DOCUMENT RESUME

ED 118 412 SE 020 226

AUTHOR Edmonson, Glenn V.
TITLE Biomedical Engineering: A Challenge to Educators and the Professions.
PUB DATE Jun 75
NOTE 16p.; Paper presented at the Annual Meeting of the American Society for Engineering Education (Ft. Collins, Colorado, June 16-19, 1975)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage
DESCRIPTORS Biological Sciences; College Science; *Engineering Education; *Graduate Study; Higher Education; Interdisciplinary Approach; *Medicine; *Program Descriptions; Science Education
IDENTIFIERS *Bioengineering; University of Michigan

ABSTRACT

The establishment and development of a graduate program in bioengineering at the University of Michigan is discussed. Included are the student entrance requirements, types of future employment for program graduates, and the philosophy underlying the choice of coursework and instructional methods for the program. (MLH)

Event 1610

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ANNUAL CONFERENCE, JUNE 16-19, 1975

COLORADO STATE UNIVERSITY

FT. COLLINS, COLORADO 80521

BIOMEDICAL ENGINEERING: A CHALLENGE TO EDUCATORS AND THE PROFESSIONS

GLENN V. EDMONSON

DIRECTOR, BIOMEDICAL ENGINEERING TRAINING GRANT

6805 MEDICAL SCIENCE II

THE UNIVERSITY OF MICHIGAN

ANN ARBOR, MICHIGAN 48104

BIOMEDICAL ENGINEERING:

A CHALLENGE TO EDUCATORS AND THE PROFESSIONS

Glenn V. Edmonson

Dr. Potvin's invitation to participate in this ASEE session was rather forceful in that he was determined to assemble those who had been involved in Bioengineering for years. To this I can subscribe, but at the same time will hesitate to acknowledge other implications of the word 'years'. I do appreciate the opportunity you offered me.

At the outset, may I urge you to read the series of papers of very high quality published in the special issue of the IEEE Transactions, Biomedical Engineering, Volume BME-22, No. 2, March, 1975 on the topic "Biomedical Engineering Education and Employment". These papers cover the elements of history, name, need, opportunities, and conclusions very completely. While these papers display differing philosophies, they all point to the increasing need for the engineers in health care. The authors reaches a final common conclusion that opportunities for a satisfying career are becoming more and more widespread.

Because of differing institutional philosophies tempered by constraints, faculty and student interests and objectives, and facilities, operating experiences differ. These experience differences make it possible to have meaningful dialog. Please forgive me for the few provincial references I will make.

In the Fall of 1962, a group of University faculty interested in participating in an engineering science - health science based program petitioned the Horace H. Rackham School of Graduate Studies for a Bioengineering Program. The proposal for a committee administration of the Program was not without precedent and, therefore, avoided the hurdles over which prior proposals had traversed. The name 'Bioengineering' for the Program didn't have any earth shaking implications at that time and there has been no compelling reasons to alter it since first adopted.

The petition included:

1.) A description of a multi-departmental participation in a new educational program.

2.) Provision for the award of the M.S. and Ph.D. degree in Bioengineering by the Graduate School for qualifying students.

3.) Endorsement by the Medical School and the College of Engineering.

The Executive Board of the Graduate School on granting the petition opened the way for a very active program which has continually attracted a very capable group of graduate students who have found deep satisfaction in their choice of career.

Forty (40) students have qualified for the Ph. D. degree in Bioengineering. Of this number, two (2) are fulfilling a commitment to the U.S. Air Force. The remainder have found opportunities in several different environments. Eighteen (18) students have academic appointments; eight (8) are in Research/Hospital assignments; seven (7) are involved in Industrial Research; four (4) are in Research Institutes; and one (1) has continued in Medical School and now is a Resident in Neurology.

The program admits qualified students who present a B.S. or M.S. degrees awarded in engineering or the physical sciences or those who have completed a M.D., D.D.S., or D.V.M. program. The entrance requirements for students presenting a B.S. degree will include approximately 11% of their completed undergraduate academic program in the life sciences. They may be admitted with an academic deficiency if otherwise qualified. The M.S. program in Bioengineering will include approximately 45% academic preparation in Bioengineering specified life science instruction and 55% in engineering science, mathematics and technology by the time the degree program is satisfied. The distributed academic preparation at the Ph. D. degree level varies based upon the student selected thesis area. The cumulative average distribution over the Program history of all students evaluates to approximately 35% in the life and medical sciences, and 65% in engineering sciences, mathematics, and technology.

The development of specifically oriented courses to meet the specific need of a Bioengineering student has been gradual. From the outset, where an academic need could be satisfied by classifying a student in a course any place within the University, appropriate arrangements were made. With few exceptions, Bioengineering students were welcomed. They performed with credit to the Program and further classifications have been welcomed by the faculty. Some course content over-lap has occurred as a student moves from one departmental educational program to another.

From the beginning of the Program, all students have been classified in a special course in quantitative Physiology for Bioengineers. Students consider this course the first milestone in their special training. It was introduced in an accelerated sequence into the Engineering Summer Conference Program in 1964. To date, more than 550 engineers, largely from industry and government, have attended this summer program. The response to this program by the conference group has been continually helpful in furthering the objectives of the course. As specific academic needs of the Program developed which were not met by departmental course offerings, Bioengineering courses have been planned. At this time sixteen courses are specifically identified by the Bioengineering Program and, in several cases are cross-listed with one or more of the departments. Frequently the demand for these courses outstrip the available facilities. These demands seem to develop most often where the course is supported by a well-managed, well-equipped laboratory.

A life science or clinical laboratory research participation, minimally required of all students, is a very important part of their training program. Factually, the requests from the student group for participation opportunities in the laboratories beyond the required minimum is such as to tax faculty imagination and time for supervision. This occurrence is viewed by the Program group with great satisfaction.

This educational experience, which is followed by the student's satisfaction in finding career opportunities, tends to lend credence to our belief that these training efforts are not contributing to group of unwanted, poorly understood hybrid engineers. Instead, they are a relatively new group who have taken advantage of an new educational opportunity with the result that the profession of engineering has yet another dimension in its catalog of disciplines. They are trained as engineers with an additional science base upon which to draw. Their acceptance as a professional group is occurring because of the contributions they are making to health care.

A long time, respected friend will state flatly that Civil Engineering is really the only true professional engineering group. In his view, for the purpose of debate, all other named disciplines are satellites. His argument is very effective and persuasive. For our purposes it is not important whether this view is accepted. It is important, however, to realize that professional groups become identified because participants find a meaningful career based upon their in-depth understanding of applicable sciences, mathematic, and applicable technology as they may contribute to the solution of a class of unsolved problems.

My first office at the University had been occupied by an authority on hydraulic turbine design, a Civil Engineer, a competence now sought in the Mechanical Engineering group. I found a brochure in the archives, printed in 1907 by what is now the Consumers Power Company, describing a water-powered 50KW dynamo installed on the Huron River near Chelsea, Michigan. I relate this incident, not to point out that a Civil Engineer did design and put into operation an electric generating station but, instead, to draw your attention to a mode of emergence and identification experienced by many professional groups, engineers and physicians alike. The identification and acknowledged potential for the engineer in the field of health care is occurring in much the same manner.

While the recognized need for training in Bioengineering is very broad, the ability of any one program to respond is a function of other organized departmental facilities available to it. At this time, many activities in which an engineering student could and should become involved requires authorizations, approvals, and responsibilities to which a given department with its facility may not respond or accept. A clinical research investigation falls within these constraints.

From our vantage point, the clinic introduces some of the most challenging and rewarding research opportunities in the total spectrum of the Program. There can be many long hours of discussion of this facet of research. It will suffice to indicate that clinical research investigations are always concerned with a controlled dynamic system, some portion of which is out of control as a result of abnormalities of some sub-set of parameter values. Simultaneous dynamic measurement of variables is a prerequisite to such work. A struggle for better, more responsive instrumentation is always intense. The need to extract more and more information from the dynamic signal is always present.

The research investigating team in the clinical laboratory generally performs in a multiple task environment. The principal investigator and the responsible attending physician form the decision making group within the task force. Enrollees in the Bioengineering Program who may be terminal at the M.S. degree level, some of those students training at the predoctoral level, and training physicians and technicians frequently round-out the task force. Members of the team gain experience that will enhance their productivity regardless of their educational goals. Predoctoral candidates gain knowledge that assist them in defining a research investigation which they will conduct.

The task of providing guidance for a bioengineering student working in this clinical environment is exacting. It is easy to accept a trivial question and pursue an investigation which is trivial at its conclusion. It is not difficult to become involved in an investigation in which the principal thrust is that of statistically extracting new significant information from a data base and the results can be very useful for the purpose of health care. These efforts may or may not reflect uniqueness of an engineering approach. On the other hand, if attention is focused upon the individual patient, the state of a controlled system is the critical question.

The engineering approach to this problem strains the upper bounds of our control technology, our engineering sciences, and mathematics. The resulting values from computation are useless until related to the time-dependent state of health of the patient. This relational requirement necessitates a thorough background in medical science on the part of the student and collaboration of the physician to bring the results to usefulness.

These are difficult, however rewarding engineering tasks of which there are many, yet unsolved.

As indicated, several students who were awarded the Ph. D. degree have accepted Research/Hospital opportunities. The methods of research which has been evolved in their clinical association in the Program seems to have carried across as they moved into professional participation. As engineering directors of clinical research, the spectrum of talent with which they worked in the Program clinic and the experience they gained as predoctoral candidates appears to be guiding their present efforts.

Bioengineering training programs are expensive. Throughout our experience history a continuing, time-consuming effort has been expended to meet the financial needs of Program. Agencies of the Federal government have been and continue to be the principal source of funds. These agencies are governed by policies without which they would find survival very difficult. At the same time, some of their procedure, implemented to satisfy policy, leads to frustration. A proposal for work about which an agency sub-group is familiar and the review committees conversant with the state-of-the-art represented by the proposal, finds a home and is considered with dispatch. On the other hand, with somewhat less than a sense of responsibility as far as the proposer is concerned, a proposal for quantitative work about which an agency sub-group is unfamiliar, and therefore indecisive, is frequently reviewed by a group (supposed peer groups), a portion of which are seemingly threatened. Others of the group appear to be qualitatively experienced and professionally competent but who are unsure of the quantitative aspects of the proposal and therefore lack confidence. The latter group, in time, will accept a new concept. The former group dampens the ardor for a revelation of advanced thinking. It is perhaps of some comfort to realize that this dilemma is not new.

A frustrated acquaintance, a well qualified, analytical research worker whose experiences with NIH have left something to be desired recently called to my attention a passage from Theodore Von Karman's book 'The Wind and Beyond'. I decided to read it to you, if for no other reason, than to re-focus upon the task at hand.

Dr. Von Karman is discussing Issac Newton:

"He led the way for generations of scientists to believe in, and seek to understand, the laws that dominate the destiny of the Universe. This, of course, was always a great stimulus to me, but I also relished the little-known fact that Newton could take time from his august theoretical researches to design the bridge over the River Cam behind St. John's, Cambridge."

He continues: "The atmosphere for research has changed so radically since Newton's day, with the emphasis on organized collective government-financed research, that I was delighted to read in the American Scientist[o] a description of what might have happened to Newton had he lived in a version of the present aerospace age and submitted to the King his idea for the study of the falling apple.

The author of this charming satire goes on to say:

After Newton was sworn to tell the truth and had denied that he was a member of His Majesty's Loyal Opposition, had never written any lewd books, had traveled in Russia, or had seduced any milkmaids, he was asked to outline his proposal. In a beautifully simple and crystal clear ten minute speech, delivered extemporaneously, Newton explained Kepler's laws and his own hypothesis, suggested by the chance sight of an apple's fall. At this point one of the committee members, an imposing fellow, a dynamic man of action, demanded to know if Newton had a means of improving the breed of apples grown in England. Newton began to explain that the apple was not an essential part of his hypothesis, but he was interrupted by a number of committee members, all speaking at once in favor of a project to improve applies. This discussion continued for several weeks, while Newton sat in characteristic dignity waiting until the committee wished to consult him. One day he arrived a few minutes late and found the door locked. He knocked circumspectly, not wishing to disturb the committee's deliberations. The door was opened by a guard who told him there was no more room and sent him away. Newton, with his logical way of reasoning, deduced that the committee did not wish to consult him further, and forthwith he returned to his college and his important committee work.

Several months later Newton was surprised to receive a bulky package. He opened the package and found it contained a variety of governmental forms, each in quintuplicate. His natural curiosity, the main attribute of the true scientist, provoked him into a careful study of the forms. After some time he concluded that he was being invited to submit a bid for a contract for a research project on the relationship between breed, quality, and rate of fall of applies. The ultimate purpose of the project, he read, was to develop an apple that not only tasted good but also fell so gently that it was not bruised by striking the ground. Now, of course, this was not what Newton had in mind when he had written his letter to the King. But he was a practical man and he realized that in carrying out the proposed project he could very well test his hypothesis as a sort of sideline or byproduct. Thus he could promote the interests of the King and do his little bit in the bargain."

It would be a little bit too bad in our enlightened era to find it necessary to continue important work in a manner depicted by this satire. May I recommend that all of you give serious thought to the processes now in force.

I would like to conclude by pointing out that professional careers being carved by students who have passed through training programs provide a better basis for evaluating the contribution made by the Bioengineer than all of the planning documents that could be generated. It is beginning to be possible to use this kind of information to form the descriptions and definitions which formerly eluded us.