PART II: CROSS-DISCIPLINARY AND CROSS-INSTITUTIONAL RELATIONSHIPS IN ENGINEERING EDUCATION

BIOTECHNOLOGY EDUCATION IN THE FIELD OF ENGINEERING

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INTRODUCTION

First of all, I would like to explain about biotechnology-related research being undertaken at the University of Tokyo. At the Faculty of Engineering artificial organs, otherwise known as medical mechanics, and medical electronics have been studied with the cooperation of the Faculty of Medical Science. In the chemistry field, researchers have begun to study biomimetic chemistry, and investigations are also underway on biosensors and biotips. In the Department of Chemical Engineering, bioreactors have been studied, with the cooperation of the Faculty of Agriculture.

Recently, the field of biotechnology has entered a new phase, because of the unknown future possibilities associated with the development of molecular biology and with the establishment of gene engineering and cell engineering technologies. Therefore, departments relating to applied chemistry have to deal with the new research directions. As you well know, industry has recognized the need to obtain these new technologies. Due to these circumstances, biotechnology courses are now being taught in the Faculty of Engineering. Although molecular biology and its typical techniques of genetic engineering were first studied or taught in the faculties of science, agriculture, medicine and pharmacology ten years ago at the University of Tokyo; these sub-fields were included in the Faculty of Engineering curriculum.

Other Japanese universities were in the same situation as Tokyo University; however, at Osaka and Hiroshima Universities there was no Department of Agriculture, so the Department of Fermentation Engineering was included in the Faculty of Engineering. For this reason, gene engineering and cell engineering technologies were introduced there into the engineering curriculum much earlier than at other universities. Thus, we can say that Osaka University and Hiroshima University are more advanced in the engineering field than other universities. Major universities, including the University of Tokyo, have just started to include new biotechnology courses in the Faculty of Engineering. Under these circumstances, I was recruited as a chemist and molecular biologist from the National Institute of Genetics to the Faculty of Engineering at the University of Tokyo four years ago. In the Department of Chemical Engineering recently, some researchers have changed their major research emphasis to the fields of gene and cell engineering. In my opinion, there is a need for more people and better equipment in this field. Further, the Tokyo Institute of Technology and the Tokyo University of Agriculture and Engineering seem to be planning to establish new Faculties of Biotechnology.

As I mentioned before, the new biotechnology has many faces. Since the development of gene and cell engineering has made rapid changes in biotechnology, some use the term biotechnology only in reference to the field of gene and cell engineering. It is quite impossible to cover everything about biotechnology here, so that I would like to deal with it in a narrow sense.

HISTORY OF BIOTECHNOLOGY

In order to comprehensively discuss biotechnology education, it is necessary to understand how the field of biotechnology has developed so rapidly in recent years. So, I shall describe briefly the history and progress of biotechnology in Japan. Historically, biotechnological research has been deeply involved with "fermentation." Brewing especially has a long history, probably beginning with the history of the human race, since many items such as liquors, foods, fuels and drugs are produced by using certain bacteria and fungi. The improvement of methods of producing these products has been an important objective of modern chemical engineering.

In the brewery and pharmaceutical industries, actual techniques have been improved. In Japan, liquor, vinegar, miso and shoh-yu (soy sauce) traditionally have been produced in breweries. In modern times, Ajinomotoglutamic acid was discovered; and, during the 1950s inosinic acid (which tastes like fish) and guanylic acid (which tastes like mushrooms), were found and produced by using the fermentation method. In addition, many types of antibiotics have been discovered, produced not only by chemical synthesis but also by fermentation techniques. Biotechnology related to fermentation and the pharmaceutical and food industries has proceeded independently in Japan. On the other hand, the U.S. as well as European countries, have made progress in the production of dairy and alcoholic beverages, and, of course, in the production of such things as antibiotics and so-called fine chemicals. Fermentation methods have also been employed actively in these fields.

In fermentation, microbes are used to produce unique enzymes which change materials. For example, starch is decomposed to sugar, and then to alcohol by a series of enzymes in microbes. Thus, it was difficult to locate microbes which produce useful enzymes, and to create such microbes. Microbial genetics were suited to this purpose, but years ago knowledge of this field lay with the Americans. At the request of the Japanese government, soon after World War II, Professor Francis Ryan of Columbia University under the aegis of the Fulbright scientists' exchange program was the first to come to the University of Tokyo Institute of Applied Microbiology to lecture on microbial genetics. Before and after that, many young Japanese biologists visited the U.S. to learn about microbial genetics.

The early stages of biotechnology were based on the study of microbial genetics. Dating from 1950, the revolutionary progress in genetics began to be achieved. A major discovery in genetics was in understanding the gene substance deoxyribo-nucleic acid; namely DNA. With this breakthrough, scientists began to make great advances, as the study of heredity now could be conducted at the molecular level. This breakthrough represented the birth of molecular genetics, more generally known as molecular biology.

The molecular structure of DNA, which began to be understood in the 1960s, was shown to be a linear, unbranched nucleotides polymer. Each nucleotide consists of a sugar deoxyribose, a phosphate and a nitrogeneous base. DNA is made up of a backbone associated with deoxyribose sugars and phosphate, and four different kinds of nitrogeneous bases attached to the backbone in a certain order. Genes in every organism have their own unique configurations. Information on genes actually provides information about creating certain proteins. The configuration of the nitrogeneous bases decides the arrangement of amino acids and synthesizes protein. So, the expression of gene information is used to achieve the synthesis of protein.

Since the DNA molecule is made up of thousands of units of nucleotides, the whole structure of DNA could not be determined by methods which are used for other ordinal polymers. However, the base arrangement in DNA has been clarified by using chemical methods and enzymes, and it is now understood how protein information is engraved on a long DNA molecule. In addition, a short chain of DNA has been made available by chemical synthesis. In 1970, restriction enzymes were found, and now we can manipulate these long DNA molecules. We can cut DNA at certain specified points to make small segments, and it is also possible to join these DNA segments together with enzymes. These techniques, which recombine parts of the DNA molecule, are called "gene manipulation" or "gene engineering," and were more or less established by the end of the 1970s. These techniques have inspired new developments; not only for studies on hereditary phenomena; but also for studies on life mechanisms of organisms which are regulated by genes. These new techniques have led also to new possibilities in medicine and the production of new materials. These days, the word "biotechnology" is often defined in a narrow sense as "the technique that uses gene engineering," therefore, the impact of gene engineering on science and technology has been enormous.

The increasing number of articles on molecular biology and biotechnology in general scientific magazines such as Nature or Science indicate the increasing popularity of these fields in the United States and that the U.S. has a great advantage world-wide in molecular biology and biotechnology. The unique research of European and Japanese scientists has made a great contribution to the field, but probably the greatest contribution has been made by the U.S.

EDUCATION OF BIOLOGY IN BIOTECHNOLOGY

When you see the development process of gene engineering, you will notice how important chemistry and physics have been in the creation of these new fields. Furthermore, this technique fully utilizes the cellular function of an organism. We should recognize this point when we begin to educate others in biotechnology.

It should be required that engineering students study fundamental physics, chemistry and biology in order to create new techniques; but at this point, the problem is how to integrate biology courses into the Faculty of Engineering. I believe that molecular biology, cell biology, microbiology, biochemistry, physiology and such courses must be offered within the Faculty of Engineering, and should not be simply an enumeration of facts. Of course, retaining facts is important, but problem-solving skills are also crucial in the emerging field of biotechnology.

CURRICULUM OF BIOTECHNOLOGY COURSES

I have explained about the principle of biotechnology education in the field of engineering, and now I would like to give some examples. In the U.S., two famous colleges of engineering, the Massachusetts Institute of Technology (MIT) and the California Institute of Technology (Cal. Tech.) have fine departments of biology, and are actually pioneers of modern biology. At Cal. Tech., the activity of one group, that of Dr. Delbruck, a physicist and promoter of the development of molecular biology, has attracted notice. I was impressed, upon visiting the laboratory, to discover that it was named "Laboratory of Chemical Biology".

During the period when the field of biotechnology emerged out of molecular biology, MIT has been a center of these studies. The Department of Biology in MIT includes a great staff, such as Dr. Luria, who is a physicist and received the Nobel prize with Dr. Delbruck; Dr. Khorana, who was the first man to achieve success in synthesizing DNA chemically and Dr. Baltimore, one of those who discovered the reverse transcription enzyme. These latter two scholars are also Nobel prize winners.

I would really like to understand the interaction between the engineering and biology groups at these institutes. Colleges of Engineering in Japan have not yet accepted many biology faculty members; nevertheless, this movement has started very recently. For instance, the Tokyo Institute of Technology is presenting a new plan to the Japanese government to establish a Faculty of Biotechnology. As mentioned, only the Faculties of Engineering in Osaka and Hiroshima Universities, which do not have Departments of Agriculture, have regular biotechnology courses. Other Japanese universities are just beginning to integrate biotechnology courses into the curriculum.

CURRICULUM OF DEPARTMENT OF FERMENTATION TECHNOLOGY, HIROSHIMA UNIVERSITY

1. Experiments in Analytical Chemistry
2. Experiments in Physical Chemistry
3. Experiments in Organic Chemistry
4. Fermentation Technology
5. Organic Chemistry
6. Physical Chemistry
7. Analytical Chemistry
8. Biological Chemistry
9. Biophysical Chemistry
10. Industrial Microbiology
11. Microbial Genetics
12. Enzymology
13. Fermentation Physiology
14. Chemical Engineering
15. Chemical Reaction Engineering
16. Biochemical Engineering
17. Fermentation Process Design
18. Cultivation of Microorganisms
19. Assignment in Biochemical Engineering
20. Technology of Sterilization
21. Technology of Food Preservation
22. Technology of Brewing
23. Enzyme Engineering
24. Industrial Waste Water Treatment
25. Inorganic Chemistry
26. Introduction to Mechanical Engineering
27. Introduction to Strength of Materials and Mechanical Design
28. General Electrical Engineering
29. Numerical Analysis
30. Polymer Chemistry
31. Quantum Chemistry
32. Theory of Quality Control
33. Special Lecture on Fermentation Technology

CURRICULUM OF DEPARTMENT OF APPLIED CHEMISTRY, UNIVERSITY OF TOKYO

1. Experiments in Analytical Chemistry
2. Experiments in Physical Chemistry
3. Experiments in Organic Chemistry
4. Experiments in Chemical Engineering
5. Organic Chemistry
6. Polymer Chemistry
7. Quantum Chemistry
8. Chemical Reaction
9. Inorganic Chemistry
10. Analytical Chemistry
11. Technology of Heat and Energy
12. Industrial Inorganic Chemistry
13. Industrial Organic Chemistry
14. Thermodynamics
15. Solid Structure
16. Molecular Biotechnology
17. Structural Analysis
18. Energetics
19. Chemical Industry
20. Functional Organic Materials
21. Biochemistry
22. Industrial Catalyst Chemistry
23. Chemical Engineering
24. Theoretical Organic Chemistry
25. Polymer Material
26. Metal Material
27. Chemical Bond
28. Numerical Analysis
29. General Electrical Engineering
30. Special Lecture on Applied Chemistry

REMARKS ON CROSS-DISCIPLINARY AND CROSS-INSTITUTIONAL RELATIONSHIPS IN ENGINEERING EDUCATION

F. Karl Willenbrock
American Society for Engineering Education

Engineering practice is increasingly cross-disciplinary. For example: advanced materials requires an understanding of chemistry, mechanical engineering, surface physics, manufacturing process and other skills; computer technology requires hardware and software capabilities and a wide variety of manufacturing process skills; biotechnology requires molecular biology, biochemical processing, and other skills.

In both the teaching and research components of engineering education, therefore, there are needs for strong cross-disciplinary and cross-institutional ties. These rapidly changing technologies in fields such as computers and communication, biotechnology, and materials typically draw on many of the disciplinary fields of engineering and science. The expertise in these disciplines may reside in other departments in the same academic organization but there are many cases in which the expertise resides in other academic or industrial organizations. Thus the thrust for stronger cross-disciplinary and cross-institutional ties frequently comes from the grass-roots and may not come from a top-down policy.

A result of the bottom-up nature of the thrust is that there are many mechanisms and modes for such linkages. The collegial ties between leading researchers in the various U.S. and overseas universities have been long-standing. These ties are strengthened by the faculty exchanges during sabbatical leaves, by the exchange of students, and by the appointment of junior faculty members from the Ph.D. recipients of other universities. The ties to industrial companies can be started via the faculty member acting as a consultant to the company or an industrial engineer spending a "sabbatical" leave at a university; most frequently the tie comes from the company's hiring of recent doctoral or advanced degree recipients.

Traditional disciplinary-structured engineering schools are not well-matched to such technological fields. Both students and faculty are more oriented to the traditional disciplines. Although the traditional fields have shifted their emphases as technological developments have been made, they have not usually covered the breadth which many fields of technology now require.

There are, however, many advantages in disciplinary orientations in universities since the faculty appointment procedures and curricular developments are run efficiently and effectively. There are well-developed and well-understood procedures; disciplinary progress has been very rapid in many fields.

It is undesirable for engineering education and research to be disconnected from advancing technology and the associated engineering practice. In most cases, engineering research is applications-driven, although some engineering research may precede engineering practice by many years.

Both governmental and private funding organizations can encourage the development of cross-disciplinary programs in universities. Many universities have developed regional research activities involving the participation of economists, historians, political scientists, and sociologists. A few examples in U.S. universities are in Russian research centers and the Far East research centers. In engineering, both governmental and industrial policies have effectively encouraged development of cross-disciplinary technology centers.

A prime example of a governmental program directed toward this objective is NSF's Engineering Research Centers. The enthusiastic response of both universities and industrial companies to this program demonstrates its importance and relevance to current technological developments. For the university to receive federal agency funding under these programs, it must demonstrate active industrial participation in the proposed research effort. While the industrial participation may involve financial support from the industry, other forms of participation such as industrial personnel on campus or the use of industrial facilities and equipment are also desirable. Support involving all of the above would be in most cases preferable.

A key example of the ability of an industrial company to encourage change in academic research and instruction programs is the IBM program in manufacturing technology. Universities have enthusiastically used the program to update their academic offerings.

While problems do arise because of the inherently different objectives of public, not-for-profit, and for-profit private organizations, such problems are resolvable if there is a strong enough commitment on the parts of the top-management of the organizations involved. The benefit to all the participants can outweigh the costs if the effect of the linkage is to increase the quality, up-to-date, and relevancy of the academic research program. Since academic research programs can be closely coupled to the instructional program, the benefits can reach both graduate and undergraduate students. Since the rate of technological advance is highly dependent on the influx on a continuing basis of new bright, well-educated, and highly motivated men and women to the work force, the effect on the national economy can be very positive.

Industrial-academic linkages are particularly important in fields where the major research advances occur in industrial laboratories. In the U.S., computer and communication technologists have advanced primarily in industrial laboratories. Here linkages are essential to keep universities at the state-of-the-art.

The inverse problem is less severe since graduate students completing their degrees and accepting industrial employment provide an efficient and effective means of transferring technology. Also the modalities of academic institutions encourage a full exchange of information. While some companies encourage technical information dissemination, they protect proprietary information important to their competitive position.

Although problems arise with respect to handling potentially proprietary information which is developed at an academic institution, it has proved possible to work out mutually satisfactory procedures in a variety of fields and among a variety of companies and universities. Both parties must be convinced of the desirability of joint operations in order to work out the procedural problems.

The overall effect of close cross-disciplinary, inter-institutional ties has proved to be beneficial for both academia and academic organizations.

LIFE LONG LEARNING: INDUSTRY/ACADEMIA ROLES IN U.S. ENGINEERING EDUCATION

Terry L. Gildea
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U.S. ENGINEERING EDUCATION SYSTEM

Educational responsibilities are shared in the U.S., since our system of higher education, including colleges and universities, consists of a mixture of private and public institutions. There seems to be no general rule about size or quality being the province of either public or private institutions. In the San Francisco Bay Area, Stanford University stands in the front rank of the nation's private universities, while not fifty miles away, the University of California at Berkeley is a prime exemplar of a publicly supported university of equal quality and stature.

Much of the university research and graduate education in technical subjects is supported by means of research grants funded by federal government agencies. Both private and publicly supported state schools receive significant support via these federal grants.

The question of public and private roles in engineering research and education is exceedingly complex. We have no central government Ministry of Education as many other countries do; moreover, state-federal issues also must be considered. Further, hundreds of local community college districts play a significant role in supplying early undergraduate education. There are some significant differences between the way U.S. universities are supported and support mechanisms commonly found in other parts of the world. Much of the financial support for U.S. universities comes from voluntary contributions, in short, from philanthropy. These gifts come from wealthy private individuals, from alumni who typically are ordinary middle class people from industrial corporations, and from that uniquely American institution, the private foundation. What is most interesting about the range of private support is that by and large it is pure philanthropy (possibly though with tax deductions in mind). It involves no policy direction, (with the possible exception of football policy!) Even colleges and universities which are state-supported receive considerable monies from these private sources.

Never having lived in Japan, I am really not qualified to discuss the relative roles of universities and companies in the U.S. and Japan as regards education of the engineering work force. After limited conversations with Japanese managers over the years, I am of the opinion that in Japan the companies take a greater share of the responsibility for engineering education than is the case in the U.S.

Our major engineering colleges are heavily research-oriented. This is a direct outgrowth of the original historical roles of industry and academia, namely, that new knowledge would be discovered on campus and applied in the factory. This research orientation of our engineering faculties is one of the great strengths of the U.S. system. It produces faculty uniquely positioned, as a result of interest and skill to impart basic theoretical skills to young engineering students.

In the U.S. we have evolved a fairly clear division of responsibilities by which industry and academia share the education of engineers. The engineering schools accept the job of supplying basic science and theoretical engineering studies. Industry supplies the all-important practical side: how to produce what the market demands in a cost-effective manner. This division capitalizes on the strengths of each sector, and it has many positive points, but it also carries some liabilities.

U.S. INDUSTRY ENGINEERING EDUCATION

Industry is organized and managed to achieve concrete results i.e., products and, ultimately, profits. There has been a good deal of discussion in recent years about the advantages and disadvantages of the long-term planning horizon which characterizes Japanese management and the short-term horizon used by U.S. managers. Whatever the merits of the two positions (or the truth of the characterizations), U.S. industry wants its engineers to produce low cost, high quality, high profit products, over the very short term. This means that the training provided by industry is heavily oriented towards production, and concentrates on applications.

There are some exceptions to the general rule. Some of our major engineering schools, such as MIT, operate a significant number of cooperative programs where students alternate time on campus with periods of work at an industrial sponsor's plant. This mixing of theoretical study at the university campus with practical studies at an industrial work site is very beneficial, as many of the students who drop out of undergraduate engineering programs do so because they can see no application for the theory they are studying. In much the same way a good deal of the on-the-job training by industry is ineffective because it is not accompanied by a strong theoretical foundation.

What strategies do U.S. companies follow in training their engineering work force? I would not pretend to represent all U.S. industry, but I do know something about how Hewlett-Packard practices, and I am familiar with a few other representative companies. Based upon the situation at these companies, I would conjecture that our practices are not terribly different from the norm in large technology-oriented U.S. companies.

HEWLETT-PACKARD PRINCIPLES

At Hewlett-Packard we prefer the term "life long learning" to either training or education. That phrase recognizes that the process is a continuous one and that it extends throughout one's career, and it also emphasizes the fact that a great deal of education takes place outside the formal classroom setting. Job assignments, colleagues, professional meetings, and personal hobbies all contribute to life long learning.

We strive hard to create a culture and an organizational environment in which education and learning is expected as a normal, every day part of the job, starting with our practice of evaluating managers on their effectiveness in developing their employees. This item is an important part of a manager's annual performance review, and the result is a workplace where managers are as interested in what engineers are thinking about as they are in project completion schedules. The famous MBWA which received wide renown with the publication of Peter's and Waterman's "In Search of Excellence" is part of this practice. The content of these informal chats often center on new intellectual ideas and quite often on additional training and skills or knowledge required to bring the ideas to fruition.

The engineer's annual performance review contains a section in which the manager and the employee jointly plan additional development activities and quite often additional training and skills or the knowledge required to bring the ideas to fruition. These activities may be job assignments, design projects, external university classes or course work given within the company. In addition, the annual performance review often contains a discussion of possible future assignments for the engineer, perhaps as the result of professional interest on the part of the engineering employee suggestions originating from the manager.

HEWLETT-PACKARD EXPERIENCE

Within the context of these general principles, we at Hewlett-Packard have developed a wide range of programs in the general area of continuing engineering education. These have had a significant impact on our own engineering success, and I suspect that they have also had an impact on the programs and curricula of our friends in academia.

More than 20 years ago we developed what at that time was an innovative program with Stanford University which allowed Hewlett-Packard engineers to register at Stanford as regular part-time students taking classes with full-time students while at the same time remaining full-time employees of the company. The program was made possible by the geographic proximity of Hewlett-Packard engineering labs and Stanford classrooms, (in fact, company facilities are located on Stanford land immediately adjacent to the educational buildings.) It was also made possible by innovative leadership on the part of Hewlett-Packard management and the Stanford administration. Hewlett Packard's engineers simply left their labs, biked or walked to the university, and sat in the classroom. After class they returned to their industrial jobs. That doesn't sound like much today, but when first proposed it was revolutionary, and it met with some opposition from both sides.

Several years later the program was expanded when the university agreed to use television to broadcast the classroom lectures, enabling employees to attend class without the loss of time associated with commuting to and from the campus. This program was driven by Hewlett-Packard's expansion and the opening of several new facilities located too far from Stanford for effective commuting.

Later still, the concept of Tutored Video Instruction was implemented. This allowed students too remote from campus to be within the television signal range necessary, to participate in graduate level education. Since these student-employees had diminished opportunities for faculty contact, the company provided tutors from its own ranks upon approval of the faculty. The research on this teaching method has been duplicated several times, always with the same results; industrial students learn from tutored video as well as, or better than, students using traditional on- campus methods.

More recently, we have begun similar programs of televised instruction with Chico State in the area of computer science. Other significant programs are conducted with Colorado State, and on a smaller scale, with most local universities in areas where the company has facilities.

Hewlett-Packard was an early and enthusiastic supporter of the National Technological University. This consortium of about 30 engineering schools uses satellite broadcast technology to make it possible for engineers anywhere in the United States to earn a master's degree in electrical engineering, mechanical engineering, computer science, or engineering management right at their own work site. As long as the students meet the curriculum requirements, i.e., take courses necessary to meet the breadth and depth requirement, they are permitted to take these courses from any of the participating universities.

In addition to utilizing the course material prepared by faculty in the nation's graduate engineering colleges, we offer a wide range of educational opportunities from other sources. We have installed what we believe is the world's largest television network -- in the U.S. alone we have over 80 receiving sites. Educational programming occupies the lion's share of the broadcast day; in fact, we broadcast over 100 hours per week of educational material. The range of subject matter is impressive: simple software applications on personal computers, e.g., spreadsheet, word processing, graphics, and database applications; management training, interpersonal skill development, quality training. Even artificial intelligence and semiconductor physics pass through the satellite transponder. Naturally, we also use the traditional classroom setting for much of our training and education. In fact, we even have lab sessions which accompany some of our classes in the same manner as the well-known university lecture/lab structure.

ACADEMIC IMPACT

In what way does all this impact the university? The report card carries mixed messages. Industry is certainly a major revenue source for the universities; in many cases we pay the university more than the standard tuition assessed the on-campus student. At the same time it can be argued that the in-house courses taken by our employees are courses which potentially could be taken from the university. Perhaps we are competitors.

However, the more significant impact, I think, is the influence on subject matter offered and on teaching techniques. By offering nationwide courses using satellite and telephone communications we are providing a role model, showing by example that the traditional college classroom structure is not the only effective way to teach and learn. We have used young graduate students who are finding it relatively easy to make modern communications technologies an integral part of their tools. Some colleges are trying the tutored video instruction model on campus with undergraduate students. Having access to a video-taped lecture provides an opportunity to review the lecture and can be used with minority or foreign students whose required preparation time makes it difficult to follow the original lecture.

While I haven't discussed it yet, we have also found computer networks to be powerful tools for employee education. Our engineers have organized a large number of informal courses, which really amount to technical discussion groups to further their understanding of relevant technical problems. On the academic front, Project Athena at MIT is a marvelous experiment which should lead to significant advances in our understanding of just how to apply computer technologies to enhancing the learning experience.

THE EVOLVING ROLES OF INDUSTRY AND ACADEMIA

This century has witnessed a continuing evolution of educational roles for industry and academia. In the 1920s and 1930s most engineering curricula contained large amounts of practical field and laboratory work. Engineering students were expected to build things as part of their college training. In the 1950s and 1960s the emphasis changed to more theoretical curricula; many labs were dropped and the subjects taught to undergraduates contained large amounts of basic math and science. It appears that in the 1980s and perhaps into the 1990s we will see an intertwining of the practical and the theoretical.

It is not clear yet what portion of this will be taught in university classes and what will be taught by industry instructors, as we will first have to work through the redefinition of the respective roles of industry and academia. Industry will have to accept the fact that in an information age, continuing education and training are every bit as important to corporate strategic success as finance or marketing. Education needs to receive the same attention and resources that the more traditional business functions receive. Academia is beginning to recognize that its mission extends beyond the teaching of 18-22 year olds with a few graduate students thrown in for spice.

The success of "Sesame Street" has made obsolete forever the idea that standup lectures are the only, or even the best, teaching method, and the demands of the information society have made obsolete the concept of an education which ends in one's early twenties or before. Life-long learning is an imperative and the use of appropriate communication technologies appears imperative if we are to achieve this goal.

ACTIVITIES OF THE JAPANESE SOCIETY FOR ENGINEERING EDUCATION

Dr. Kenji Ogata
Chairman of the Board
ANDO Electric Company
Vice-President, Japanese Society
for Engineering Education

ESTABLISHMENT OF THE JAPANESE SOCIETY FOR ENGINEERING EDUCATION

My personal career began as an electrical and telecommunications engineer, and most of my life has been spent in that field. I was therefore very much interested when I learned that Japanese engineering education following World War II had been deeply influenced by a suggestion made for reconstruction of the telecommunications network by Mr. F.A. Polkinghorn, who worked with the Allied Occupation forces as a Bell Laboratory researcher. He reviewed the existing Japanese education of telecommunication engineers and felt keenly the necessity for its reform.

As a result of Mr. Polkinghorn's efforts, a University Electric Professional Council was established and, in time, the movement extended to fields other than electricity. In 1952 the Japanese Society for Engineering Education (JSEE) was created. At the time of this reform of engineering education, in Japan, in the early post WW-II years, there was no free and comfortable exchange of opinions between Japan and the United States. It was, however, true that moves to reconsider engineering education had also been developed independently among some intelligent Japanese persons. These committed individuals have been instrumental in promoting engineering education.

Reviewing the activities of JSEE since its inception, it is certainly obvious that its significance is less clear than its counterpart ASEE, the American Society for Engineering Education. This may be because JSEE was not created in response to a public need. Educational administration in Japan is under the jurisdiction of the government's Ministry of Education, Science and Culture and there are certain limitations on the activities of private organizations such as JSEE.

It may be helpful, also, to analyse some of the differences between the organizations of the two countries, since I am often asked in Japan why JSEE does not have the influence held by ASEE. One example is that ASEE, as a key member of the Accreditation Board for Engineering and Technology (ABET), accredits each subject program and arranges the recommendations to give degree designations for the professions, in accordance with the criteria and procedure of ABET. These, I believe, are regarded as the main activities of ASEE.

In Japan, however, the Ministry of Education accredits universities in accordance with the university chartering standards decided on by the Society for University Standards. JSEE is not involved at all in this matter.

A further difference between the two organizations is that ASEE keeps track of the number of engineering degree applicants, which provides important information on the activities of institutes and engineering colleges in the field of engineering education. JSEE, on the other hand, has not to date maintained such a record. JSEE has neither a defined responsibility delegated by the Ministry of Education nor any clear and well-defined relationship with that body and has been so far following its own path. (See Table 1 for profile.)

SOCIETY ACTIVITIES

The JSEE sponsors a wide variety of activities. Cooperative studies represent a first major effort by the Society. For the purpose of developing engineering education at institutes and engineering colleges, many kinds of meetings are held by the Society and Sections. The Society's annual conference is held in each Section in rotation and is participated in by many members.

The questions of what engineering education should be and how cooperative education can best be achieved between academia and industry are studied from many points of view. Lectures, panel discussions, section debates and other means offer some interesting ideas each year.

Second, a lecture meeting on engineering education is held each December under the auspices of JSEE with the cooperation of 15 societies and institutes. The results of individual studies and investigations on this subject are presented under the themes of:

- The ideology of engineering education;
- Methods of engineering education, including a common curriculum;
- Evaluation of engineering education.

The JSEE publishes an official journal, "Engineering Education", issued quarterly. The editorial committee of the Society makes every effort to also include reference materials for the type of education in question in a particular edition.

In addition to the above, independent activities are carried on in each section according to its principal focus. A section usually engages in many kinds of vocational training, in education-industry joint meetings, inquiries into the engineering education offered at institutes and engineering colleges, cooperative education between academia and industry, and others.

ACHIEVEMENTS AND REFLECTIONS ON THE PAST

Since immediately after its establishment, JSEE has supported newly created national universities. JSEE members, mainly those from industry, have declared that they expect these universities to advance toward realistic targets under the new educational reform.

At the time of revision of the university chartering standards in 1971, JSEE offered valuable suggestions on the manner of making decisions on minimum required units of general education for engineering students and the recommended order of offering liberal education subjects. In cooperation with the Japan Federation of Employers' Association, JSEE resolved the problems of job-finding and off-campus practical training. With regard to the latter, committee activities had to be abandoned as an increasing number of students could not be absorbed by enterprises.

Later, when the issue of the potential surplus of engineers holding doctorate degrees became recognized, JSEE clarified the actual situation and clearly showed that this was not a problem for the time being. There remain, however, those of the opinion that measures should be taken to cultivate creative doctorates in greater numbers for use in the future.

In its promotion of engineering education, JSEE presented many resolutions governing the quality of training which should be required for educators in institutes or engineering colleges, indicating the need for more such educators. It also pushed for more equipment and better facilities and strengthening of research budgets. These recommendations were partly reflected in the annual budgets during the 1960s.

A Japan-U.S. engineering conference took place at Illinois Technical University in June 1965. A second one was held in Oiso, Japan in 1966 and a third in Washington, D.C. in 1973. Several postponements have prevented a fourth conference from being held. These meetings discussed continuing education after graduation. JSEE established chairs for such continuing education, but the tenth chair was the last because of the decreasing number of participants.

Perhaps the greatest event in engineering education in Japan has been the remarkable increase in the number of applicants to institutes and engineering colleges which has occurred since the end of World War II. Certainly it is recognized that this fact has contributed to the economic growth of the country. The increase was the result of the greater number of applicants for a university education when compulsory education was extended from six to nine years. It originated from the educational reform which adopted a 6-3-3 system patterned after that which was popular in the United States. The increase in engineers was due primarily to the fact that this type of study offered a student more chances of employment and a relatively higher salary.

On the other hand, this increase in the number of students was not matched by an increase in the number of superior educators in either general education or in engineering science. As a result, Japan today suffers from a deterioration in the quality of its education. Although the late Dr. Issac Koga described these problems in detail at the annual conference of ASEE in 1965, conditions have not yet improved.

Large companies have a tendency to employ large numbers of new engineers, rather than to strive for quality, relying upon in-house education to enhance an individual's ability to cope with an assigned job. For medium and small size firms, however, it is not as easy to give employees in-house education, and these companies are more apt to immediately assign a graduate to a particular job. Although I personally am not certain to just what extent in-house education can complement an institutional education, it cannot be denied that an actual working role can provide effective education when an employee is also aware of his overall role as a member of the enterprise.

ROLE OF THE JAPANESE SOCIETY FOR ENGINEERING EDUCATION

At the time of the establishment of JSEE in 1952, seven regional sections were set up simultaneously and these have since grown to eight; JSEE has thus become an allied body. First located in the offices of the Ministry of Education, in 1961 it was moved to the existing site, Kuramae Kogyo Kaikan. The following year, it was approved as an independent corporation by the Ministry of Education and came to have many supporting members.

Despite the earlier mentioned contributions of JSEE to the progress of engineering education in Japan, in view of the recent relationship between academia and industry, the Society's mission seems to be increasingly more difficult. The academic sector is meeting industry's requirements for the number of engineers, though a much greater number could not be accommodated. For industry, therefore, there is no room for dissatisfaction and, in fact, a number of industries feel that engineering education as it is now being taught in institutes and colleges can be supplemented, to a certain extent by in-house education.

JSEE, however, is having difficulty in playing a positive role in engineering education. The present state of engineering education in this country should not be regarded as acceptable. There are many well-placed individuals who recognize that it is important that Japan make provisions for the future by nurturing more creative engineers. So it is high time for JSEE to cooperate in cultivating such an atmosphere, and one way in which this might be done is for the Society to remind educators inclined to devote themselves to research, that they have another, greater mission; that of education. It should also appeal to industries to cooperate in creating circumstances which stress the importance and need for a solid engineering education. Thus, the most important role of JSEE is to provide opportunities for the exchange of views between the academic and industrial worlds.

Although JSEE is officially recognized as an allied body composed of numerous regional sections, it has little close relationship to the various sections. This is mainly because of their geographical separation, with the exception of those in the Kanto region. ASEE, in contrast, is operated by a system of 14 councils, with members of the Society belonging to any zone and any section. Action is taken among at least six divisions of similar professional interest, and in this way members have various relationships with each other.

In order for JSEE to be an organized and effective nationwide society, like ASEE, with closer interaction between the main body and regional sections, its financial basis must be more firmly established. Some industrial firms have been forced to alter their conventional methods of operation due to the recent change in the industrial structure, and some are undergoing difficult management conditions because of the steep rise in the Japanese yen and the severe trade situation. Confronted with these urgent problems, they are having a difficult time continuing their basic funding of JSEE. Like ASEE, JSEE must depend not only upon the financial support of industry, but must also seek other means of strengthening itself financially. This may not be easily achieved in a short time.

COOPERATION WITH THE ACTIVITIES OF AEESEA (ASSOCIATION OF ENGINEERING EDUCATION OF SOUTHEAST ASIA)

It was in 1973 that AEESEA was established in Southeast Asia under the sponsorship of UNESCO. When Japan was asked to participate, the Ministry of Education asked JSEE to be the country's voting member and this relationship is still in effect. The role Japan should play in AEESEA is a bit unclear, since the circumstances of engineering education in most of the other member countries are quite different from this country.

The Association Secretariat had been located in the Philippines, Korea, Australia and Thailand before Japan assumed responsibility in September 1985 under the three-year rotational system. In May, 1988 this office will be turned over to Malaysia. A large regional conference and executive committee meeting took place in 1985 in Tokyo, the former being particularly fruitful with about 200 in attendance. It is my desire to cooperate hereafter in encouraging engineering education in Southeast Asia through close communication with AEESEA countries via the newsletters and journals being issued by this Association.

Responding to the needs of the Southeast Asian region, UNESCO intends to enhance technical levels by installing the following five networks:

1. Appropriate technology for rural development and low-income groups;
2. Alternative energy sources, especially for rural areas;
3. Exploitation of agricultural wastes and related technology;
4. Housing for low-income groups (rural and urban);
5. Instruments and control systems.

The General Secretary of AEESEA has been requested to cooperate with the activities of these networks. UNESCO recently presented a new network plan on the subject of microelectronics, and JSEE is cooperating by providing an overview of the present status of microelectronics in Japan.

With the increasing emphasis on internationalization, JSEE is likely to receive more requests to take part in international activities. Thus, one of the Society's biggest tasks is to adapt its constitution to this trend towards internationalization.

Table 1

Profile of the Japanese Society for Engineering Education

- Plenary meeting
- President/Board of Directors
  - Secretariat

- Council
- Committee
- Projects
- Editing
- Educational Policies
  - (Continuing Education)
  - Tech. College Education
  - Execution of Study Lectures
  - International Affairs
  - Financial Affairs