mr. James Kipp, Mr. Howard Scott, Dr. Dean A. Emanuel, Dr. Richard H. Ulmer, Dr. Richard D. Sautter, Mr. James Olson, Mr. William Matthews, Dr. Dieter Mr. Voss.

The meeting consisted of group discussions and tours of the hospital, clinic, and foundation facilities. The following is a condensation of the discussions. The discussions were very valuable in formulating the curriculum outline developed by Mr. Welch.

Two technicians from the Marshfield institutions (they service all three institutions) explained their electronic background and how they got started at Marshfield. One had long experience in Navy electronics. He was the first to start at Marshfield and had no medical equipment experience, but had a very fine electronic background. His main problem was to find out how instruments were being used on patients or applied to measurement in the lab. He progressed from piece to piece learning their operation from manuals and factory representatives. Many pieces were added after he started and were new to everyone. There were schools, sponsored by manufacturers and distributors of equipment. The schools were short term, one day to a week in length. Most problems requiring outside help involved engineering and application problems rather than service problems.

The second technician also had military electronic experience, some of which was specifically in medical instrumentation repair. His transition to employment in medical electronics was easy.

Question: How much would you expect a person entering the BMET field to know? Of course as much past experience as possible, but this is not a practical approach, because there are very few persons available with years of electronic experience, much less, medical instrumentation experience. Technicians with experience like the two technicians Marshfield has been able to get are just not generally available.

Question: What is needed? A good background in basic electricity and electronics, specific things like transducers, photo electric devices, wavelength of light and amplifiers would be very useful knowledge. Students coming out of an Electronic Technology Program might have the theoretical knowledge, but not the working knowledge or practical experience needed.

Question: What about an internship or clinical experience? At what level of knowledge in a program would the experience be relevent? At what level would students be capable of performing some useful work?

One suggestion would be to start the experience in the summer between the first and second years, possibly could do some simple related tasks, become familiar with the medical world. In any internship or clinical experience some problems arise, to find institutions to cooperate in the experience, institutions with competent technicians o -n engineer to supervise the experience. There are very few institutions now qualified to do this. Most institutions are just going to have to take persons with theoretical knowledge into their institution, pay them, and allow them to gain the experi- ce necessary to become competent technicians.

Schools could do more in programs to provide some hands on and familiarization experience for students. This would appear to be important in the bio-medical electronics field. More workshops by manufacturers could help, some of these might be held at the school. Exposure, at least, to some types of equipment should be possible in the school. One suggestion to help in this would be for institutions to send equipment that is no longer being used or needed to the school, where it might be good for instructional purposes.

Group indicated there was a very definite need for programs to train BMET's. They felt the greatest need was for technicians in routine maintenance and servicing and were speaking from experience. Institutions can no longer rely on outside service for most of their service. Equipment is becoming too widely used and there is too much dependence upon it to wait for service from the outside.

A sequence of job performances for technicians entering employment would be, first, routine maintenance. Here he would not be working under pressure or against time. The technician would then progress to servicing, which implies working on equipment that has malfunctioned while in operation and may need immediate service. These experiences may take several years. He then may be capable of progressing into application and modification of equipment and in some cases equipment operation. Small institutions may have some difficulty in taking on inexperienced technicians. The group felt, however, that in some cases even various experience before the training program might be valuable in employment.

Are there any areas of basic electronics that would not be necessary? None at all. Then are we talking about an electronic technician plus? Not necessarily so. An interdisciplinary approach could be used-the introduction or related medical things at the same time as electronic principles are introduced.

Things that should be emphasized. Technicians must be competent in interpretation of schematics and prints of equipment and systems. Logical trouble shooting techniques are also very important. Some familiarity with physiology, biology, anatomy, and chemistry would be desirable. Physiology would be the most important and chemistry would also be very helpful. Biology and anatomy are not as important. These need not be taught as specific courses but necessary topics in each could be taught as a part of the technical core where they would relate.

The BMET will have to have some patient relationship. Many pieces of equipment are used on patients and patient safety is very important. There are also times when equipment fails while it is connected to the patient. For example, in the operating room, intensive care, etc. This equipment must be put into operation-many times in the presence of the patient.

As the BMET matures, he must be able to communicate with medical personnel. This is important where equipment is to be modified, adopted, or applied. It is necessary for the technician to know what is expected out of the equipment.

A physician expressed the opinion that any 60 bed hospital could begin to use a BMET. Since his hospital has had a technician, the incidents of equipment breakdowns have been remarkably reduced, and when breakdown did occur in an emergency, the technician could be there in a few minutes. The availability of a technician is very important under these conditions. It was also suggested that several institutions in an area might share a technician if they could not employ one full-time.

There is possibly the need for a hybrid person (one who can operate, apply, and maintain). If such a person were to be trained, it would seem better to train him in electronics first, then in a medical application specialty.

Finally, there are also many relatively simple pieces of equipment that must be maintained, such as sterilizers, heat lamps, timers, small motors, etc. Some mechanical devices also cannot be overlooked. Points emphasized again were: practical experience on equipment, reading of schematics, interpretation of manuals, and trouble shooting techniques.

Recorded by,

William Welch

Marshfield Clinic Foundation

FOR

MEDICAL RESEARCH AND EDUCATION

510 N. ST. JOSEPH AVE.

MARSHFIELD, WIS. 54449

May 22, 1970

Mr. William G. Welch
125 South 28th Street
La Crosse, Wisconsin 54601

Dear Bill:

I have reviewed the material and would like to make the following suggestions for instrumentation for the course in medical electronics. As I indicated on the phone, I would not introduce any medical type instruments during the first quarter, but emphasize courses in basic electricity, electronics including amplifiers, preamplifiers, oscilloscopes and transducers. This course will probably have to run through at least four to six quarters. This, I think, is particularly true as the equipment gets more sophisticated. You might even want to consider spending the greater part of two quarters on courses of this type without introducing specific medical instrumentation. This may have to be worked out during the progress of the course. The second quarter and third quarter, I would reverse as I have already suggested and label them both physiological processes I and II. During the second quarter then, I would introduce the student to three instruments, EKG, EEG and EMG. During the third quarter, I would introduce the pH meter and its electrodes, the automatic balance and a blood gas analyzer for oxygen and carbon dioxide. You may want, during this third quarter, to introduce some of the chemical processes, particularly those aimed at pH measurements. During the fourth quarter, I would continue work on the pH meter, if necessary, introduce the colorimeter and spectrophotometer. During the fifth quarter, I would introduce special spectrophotometric techniques, including ultraviolet and fluorescence. That quarter could also involve electrophoretic apparatus and an introduction to isotope equipment for gamma counting. I think I would spend the sixth quarter reviewing such instruments as the automatic analyzers, i.e. the Technicon Systems. The sixth quarter should also have emphasis on trouble shooting techniques at which time instruments previously studied could be altered and the students could attempt to solve the problem.

As I mentioned on the phone, if you need further definition of each one of these areas, I would be very happy to provide them. I think, however, that

this will give a pretty good overview of some of the medical instrumentation needs.

Sincerely yours,

FREDERICK J. WENZEL
Executive Director
Marshfield Clinic Foundation

FJW:jh

APPENDIX E

Bio-Medical Electronics Curriculum

BIO-MEDICAL ELECTRONICS

PROPOSED CURRICULUM

First Quarter	Credit	Class	Lab
Communications Skills 1	3	3	0
Technical Mathematics 1	5	5	0
Electronic Methods 1	3	1	4
DC Circuits	4	2	4
*Introduction to Bio-Medical Electronics	3	2	2
	18	13	10
Second Quarter			
Communications Skills 2	3	3	0
Technical Mathematics 2	5	5	0
Technical Physics 1	3	2	2
AC Circuits	4	2	4
*Physiological Processes 1	3	2	2
	18	14	8
Third Quarter			
Social Science	3	3	0
Technical Mathematics 3	4	4	0
Technical Physics 2	3	2	2
Active Devices	4	2	4
*Physiological Processes 2	3	2	3
	17	13	9
Fourth Quarter			
Social Science	3	3	0
Technical Physics 3	3	2	2
Linear Electronic Circuits	5	3	4
Pulse Circuits	3	2	2
*Bio-Medical Techniques 1	3	2	2
	17	12	10
Fifth Quarter			
Social Science	3	3	0
Social Science	2	2	0
Non-linear Electronic Circuits	4	2	4
Introduction to Computer Science	3	2	2
*Bio-Medical Techniques 2	3	2	2
*Medical Instrumentation 1	3	2	2
	18	13	10
Sixth Quarter			
Communication Skills 3	3	3	0
Social Science	3	3	0
*Bio-Medical Techniques 3	3	2	2
*Medical Instrumentation 2	3	1	4
*Medical Instrument Construction and Application	3	1	4
*Elective any area	3	2-3	0
	18	12-13	10

* Technical Core courses specifically developed for this technology.

BIO-MEDICAL ELECTRONICS TECHNICAL CORE SUBJECTS

1st QUARTER	2nd QUARTER	3rd QUARTER
Introduction to Bio-Medical Electronics	Physiological Processes 2	Physiological Processes 2
3 Cr. 2 Class 2 Lab	3 Cr. 2 Class 2 Lab	3 Cr. 2 Class 2 Lab
General Introduction	Physiological Processes	Physiological and Chemical Processes
Hospital & Clinic Operation & Organization Regulations, Procedures Terminology Instrument Safety	Physiology & Anatomy of the Human Body Familiarization with Physiological Measurements and Tests Gross Electrical Activity Monitoring Devices Introduction to Instrument Calibration	Response Stimulus Fine Electrical Activity Basic Chemical Concepts Redox Chemical Equilibrium Ionization Human Related Chemistry pH Measurement Fluid Dynamics
Possible Lab Instruments	Possible Lab Instruments	Possible Lab Instruments
Oscilloscopes Amplifiers Transducers Tape Recorders Power Supplies	EKG EEG EMG Electrodes Audio Monitors	pH Meters Blood Analyzers Automatic Balance Basic Chemical Analysis Additional Physiological Measurements

BIO-MEDICAL ELECTRONICS TECHNICAL CORE SUBJECTS

4th QUARTER

Bio-Medical Techniques 1

3 Cr. 2 Class 2 Lab

Biological Processes

- Cell Structure
- Biological Measurements and Tests
- Terminology
- Relations to Electronic Lab Equipment

Possible Instruments

- pH Meters
- Spectrophotometer
- Colorimeter
- Oscillographs

5th QUARTER

Bio-Medical Techniques 2

3 Cr. 2 Class 2 Lab

Special Techniques

- Electrophoresis
- Ultra Violet Processes
- Spectrophotmetry
- Chromotography
- Fluorescence
- Gamma Counting
- Closed Circuit TV

Possible Instruments

- Electrophoretic Apparatus
- Flame Photometer
- Chromatographs
- Isotope Equipment
- Closed Circuit TV

Medical Instrumentation 1

3 Cr. 2 Class 2 Lab

Theory and Operation of Basic Measuring Instruments
Calibration and routine Maintenance Procedures

Possible Instruments

- Blood Analyzers
- Carrier Amplifiers
- Differential Amplifiers

BIO-MEDICAL ELECTRONICS TECHNICAL CORE SUBJECTS

6th QUARTER

Bio-Medical Techniques 3

3 Cr. 2 Class 2 Lab

Research Techniques and Requirements
New Concepts
Things Predicted for the Near Future
X-ray
Ultra-Sonics
Lasers

Possible Instruments

- Recording Devices
- Observation Devices
- Medical Computers

Medical Instrumentation 2

3 Cr. 1 Class 4 Lab

Theory and operation of Bio-Medical Measuring Instruments
Calibration, Serviceing, and Troubleshooting Techniques
Design of Electrodes
Thermography
Servo Mechanisms

Possible Instruments

- Automatic analyzers
- Micro-electronic Transmitters and Receivers
- Troubleshooting Problems

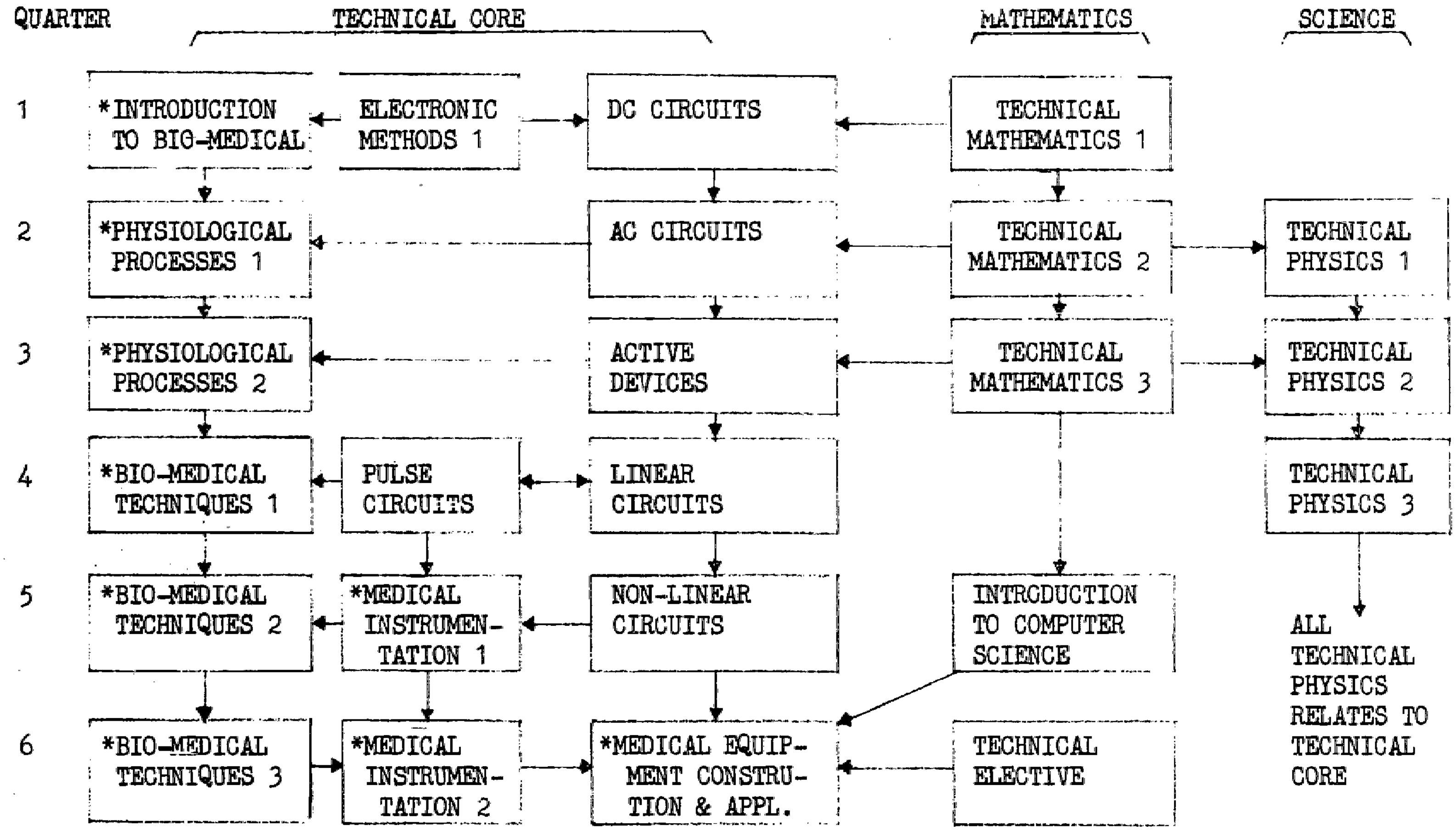
Medical Instrument Construction and Application

3 Cr. 1 Class 4 Lab

Problems in construction, modification and adaption of fundamental components to meet special needs
System Calibration
Transducers and Electrodes

Suggested Problems

- Analog to digital Converters
- Adaptation of Recording Devices



* TECHNICAL CORE COURSES SPECIFICALLY DEVELOPED FOR THIS TECHNOLOGY

BIO-MEDICAL ELECTRONICS PROGRAM FLOW CHART

APPENDIX F

List of Hospitals, Manufacturers, and Research Institutes Responding to the Survey

Anoka State Hospital
Anoka, Minn.

St. Mary's Hospital
Duluth, Minn.

Veterans Administration Hospital
Minneapolis, Minn.

St. Mary's Hospital
Minneapolis, Minn.

Methodist Hospital
St. Louis Park, Minn.

Rochester Methodist Hospital
Rochester, Minn.

St. Mary's Hospital
Rochester, Minn.

St. Joseph's Hospital
St. Paul, Minn.

Community Memorial Hospital
Winona, Minn.

St. Elizabeth's Hospital
Appleton, Wis.

Beloit Memorial Hospital
Beloit, Wis.

St. Joseph's Hospital
Chippewa Falls, Wis.

Luther Hospital
Eau Claire, Wis

St. Agnes Hospital
Fond Du Lac, Wis

Wausau Memorial Hospital
Wausau, Wis

Veterans Administration Center
Wood, Wis.

St. Luke's Methodist Hospital
Cedar Rapids, Ia.

Mercy Hospital
Cedar Rapids, Ia.

Sacred Heart Hospital
Eau Claire, Wis.

University of Iowa Hospital
Iowa City, Ia.

St. Joseph's Hospital
Mason City, Ia.

Kenosha Memorial Hospital
Kenosha, Wis.

La Crosse Lutheran Hospital
La Crosse, Wis.

St. Francis Hospital
La Crosse, Wis.

Madison General Hospital
Madison, Wis.

University of Wis. Hospital
Madison, Wis.

St. Joseph's Hospital
Marshfield, Wis.

Memorial Hospital & Nursing Home
Menomonie, Wis.

Mercy Hospital
Oshkosh, Wis.

St. Joseph's Hospital
Waukesha, Wis.

St. Mary's Hospital
Wausau, Wis.

Mercy Hospital
Mason City, Ia.

Hospital Sisters of the 3rd Order
of St. Francis
Springfield, Ill.

E and M Instrument Co. Inc.
Houston, Texas

Hewlett-Packard Co.
Waltham, Mass

Beckman Instruments Inc.
Fullerton, Calif.

Gunderson Clinic
La Crosse, Wis.

Electronics/Management Center
New York, N. Y.

Whitlock Sales Corporation
Green Bay, Wil

Ames Company
Elkart, Indiana

Department of Bio-Medical Engineering
University of Wisconsin
Madison, Wis.

Technology/Versatronics, Inc.
Yellow Springs, Ohio

BioCom Inc.
Culver City, Calif.

Mayo Clinic
Rochester, Minn

Technical Education Research Center, Inc.
Cambridge, Mass

Medical-Research Engineering
Great Notch, New Jersey

APPENDIX G

Electrical Technology (6-05)

6-05-101 FUNDAMENTALS OF ELECTRICITY AND ELECTRONICS *3 credits*

The purpose of this course is to provide information on the basic fundamentals of electricity and electronics to technical students in fields other than electronics technology. Sources of electricity, circuits and power, magnetism, resistance, inductance, capacitance, transformers, tuned circuits, instruments, vacuum tubes, transistors, power supplies, radio waves, pulse and industrial electronics devices are presented in a manner which relates the subject to the specific technology of the group involved. The laboratory work is related to the material studied so as to substantiate the theory presented.

6-05-111 ELECTRONIC METHODS 1 *3 credits*

Electronic Methods 1 is a first course for the student of Electronics. It is a non-mathematical introduction to electricity and magnetism, A.C. and D.C. currents, tubes, and transistors, and basic test instruments. The course also incorporates all the aspects of shop processes, the use of tools; both hand and power, techniques of soldering and handling components, cables, printed circuitry and hardware.

The laboratory work in this course is aimed at developing a liking and curiosity for the field that is so essential to a good technician.

6-05-116 D. C. CIRCUITS *4 credits*

In D. C. Circuits the student is to learn the fundamental concepts of unidirectional circuits and the parameters associated with these concepts. To have a firm foundation he must have a good understanding of the modern concepts of electron physics, and some portions of modern physics; a thorough understanding of Ohm's Law, series and parallel circuits, and some of the more complex network theorems.

The associated lab is designed to relate and reinforce the concepts taught with the practical aspects of the subject.

6-05-121 ELECTRONIC METHODS 2 *2 credits*

Electronic Methods 2 presents a non-mathematical introduction into both low and high frequency amplifiers, oscillators, radio receivers and the block diagram approach to several other electronic systems.

Methods 2 will also include topics involving the volt-ohm-milliammeter; the vacuum tube voltmeter; the oscilloscope; audio and radio frequency generators; bridges and power supplies.

The first section of this course is designed to give the student an overview of the electronic field. The second section deals with fundamental test equipment used in the electronic industry.

6-05-127 A. C. CIRCUITS *4 credits*

A. C. Circuits is a basic core subject in the fundamental concepts and theories of alternating or bidirectional sinusoidal current. Topics covered will be instantaneous voltage and current, frequency, phase, rms, and maximum values, computation of power, vector methods of circuit solution, series and parallel R-C-L circuits, series and parallel resonance.

6-05-154 NON-LINEAR ELECTRONIC CIRCUITS *4 credits*
The use of amplifying devices in non-linear electronic circuits. The development of sine wave oscillators with LRC, and RC circuits. Complex wave form generators, multivibrators, blocking oscillators, relaxation oscillators, gating circuts, clippers and clampers are introduced.

6-05-155 INDUSTRIAL ELECTRONICS 1 *3 credits*
Industrial Electronics 1 is a study of the important industrial applications of electronics. Emphasis has been given to broad techniques which have wide applicability to a variety of industrial equipment. Principles are of first order, but many of the devices and circuits described are those actually used in industrial electronics.

The laboratory section of this course, like the class work, investigates the practical applications of electronics to industry.

6-05-156 INSTRUMENTATION FOR POWER 2 *5 credits*
A survey of the measurements, transducers, indicating and registering equipment used for industrial measurements.

6-05-161 POWER TRANSMISSION 2 *3 credits*
Advanced computational techniques applied to the solution of electrical power transmission system problems.

6-05-162 POWER GENERATION 3 *4 credits*
Survey of internal combustion engine power stations and hydro-electric stations. Application of engineering economics to power generation.

6-05-165 INDUSTRIAL ELECTRONICS 2 *4 credits*
A course in industrial instrumentation and measurement. Measurement and analytic principles in industrial processes are introduced along with types of instrumentation used in industrial processes. Analog computer circuits are also studied.

6-05-166 INSTRUMENTATION FOR POWER 3 *4 credits*
Introduction to control principles, control system elements, computers, types of controllers and final control elements, general systems of control layouts.

6-05-169 ELECTRONIC PROBLEM *3 credits*
The previous acquisition of theoretical knowledge and laboratory experience are applied to a practical design or research problem in the electronics field. The student selects an approved project or problem and then carries it to completion. He then presents the materials, processes specifications and results of the problem in a written report.

1-07-108 INTRODUCTION TO COMPUTER SCIENCE *3 credits*
The course is designed to meet the requirements of technical students in the Trades and Industry Department. They will receive an introduction to computer concepts, recording media, flow charting, and problem solutions. FORTRAN will be the computer language emphasized with laboratory problems provided by the student's own department. The student will also learn to operate the key punch machine and sorter in order to prepare data for input to the computer.

8-04-120 SURVEY OF ALGEBRA *5 credits*

A one-quarter study of basic algebra designed to review the necessary concepts for an understanding of the Technical Mathematics sequence. Covers topics similar to those in Elementary Algebra 1 and 2. A previous course in algebra is required.

8-04-140 TECHNICAL MATHEMATICS 1 *5 credits*

A study of basic algebra and trigonometry. The slide rule is covered early in the course to facilitate its use throughout. Includes fundamental algebraic operation, equations and formulas, proportion and variation, graphs of algebraic functions, trigonometric solutions of triangles, and vector solutions. Emphasis is placed on the use of mathematics for problem solving.

8-04-141 SLIDE RULE *1 credit*

Designed to give the student a working understanding of the basic scales of the slide rule. Covers topics on scientific notation, laws of exponents, and the operations of multiplication, division, squares, cubes, and roots. Open to anyone interested.

8-04-145 TECHNICAL MATHEMATICS 2 *5 credits*

Continues the study of algebra and trigonometry to include systems of equations, factoring and fractions, quadratic equations, exponents and radicals, logarithms, graphs of trigonometric functions, and complex numbers. Applications support the theory of each topic.

8-04-155 TECHNICAL MATHEMATICS 3 *4 credits*

Completes the algebra and trigonometry needed for a study of the calculus. Covers such topics as inequalities, arithmetic and geometric progressions, trigonometric identities and equations, basic analytic geometry, derivatives of algebraic functions, and the antiderivative. Calculus is introduced from the graphical approach and applications are stressed.

8-04-160 TECHNICAL MATHEMATICS 4 *4 credits*

Basically, a course in calculus emphasizing applications where appropriate. Reviews the meaning of a derivative and continues with topics on integration, transcendental functions, series expansions, and an introduction to differential equations. Intended to prepare the student for further study in higher mathematics.

Natural Science (8-06)

8-06-100 PHYSICAL SCIENCE 1 *3 credits*

Explores the fundamental laws of physics and chemistry with a minimum use of mathematics. Emphasis is placed on the methods of science through demonstrations, simple experiments, and problem solving. Covers such topics as measurement, force and motion, work and energy, simple machines, properties of fluids, heat and temperature, and chemical composition of matter.

8-06-108 PHYSIOLOGICAL NEEDS OF MAN *3 credits*

Today's interiors are meant to fill the cultural, social, and commercial needs of the people who use them. The environment in which individuals live and work must enable them to be efficient and comfortable.

In eliminating an exhaustive array of data, this course is designed to present in an integrated and meaningful pattern the more important human physiological processes. The course should help thr student acquire a fuller knowledge and understanding of the way in which his body works.

8-06-140 TECHNICAL PHYSICS 1 *3 credits*

A study of basic physics with emphasis placed on problem solving. Covers topics on statics, velocity and acceleratiòn, force and motion, work, energy, power, and momentum. Includes a two-hour laboratory session each week for the purpose of verifying physical concepts and developing scientific methods of study.

8-06-144 TECHNICAL PHYSICS 2 *3 credits*

A continuation of Technical Physics 1 covering such topics as angular motion, properties of matter, fluid pressure and hydraulics, heat and temperature, wave motion, and sound. Lectures and demonstrations are accompanied by laboratory experiments.

8-06-154 TECHNICAL PHYSICS 3 *3 credits*

A study of the properties of light, electromagnetic waves, mirrors and lenses, wave interference, diffraction, relativity, atomic theory, and radioactivity. Emphasizes new findings of modern physics. Laboratory experiments support the theory presented.

English (8-01)

8-01-140 COMMUNICATION SKILLS 1 *3 credits*

The first quarter of Communication Skills is designed to give the student an understanding and practical application in the basic communication skills — Reading, Listening, and Writing. A brief history of the English language is given. Composition is stressed in written communication. Emphasis is placed on the rhetoric and structural values of sentences, paragraphs, and themes. Methods of improving listening and reading skills are also given.

8-01-145 COMMUNICATION SKILLS 2 *3 credits*

In Communication Skills 2 the basic principles of speech are applied to improve the listening and speaking skills of a student as a conversationalist and formal speaker and in discussions and interviews.

8-01-155 COMMUNICATION SKILLS 3 *3 credits*

Communication Skills 3 is designed to teach the technical student to communicate with proficiency in both oral and written reports. Primarily, the course is designed to teach the four types of technical reports, (exposition, narration, description, and argumentation), and give the student the opportunity to prepare a 5,000 to 10,000 word technical report as a culminating exercise. Finally, the course offers the technical student an opportunity to use his oral skills in giving a speech of demonstration, defense of his project, progress report of his project, and participation in group discussion.

8-09-150 PSYCHOLOGY OF HUMAN RELATIONS *3 credits*

This course includes a brief history of psychology; the importance of human relations to workers of all levels; and introduction to the learning process (perception, attitudes, motivation, and the influences of heredity and environment); terminology necessary to understand effective human relations; personality in life and business.

8-09-152 AMERICAN INSTITUTIONS *3 credits*

This course is offered as a guide to better understanding of the complex technological society in which we live. It is intended to show how we acquire the knowledge, skill, ideas, ideals, and responsibilities which enable us to play our respective roles in that society and some of the factors which determine the kind of life we can make by living and working with others. Topics considered are: social groups, culture, culture changes, social control, problems of city living, the American system of government, public opinion and propaganda, religion, democracy and its rivals, political parties and elections, government and business, the development of the American system of capitalism, and international relations.

8-09-154 AMERICAN COURTS *2 credits*

This course is an inquiry into the history and function of the various American courts. Special emphasis is placed upon the methods of legal process as it relates to the various civil and criminal trial procedures.

-09-156 CHILD PSYCHOLOGY *2 credits*

This course includes a study of early stages of personality and psychomotor development and the behavior which is apparent during each stage; discussion includes accepted standards for normal behavior and human development as well as criteria for evaluating the unusual child.

8-09-157 AMERICAN GOVERNMENT *2 credits*

This course is offered with the intent to provide the student with a deeper understanding of our national system of government, its methods of functioning, and its relationship to the people whom it governs under the tenents of a constitutional democracy.

8-09-158 APPLIED PSYCHOLOGY *2 credits*

This course includes the basic concepts of personality, the importance and improvement of personality, self-evaluation, adjustments in later life, and the individual's relation to others; the principles, promotion, and rehabilitation of mental health and its importance to American society.

8-09-160 MARRIAGE AND THE FAMILY *3 credits*

This course includes social customs affecting the individual's concept of marriage, the parents' role in determining attitudes of children toward marriage, motivations of an individual to marry, the development of the interpersonal relationship of man and woman from early age through courtship and into marriage — expectations, resolution of conflicts, importance of self-image. Discussion includes financial considerations, physical aspects of marriage, planned parenthood, religion, psychological/emotional components of courtship, marriage ceremony and divorce.

APPENDIX H

Correspondence Received Pertaining to the Bio-Medical Electronic Study

TERC Technical
Education
Research
Center

44A Brattle Street, Cambridge, Massachusetts 02138 Telephone 617-547-0430

April 17, 1970

Mr. William G. Welch
Supervisor of Trade and Industry
Western Wisconsin Technical Institute
Sixth and Vine Streets
La Crosse, Wisconsin 54601

Dear Mr. Welch:

In our previous correspondence with you on the educational programs to be developed for bio-medical equipment and nuclear medicine technicians, the need has been mentioned for a mechanism to ensure that the curricula and materials for those programs should be constantly updated to keep pace with changes in the technologies. We would now like to discuss with you how this need might be met through an interactive network comprising appropriate educational institutions, employers, manufacturers of bio-medical and nuclear medical equipment, professional associations, interested government agencies and educational publishers.

The present concept of the network is that it should function

(i) To maintain the development of educational curricula in step with the development of the bio-medical and nuclear medicine technologies

(ii) To ensure a constant exchange of information on these developments

(iii) To obtain and circulate information on the job characteristics and manpower needs of the fields, and hence on the opportunities and prospects of employment.

The network is envisaged as functioning largely through collaboration between the various interested organizations in an appropriate locality, with TERC acting mainly as contact center and a broker of information and ideas between localities.

TERC would be glad to have your views on the matter. To facilitate your reply a postcard questionnaire is enclosed, but, should you have more suggestions to offer, TERC would be only too pleased to receive them as well as the questionnaire.

You will be interested to learn that TERC is presently conducting a survey of the requirements of prospective employers of bio-medical equipment technicians. The results should reveal both what employment is likely to be on offer in the near and further future, and also what should form the basic educational curriculum in the field.

We shall appreciate hearing from you.

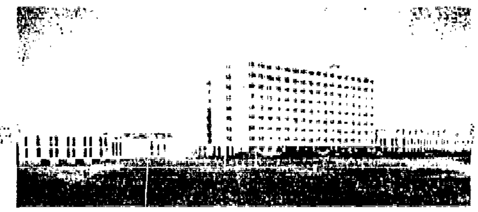
Sincerely,

P. J. Cadle

P. J. Cadle

PJC/cpk
Enclosure

Sacred Heart Hospital



900 W CLAIREMONT AVENUE • EAU CLAIRE, WISCONSIN 54701
TELEPHONE 715-832-8371

January 29, 1970

Director
Vocational and Technical School
LaCrosse, Wisconsin

Dear Sir:

We are interested in securing a technician trained in repair and preventive maintenance of medical laboratory equipment.

Kindly advise this office whether your school offers such training and when is the next class graduating having this training.

If possible, kindly submit to us the name of at least one person with this training who might be interested in a position of this nature at our Sacred Heart Hospital in Eau Claire.

Sincerely yours,

H. H. Helminiak
Personnel Director

HHH/hh

REC[illegible]D

AM PM
7,8,9,10,11,12,1,2,3,4,5,6

HOSPITAL SISTERS OF THE THIRD ORDER OF ST. FRANCIS

ST. PAUL-RAMSEY HOSPITAL
ST. PAUL, MINNESOTA 55101

Western Wisconsisn Technical Institute
6th and Vine Streets
La Crosse, Wisconsin 54601

Attention: William G. Welch
Supv. of Trade and Industry

Dear Mr. Welch:

Thank you for your interest in filling a much needed gap in our medical electronics field. As you probably know, equipment received from manufactures very often have to be revised or modified to meet the needs of individual doctors. A person trained to be sensitive to the special needs of doctors and capable of adapting equipment to meet those needs and maintaining the original safety features at the same time can be an invaluable addition to any hospital or clinic facility.

I find, after looking over your curriculum, that a decided lack of time is spent on electronics. After multiplying the number of quarters by 20% only slightly over 3-1/2 months deals with the problems of electronics. This is grossly inadequate for a person expected to trouble-shoot and repair much less adapt and modify medical electronic equipment.

All is not lost, however, the rest of the course is well planned and very worthwhile. It would be my recommendation to establish no less than a two-year (12 quarter) course in electronics and mathematics to precede a one year additional course in associated subjects such as you have outlined.

Please accept this letter as constructive criticism.

I am desirous to hear of the outcome of your survey.

Yours truly,

Earl Sullwold

Earl Sullwold
Electronics Engineer

ES:JM

PS: Our Executive Director and Administrator is Mr. Otto M. Janke sho succeeded Dr. Thomas E. Broadie.

SMH ST. MARY'S HOSPITAL 720 SOUTH BROOKS STREET • MADISON, WISCONSIN 53715

D. M. CONNORS M.D.
B. J. BAUMAN M.D.
J. M. ANGEVINE M.D.

Laboratory Department

November 4, 1969

William G. Welch
Western Wisconsin Technical Institute
Sixth Street, Vine to Pine
La Crosse, Wisconsin 54601

Dear Mr. Welch:

I am enclosing a copy of an article, Would Your Lab Pass Inspection?, written by Dennis Dorsey who has been active in the College of American Pathologists Commission on Laboratory Inspection and Creditation. You might be particularly interested in the comments made on page fifteen relating to the internal quality control program, especially the requirements of instrumentation and preventive maintenance programs in medical laboratories.

I don't know how much documentation of need for biomedical electronic technologists you will require. Those of us working in the field are only too aware of our own requirements for people with the type of training you are proposing. I am sure you are aware of the fact that in the past we have managed to get by rather poorly using medical technologists, various kinds of specialists, the on-call service from the various supply houses and so on, but this is not going to meet the needs much longer. Most of our medical technologists are girls. They have serious problems with mechanical aspects of some of these pieces of equipment. There is no point in having a PhD chemist spend all of his time working with an apparatus as a technician. We definitely feel the need is there. The question is, how we are going to meet it and it seems to me that your specially trained biomedical electronic technician is just what we are looking for. The proposed program that you submitted at the meeting Thursday looks very good. I think there is going to be a problem of giving practical experience to those who are going to go into technical laboratory work. This very likely will not be as important to those technicians who are planning to work in industry but there is a special slant in medical laboratory work which has to do with such things as medical ethics, the responsibility of working with sick patients and the need to have the services constantly available, all of which, I think, present a special aspect which would require practical experience and supervised experience in medical laboratories. This, of course, is going to be somewhat of a problem to be worked out but I am sure it can be.

Finally, I think this program should be classified in an urgent category.

We need these people now. In three or four years our requirements will be really desperate. I think whatever we can do to speed up the program will be worthwhile.

I am very anxious to cooperate with you in any way that I can. I am sure that the pathologists and other people working in medical laboratories are just as anxious as I am to see that your program and perhaps others in the state get going as soon as possible.

Sincerely,

D.M.Connors

D.M.CONNORS, M.D.
Director
Laboratory Department

DMC:lr
encl.two.

TECHNICAL EDUCATION RESEARCH CENTER
142 MT. AUBURN STREET, CAMBRIDGE, MASSACHUSETTS 02138
AREA CODE 617 547-0430

August 7, 1969

Mr. William G. Welch
Supervisor of Trade and Industry
Western Wisconsin Technical Institute
Sixth and Vine Streets
La Crosse, Wisconsin 54601

Dear Mr. Welch:

I have received your form letter of July 15th and am replying to it in as much detail as time permits.

As you may be aware, our organization has conducted a manpower study on the need for bio-medical equipment technicians. A copy of this report is enclosed.

We have currently been engaged in developing and evaluating curricula for training such technicians. Programs are in existence at the Springfield Technical Community College in Springfield, Mass. and the James Connally Technical Institute in Waco, Texas. In addition, we have been in contact with approximately a dozen other institutions who also conduct programs in this field.

You might be interested to know that no one from the first graduating class (June 1969) from Springfield Technical Community College is employed by a hospital. Approximately half of the class is employed by the bio-medical equipment industry. The rest have eigher gone on to further their education, with the military, or are employed in a different field. In addition, we have had some difficulty in obtaining cooperation from hospitals for purposes of internship.

The reason is very simple: very few hospitals are equipped to supervise such technicians, much less supervise their training. We have felt that, ultimately, the greatest demand will be in hospitals, despite the fact that our survey indicated that only ten per cent of the projected need would be met by this employer.

In addition to the research report, I have enclosed a draft copy of some thoughts regarding job descriptions and performance objectives of such technicians. This was developed in conjunction with a conference we held between a number of institutions training such students (including the Army school in Denver and the Air Force school in Wichita Falls, Texas), employers and professionals in the field. I suspect that you may find the divergent interests rather interesting.

We are currently preparing a report to be published approximately in December of this year, which will contain much information relating to the establishment of such a program to the obtaining of curricular materials and the training of teachers. I will make sure that you receive this report.

In the meantime, should you wish to find out more details, please feel free to call either myself or Dr. John Cadle, our Project Director.

Sincerely,

J. E. Abele

John E. Abele

JEA/dac

Enclosures: BMET Research Report
Job Descriptions and Performance Objectives

cc: BMET Staff

TECHNICAL EDUCATION RESEARCH CENTER
142 MT. AUBURN STREET, CAMBRIDGE, MASSACHUSETTS 02138
AREA CODE 617 547-0430

January 26, 1970

Mr. William G. Welch
Supervisor of Trades and Industry
Western Wisconsin Technical Institute
6th and Vine Streets
La Crosse, Wisconsin 54601

Dear Mr. Welch:

Thank you very much for your preliminary report. I will be happy to review it at my earliest convenience.

Enclosed you will find the draft proposal for certification of biomedical electronic technicians. If, after reviewing it, you have any suggestions, recommendations, or remarks, please forward them to me.

We at Technical Education Research Center are presently in the process of finalizing the Phase II Report for BMET research. As soon as it is complete you will receive a copy.

Sincerely yours,

Dean DeMarre

Dean A. DeMarre, Sc.D.
Senior Biomedical Engineer

DAD/cpk
Encl.

A Non-Profit Corporation

The State of Wisconsin

STATE BOARD
OF
VOCATIONAL, TECHNICAL AND ADULT EDUCATION
ROOM 720, 1 WEST WILSON STREET
MADISON 53702

C. L. GREIBER
DIRECTOR

April 6, 1967

Mr. Charles G. Richardson, Director
School of Vocational, Technical
and Adult Education
LaCrosse, Wisconsin 54601

Subject: Program Considerations

Dear Mr. Richardson:

Following the visit to your school by representatives from our office, the staff has met and considered all of the matters which were presented to us by you in several letters which concerned the development of programs in your school. In the following material I am addressing myself to each of the separate areas in your school.

A. Agri-Business

In light of the discussions with staff representatives, your request for designation in this area will be reviewed for proposal at the next State Board meeting.

B. Health Occupations

In planning your new facility, you may study the following areas:

1. Surgical aide
2. Bio-medical electronics technology
3. Medical laboratory technology

Consideration should be given to the upgrading of equipment in the present health occupation areas as soon as possible. These matters have been discussed with you and your staff members by Miss Palen.

Dr. Gunderson is invited to appear at the para-medical advisory committee meeting on April 13 to explain the X-ray technology program. The State Board will take this under consideration with no indication at present that you are to study this area.

Your question relative to a training program for opticianary aides will be studied by the State Staff with no indication at this time for you to proceed with the study in this area.

State of Wisconsin \ BOARD OF VOCATIONAL, TECHNICAL & ADULT EDUCATION

October 13, 1969

Mr. Charles G. Richardson, District Director
Vocational, Technical and Adult Education
District 2
Sixth and Vine Streets
La Crosse, Wisconsin 54601

Dear Mr. Richardson:

This is to acknowledge receipt of your recent Indication of Interest Form requesting consideration of the following program:

Code No.	Program	Type
10-605-6	Bio-Medical Electronics	Associate Degree

After review by the State Director and his staff you will receive notification of the action taken on your program request.

Sincerely,

Jack W. Smythe

Jack W. Smythe, Program Administrator
Division of Educational Development & Special Services

John R Plenke

John R. Plenke, Program Administrator
Division of Occupational Services

rg

RECEIVED
WESTERN WIS. TECH. INSTITUTE
OCT 16 1969
AM PM
7,8,9,10,11,12,1,2,3,4,5,6
A

WISCONSIN BOARD OF VOCATIONAL, TECHNICAL AND ADULT EDUCATION 43
Madison, Wisconsin 53703

Indication of Interest

This form is an indication of interest in the development of a new program and does not replace a program proposal. The information need not be in detail, but should be a brief, realistic appraisal of the program.

District: # 2 **School:** Western Wisconsin Technical Institute

Type of Program: Associate Degree [X] Diploma 1 Year [ ] 2 Year [ ]

Program Title: Bio-Medical Electronics

Program Objectives: To prepare personnel capable of operating, adapting, servicing, and maintaining electronics and instrumentation in the Bio-Medical field.

Reason for Interest: To meet a demonstrated need for this type of semi-professional worker and to expand the educational opportunities in District #2 and the state.

Allied Programs Presently Offered: Electronics Technology, Electrical Power Technology, LPN, Medical Assistants, Operating Room Assistant, and proposed program for Medical Lab Technicians.

Projected Student Enrollment: 24

Core and Related Staff Needs:

Presently Employed 13 Professional staff

Projected 1 in Bio-Medical specialties

Facility Needs:

Present Space for this program is provided for in the new Health-Science

Projected Building

Funds Available for Program Development: The district will provide necessary funds to carry out this program.

Form No. VE-AD 132