PART IV: INTERNATIONALIZATION OF ENGINEERING

INTERNATIONALIZING ENGINEERING EDUCATION IN JAPAN

Takashi Mukaibo
Acting Chairman,
Japan Atomic Energy Commission

Japan Co-chairman
U.S.-Japan Committee on
Scientific Cooperation

It is well recognized in Japan that universities and other research organizations are not yet satisfactorily international in their orientation and lag far behind those in the United States and European countries in this respect. The necessity of improving the situation is also recognized, and various measures have been taken. However, efforts made up to now have been aimed at the promotion of international cooperation, rather than at making institutions truly international.

In the Meiji era, the Japanese Government spent about one third of its higher education budget on bringing good teachers from abroad and sending able Japanese students overseas. The government endeavored to import advanced knowledge and technology because it seemed the most efficient route to modernization. The primary intention, therefore, was not internationalization. According to a survey of Tokyo University in recent years, almost 100 percent of its faculty members go abroad on average once a year. One quarter of them are supported by the Japanese government, about 35 percent by fellowships or invitation from abroad, and about 35 percent by academic societies (which often is actually indirect support by industry). Some professors participate in seminars, some give lectures abroad, some go for short visits to universities or other research institutions, and some travel overseas to take part in cooperative research projects.

By going overseas, these faculty members are contributing to international cooperation and could be said to contribute at least partly to the "internationalization" of Tokyo University. However, the fact that many professors go abroad and work actively in international cooperation is not enough to make Japanese universities international. Why has the internationalization of Japanese universities not been promoted? We can cite the following major obstacles.

1. Language barriers--Most Japanese students can read or write a foreign language to some extent, but their speaking skills are usually inferior. On the other hand, almost all lectures in Japanese universities are given in Japanese, and textbooks are written in Japanese. The Japanese language is said to be difficult to learn, and it is not considered an "international

language". Therefore, for foreign students, there is not enough incentive to learn it.

2. Poor living and research accommodations for foreign students.
3. Lack of organizations with adequate budget and personnel trained to assist foreign students or researchers. Such organizations as JSPS must be strengthened.
4. Scarcity of fellowships, research space and facilities, and funding for internationalization from both the public and private sectors.

Certain institutions of higher education in Japan are active in their drive to become international, such as the National Institute of High Energy Physics in Tsukuba, or the National Institute of Molecular Science in Okazaki. But most work undertaken at these institutes is in the basic sciences or in fields other than engineering.

Recently, the number of foreign students in engineering colleges has been increasing rapidly, at both the undergraduate and graduate levels. Most of these students are from Asian countries; very few are from the United States or Europe. The number of foreign faculty members is very small.

There are now some big projects being planned which will be carried out with the participation of foreign researchers or engineers, together with Japanese researchers from industries and universities. However, the number of such engineering projects is quite limited.

To actively promote internationalization, various measures have been taken or are under consideration. For example, a report prepared by the Tokyo Office of the National Science Foundation of the U.S. (Dr. Owens), a survey of the attitudes of major Japanese industries toward internationalization, drew considerable attention in the United States, as well as in Japan. According to the report, many companies have already employed foreign researchers in their research laboratories or are considering doing so in the near future.

Further, agreements for cooperation in science and technology on the inter-government or inter-university level are increasing. These have been shown to contribute to internationalization through the exchange of personnel and cooperative research. New universities are being established with special emphasis on being "international." Some private universities have established schools abroad, and foreign universities are being invited to establish school branches or projects in Japan. Many major American universities are reputed to have shown interest in this idea.

Through these various measures, Japan will continue to make efforts towards internationalization of its education and research in all fields, including engineering. We eagerly anticipate the cooperation of foreign countries, especially the United States in these Japanese efforts, which are expected to be mutually beneficial in the future.

THE CULTURAL CONNECTION

Joseph Bordogna
University of Pennsylvania

INTRODUCTION

In the mid-17th century, the U.S. sage, Benjamin Franklin, observed that "it is difficult for an empty sack to stand upright." In the mid-18th century, Yoshida Shoin, the revered Japanese sensei (teacher), preached against "empty learning." And now in the latter part of the 20th century, we still worry about what basic knowledge should fill the heads of students. Necessarily, how we think now in comparison with former times has roots in the kinds of civilizations extant at the times. In this sense, we might ponder the differences between then and now in order to develop proper notions upon which to base curriculum innovation.

The basic difference is that people and ideas are increasingly more intertwined, complicated, globally interdependent, and technological. As a result, in both universities and the workplace, effective participants must possess background knowledge appropriate to the way "global civilization" is evolving. Stated another way, citizens must be prepared to react effectively to the constant intertwining of socio-political concerns with rapid technological advance, which at any moment can mitigate against each other as well as form a complementary pair. Working effectively, efficiently, and productively in this mixed international milieu requires an understanding of a much broader range of associates and competitors than in the past. Effecting significant leadership is an even more difficult assignment. The global workplace presents a variety of challenges, opportunities, and risks which cannot possibly be faced with an educational background peculiar to one's own local or domestic culture.

Successfully associating with others in working group has always depended on creating a so-called "social chemistry" among members of the group. Subtly, sometimes overtly, decisions on interactive cooperation depend on how personal qualities and moral values coalesce with the group's corporate culture, that "group tone" that becomes identified globally with the group's productive output. In a domestic economy the individual cultural backgrounds of group membership are likely to have rather homogeneous components; in a global marketplace, cultural heterogeneity is likely to abound. Thus, getting along in other cultures is growing in importance along with the growing interdependency of the artifically separated national economies of today.

As with all modes of social communication, the precise meaning of a specific word is widely interpretable. Thus, what is meant by "culture?" Domestic U.S. dictionaries offer the following:

(1) The quality in a person or society that arises from an interest in and acquaintance with what is generally regarded as excellent in arts, letters, manners, scholarly pursuits, etc.;

(2) A style of social and artistic expression peculiar to a society, community, population or class;

(3) A particular form or stage of civilization, as that of a certain nation or period;

(4) The sum total of ways of living built up by a group of human beings and transmitted from one generation to another.

We see here the concern for ways of living, and the appreciation thereof, for both the individual and the collective group. We see here also the idea of civilizations created through long-term coalescing of identifiable collective traits over generations.

Historically, cultures defined in this way have developed regionally rather than globally. Modern technology is now forcing these disparately-developed cultures to impact on each other frequently and with growing intensity. As a result, cultural interconnections are of increasing importance in creating successful economic and political enterprises. The process of "getting to know each other" has far more relevance now than just an exercise in appreciation of each other's values. What is most exciting is the possibility that we are experiencing the dawn of the development of a global culture; that is, an era in which much time will be spent in educating about and having experiences in the manners and tastes of cultures seemingly far removed from one's own.

Since technology appears to be a root element in coalescing disparate world cultures, it is likely that engineers may be at the forefront in guiding this new social evolution. Certainly, engineers already share a common cultural base; to wit, the scientific laws, engineering concepts, and the singular global language in which they are interpreted. This commonality provides a base upon which to build the cultural facets of what we might refer to as "new engineering education." In particular, the basic engineering concept of "decisionmaking" might find universal applicability to many facets of overall global culture...that is, decisionmaking in the sense of looking at the world, defining what needs to be done, modeling the situation so that quantitative as well as qualitative studies can be conducted, "trying-out" the model to see what can result, matching the results of modeling with the reality from which it was derived, and designing something to ameliorate the situation. In this way, ideas are implemented, and in the process one learns to take calculated risks and create imperfect solutions when the ideal seems unattainable. The "engineering approach" leads to learning to "make do" within the constraints, cultural and otherwise, of what is available to accomplish change. The engineer's capacity to "make things work" can be useful as disparate cultures sometimes clash in present-day global undertakings. In this task, of course, it is important to remain aware that for technological change to be absorbed "comfortably" into a local culture it must be done so in keeping with the lifestyle of the people involved.

THE JAPAN-U.S. CONNECTION

Representing the present evolutionary peaks of two of the world's major cultures, East and West, it seems rational that Japan and the United States should study ways to coalesce the two as an example of global cultural evolution. This study could lead to modification, over time, of engineering education. It is likely that changes would proceed in a different format and at a different pace in each nation; it may be, however, that the changes would be identical in purpose and content.

In the period of modernization following the Meiji Restoration in 1868, Japan embraced Western science and technology with fervor, giving rise to significant social change and economic expansion. Yet, Eastern cultural values were not only simultaneously sustained but enhanced. The anthropological exercise here might be interpreted as indicative that Western-style technological civilization can take root in non-Western soil. (Given recent events in modern Persia, however, it might be more correct to limit the claim to "Eastern soil.")

During the past twenty years, Western civilization has garnered feedback from the Japanese endeavor and, in response, is modifying its application of technology accordingly, and is embracing Eastern philosophies with some vigor.

Much is to be learned from these experiences and serious study is underway in both countries. The more visible studies focus on "how can the United States take advantage of the refined manufacturing expertise of Japan?" and "how can Japan capitalize on the so-called creative bent of U.S. innovation?" Quietly, other perhaps more meaningful attempts at understanding recent change focus on the intellectual study of the history of technology. In the United States, the history of technology has just recently become a growing academic discipline, giving rise to such "rules of thumb" as "innovation happens locally" and "invention peaks following periods of long-term recession." In Japan, the history of technology interestingly focuses on the history of traditional technologies that were developed with no influence from the West, i.e., prior to encounters with the modern science and technology of the West; the intent is perhaps to resurrect old technologies in the context of the modern-day environment.

A NEW ENGINEERING EDUCATION

Based on the preceding argument, a principle to be learned by each national culture is that there are people of cultures different from one's own who conduct their lives based on seemingly different but equivalent values. We might refer to this as the "principle of mutual appreciation." Whereas this principle has been a truth of humanity over millennia, it is the globalization of interactive technological enterprise which brings it into focus as a fundamental facet of engineering education. In brief, the young people needed to create and lead technological enterprises into the next century must be educated to be citizens, not merely of one nation, but rather of the world. Understanding of other cultures and their languages must be coupled with the universal set of scientific and engineering principles already extant throughout all cultures. In a sense, this should be a simple task of straightforward curriculum modification; in reality, it may prove difficult to "liberalize" fixed attitudes about "softening" engineering education's technological base. Much discussion and compromise will be needed to bring about a "new balance" to engineering curricula.

There are two approaches suggested here for discussion, one designed to provide multicultural appreciation in the typical engineering baccalaureate program, the other designed as a totally new dual-degree program at the master's level.

At the undergraduate level, the United States and some other countries already require that engineering students take a small number of courses in the humanities and social sciences. However, students have been ill-motivated to plan meaningful programs of study, with the result that they select courses easily mastered. Of late, the engineering professoriate, realizing the intellectual breadth needed by modern-day engineering professionals, have attempted to rectify this deficiency. Much effort is underway to both motivate students toward serious, in-depth study of the humanities and social sciences and, in particular, to create new kinds of courses which can transcend the usual sequence of courses in writing and languages. An enlightened national engineering accreditation board in the United States embraces this attempt at change and the Association of American Colleges is presently conducting a carefully conceived study of the humanities and social sciences in engineering education. Thus, there is hope that new "liberal studies" may indeed freshen the cultural breadth of engineering education.

A small adjustment within this new educational atmosphere could reap some strong universal benefit across all engineering curricula. Suppose, for example, that year-long courses combining language with culture were developed for the several principal cultural regions of the world. These courses would dwell on the origins of cultural development in the regions and would generate an appreciation for the values (social, political, financial, family, military, religious, technological, philosophical, etc.) enjoyed by each. While any attempt to specify a "correct" finite list of "Major Regions" will be met by disagreement, an initial identification is presented here for argument, along with the languages inherent to the region specified:

East Asia (Chinese/Japanese)
Latin America (Spanish/Portugese)
North America (English/French)
South Asia (Hindi)
Soviet Bloc (Russian)
Western Europe (French/German)

Coupled with a summer or year abroad in an exchange program, ideally in an industrial task, such courses could at least begin to help engineering students see the world as it is, not as they might like it to be in terms of their own regional experience. If done well, the courses would motivate students toward lifelong learning about other cultures and give them a real base for intensive language study when necessary.

If universally conducted at the undergraduate level, this one-year, one-course program could precipitate an evolution toward appreciation not only of different cultures, but also of the societal need and personal value of such knowledge. Perhap then, later programs might encompass a more intensive educational experience in this arena.

In studying the best of undergraduate engineering schemes, one observes the trend over time of seeding the undergraduate curriculum with coursework derived from the graduate program. In other words, new technical knowledge is inexorably transferred from graduate to undergraduate programs. In this sense, an experiment on language and culture at the graduate level would most likely influence undergraduate engineering education over time. The rationale for a special graduate program would be simply a response to the challenge of global enterprise by developing technological leaders who are deeply sensitive to cultural differences and are capable of productive involvement in foreign environments. In management education, a handful of such programs at the master's degree level can serve as examples of how to proceed. In particular, the dual-degree Master of Arts/Master of Business Administration (M.A./M.B.A.) program of the three-year-old Lauder Institute of Management and International Studies at the University of Pennsylvania can be paraphrased here to develop a specific model for a radical, but feasible, modification of engineering education at the master's degree level. While at the start, only small numbers of students might be attracted to such a program, the natural trend toward diffusion into undergraduate programs over time could be positive indeed.

As one proposal, a possible M.A./M.S.E. program would be based on an intensive 24-month course of study composed of periods of on-campus coursework in engineering, humanities, social sciences, and advanced language training for one of the regions listed above, interspersed with internships abroad in industrial organizations. A major intent would be for each student to achieve a professional level of proficiency in at least one relevant language different from one's native tongue and both an appreciation for and understanding of the cultural aspects of technological enterprise in a global environment.

To develop an intimate relationship with the international technological marketplace, this program would be intellectually supported by an Advisory Council composed of leading technological executives and global intellectual leader who would recognize the need for the program and participate in planning and evaluation of ideas, curricula, internships, and the like.

While the engineering portion of the program would be based on the present concept of an M.S.E., the cultural portion leading to the M.A. might include, say, a one-semester course in general technological anthropology and on several additional one-semester courses offering both an historical perspective and a focus on comparative current issues in one of the major regional areas suggested above. One of these courses might treat the role of the family in the specific foreign culture, another the role of the economy, another the role of politics, and so on.

To integrate the coursework into a coherent M.A./M.S.E. experience, each student would be required to conduct an Advanced Study Project jointly supervised by a professor from the cooperating School of Arts and Sciences along with an engineering professor. Finally, there should be a liberal arts/engineering team-taught seminar course at the end of the program in which the entire educational experience is challenged and thereby fortified.

The language portion of the program is, of course, extraordinarily important and it is crucial that it be conducted as an integral part of the cultural and technological portion of the program. A suggested format for accomplishing this goal is the following:

- An intensive eight-week language and culture program taught in relevant foreign countries during the summer preceding initial entry to fall coursework on campus.
- Use of the language during a three-month foreign internship in the second summer.
- Specialized foreign language proficiency development coordinating coursework, writing tutorials, and public speaking workshops.

SUMMARY

A rationale for integrating foreign cultures and languages into an engineering education has been offered here for discussion. The motivation is a response to the increasingly global interactions of technological enterprise which are inexorably forcing a global corporate culture uniting the wonderfully diversified cultures enjoyed by the peoples of the world. The major goal is to modify engineering education in such a way that each student can learn to appreciate the ways of life of others to the mutual benefit of all. Specific suggestions to start trends in engineering curriculum modification towards this end have been proposed at both the baccalaureate and master's degree levels.

INTERNATIONALIZATION OF ENGINEERING

Pat Hill Hubbard
Vice President
Engineering Education and Management Programs
American Electronics Association

I am pleased to be here in Honolulu for this seminar devoted to Engineering Education. Aligned professionally with the U.S. electronics industry, I have a special affinity for this topic and appreciation for the significance of this 25th anniversary of the U.S.-Japan science and technology agreement.

Many of us in this room have met prior to this conference. We have joined in the struggle to bring about wider recognition that competition and cooperation are two sides of the same U.S.-Japan trade coin. We have long understood that before there can be trade and commerce, there must first be engineering education and research. Here, too, we realize that the U.S. and Japan can no longer afford complacency and narrow chauvinism.

For those whom I have not met before -- I wear two hats at the American Electronics Association (AEA). I am a vice president with responsibility for the Association's university management institutes, our corporate training programs, and our Quality and Productivity initiatives. I am also President of AEA's Electronics Education Foundation which embarked four years ago on a nationwide program to improve the quality of engineering education in the U.S.

AEA represents more than 2,800 electronics and information technology companies throughout the United States. Our member companies are of all sizes -- from mom-and-pop software companies and manufacturing start-ups to the large companies like IBM and Hewlett-Packard. The Association's primary goal is to foster a healthy business environment for the U.S. electronics industries and to strengthen their competitive position in the world marketplace.

Various metaphors have been put forth to explain the relationship between the United States and Japan during the last several decades. Recognizing only our differences, some might describe the situation as "parallel lines which do not meet."

This NSF Conference acknowledges the quarter century in which Japan and the United States have risen above the lines of Rudyard Kipling and the laws of geometry to cooperate in the exchange of scientific and technical information. Participants here today are aware that our countries' lines do frequently converge. We now travel together on many of the same roads, often leading towards the same destination. The internationalization of engineering research is one way which helps ensure we reach the same place.

For Americans as for Japanese, a satisfying accommodation -- whether in engineering or commercial trade relations -- is not to be found through faddish "Americanization" or "Japanization" within the other country. Twenty-five hundred years of history has created a Japan which is self-contained and homogenous. Two hundred and fifty year old America is interdependent and diverse. From these two disparate historical experiences we face a technologically based world and find ourselves key trading partners in it. Economic interests alone, therefore, dictate a symbiotic and mutually respectful relationship. The new spirit of internationalization of engineering research fosters the goal of equal technological enlightenment that benefits and strengthens both countries.

Through "internationalization" the United States is learning from Japan -- The United States' high school dropout rate is more than twice Japan's. Estimates are that anywhere from 20 percent to 30 percent of American adults are functionally illiterate compared to an estimated 1 percent in Japan. However, even those who remain in U.S. schools may not be getting the kind of education that adequately prepares them for life and work in an increasingly high-tech-oriented world.

A recent U.S. Department of Education study, conducted by the National Assessment of Educational Progress (NAEP), found that while almost 95 percent of young adults (aged 21-25) can read, some can do so only up to the fourth-grade level. The study found that performance for these young people drops sharply when they are given complex tasks that call for them to combine reading with comprehension and quantitative skills. "The real message of this report," said Gregory Anrig, president of the Educational Testing Service, operator of NAEP, "is not that young adults can't read at all, but that they can't read well enough to cope with our technologically advanced society." This translates into a workplace illiteracy that threatens the fundamental viability of U.S. productivity.

A new Japanese education initiative to promote technical literacy may prove of interest to U.S. educators: Recent articles in both the Japanese and U.S. press have described the concern of the Ministry of International Trade and Industry (MITI) with the growing shortage of technicians in the information technology fields. MITI estimates that by 1990 there will be a shortage of almost 600,000 engineers, software engineers, programmers, etc. This situation has prompted the Japanese government to devise a number of blueprints to cope with this problem. Among new programs to encourage technical education is a research center to promote the use of computers throughout the Japanese educational system. The goal is to encourage development of future systems engineers.

In the United States, we look with envy as well on other more traditional examples from the Japanese elementary and secondary school experience -- the solid knowledge base on which our future engineers are educated. We admire, for example, the fact that Japanese students spend 240 days in school each year while ours spend 180, that 65 percent of Japanese high school seniors spend more than five hours per week on homework compared to 24 percent in the United States, and that Japanese students are required to take six years of English language prior to graduation from high school. In the United States, we are struggling to facilitate foreign language literacy among a school population that has grown up with the myopic notion that English is the singular language of successful international competition.

On the other hand, the United States offers a unique model of industry-education-government cooperation that might offer some examples which could strengthen the Japanese technological base -- We would most likely agree that for most of the high technology era, the United States has had the definitive lead in productivity and technology. The foundation for much of this lead -- and thus the U.S. economic success -- can be found in the dynamic, tripartite interaction of industry, government, and higher education on behalf of engineering research and education. This tripartite partnership amazingly has come about without a stated national policy. The National Science Foundation has and continues to play a major role in fostering the partnership of government and education. Only recently, however, has industry been considered by U.S. government agencies as an important player in strengthening engineering education.

On its own initiative and in its own best interests, industry began some 8 to 10 years ago to rebuild its former strong relationships with U.S. engineering universities. The result today is a growing closeness of the three groups that has the promise to yield numerous new research discoveries which can be quickly translated into products for the domestic and international marketplace.

The United States spent 77 billion constant 1980 dollars in 1984 on research and development. This was more than Japan, West Germany, and France combined for that year (source: National Science Foundation, "International Science and Technology Data Update 1986"). However, while the U.S. still spends more on research and development, the amount we spend is now similar to that spent by each of those other nations relative to the size of their economies.

For many observers within the U.S. high-tech scene, there is an ironic sense that the high-tech success of Japan has served to quicken our sense of the importance of this industry-university research-government partnership that serves for innovation, productivity and our international competitiveness. As Ray Stata, President of Analog Devices, Inc. states -- with compliments to our Western and Pacific Rim trading partners, "We now have worthy competitors to spur us on to greater achievements." And if we hope to reduce the $8.8 billion worldwide trade deficit we had in 1985 and regain our leadership position -- one underpinned, as all in this room are aware, by preeminence in high technology -- we will need to increase our emphasis on improving our U.S. engineering research and education to produce sufficient numbers of well-educated workers who can efficiently deploy the resulting technology.

Higher education in our country performs almost 60 percent of all basic research and about 15 percent of all applied research. I believe this is a much higher proportion than is performed by universities in most other countries, including Japan. While U.S. higher education research receives more of its funding from the federal government (70 percent) than from private industry (estimated at 4 percent currently), 87 percent of all development is performed by private industry. Thus, in the U.S. high-tech landscape, while basic research is largely conducted in the universities, development is primarily in the private arena and applied research falls in the shifting region between the two. In our freewheeling society, the government plays a catalytic role rather than a directive one that fosters loose-knit and dynamic university-industry relationships.

Studies show -- and we in industry agree -- that innovation is the greatest spur to productivity growth. <u>Industry</u> and <u>Government</u> play major roles in enhancing the innovation process by choosing where to make investments in support of educating people and research.

Universities -- which are arguably the apex of the triangle-- participate in the innovation process in several important ways. Through their research mission they are a primary source of new knowledge and technology; through their teaching missions they are the primary conduit for imparting new knowledge and technology; and through consultation, collaboration and publication, the university facilitates technology transfer and development of practical applications. The contributions from each leg of the triangle leverage those of the other two with each part being essential.

The challenge for America, now, is to apply vigor and adequate resources to increase these partnerships. It may be said that as Japan seeks to foster greater creativity and innovation in its workforce, American industry's new reliance on its university system is something to note.

Let me briefly describe how one industry association--AEA--has approached improving engineering education.

Over five years ago, our member companies found themselves in the midst of a critical shortage of electrical and computer engineers that promised to worsen. The shortage was seriously affecting our ability to remain competitive in international markets. AEA's National Board of Directors established a Foundation and a department of Engineering and Technical Education and directed staff to take aggressive steps to improve faculty shortages -- viewed as a major bottleneck to a steady sufficient supply of quality graduates.

We found that faculty vacancies were primarily the result of U.S. students with BS degrees preferring to go directly into industry rather than to continue for costly Ph.Ds and salaries in Academia that were often 30 to 50 percent less than those for BS holders in industry.

Our efforts focused then and continue now to focus on increasing new U.S. faculty candidates and decreasing present faculty flight. To date, more than 250 AEA members have contributed more than $16 million to the Foundation's program to over 73 U.S. colleges and universities for electrical and computer engineering and computer science education. Over $10.7 million has flowed to U.S. schools directly through the Foundation to fund 89 doctoral fellowship-loans for U.S. citizens who want to teach engineering or computer science, for 134 faculty grants to help retain and recruit professors and for 34 gifts of equipment to improve teaching laboratories.

Nationally, an additional $6 million has been given by Hewlett-Packard to support another 53 AEA fellowships. This means that presently, 142 U.S. students, supported by AEA efforts, are getting doctorate degrees with the intention of teaching. Since we continue to be about 500 a year short of the new engineering faculty needed to remain at today's steady state, we recognize that we still have a long way to go to solve the problem.

It is interesting to note that almost one-third of the $10.7 million flowing through the foundation was given this past year -- when much of our U.S. high tech industry was flat or negative. This shows in a dramatic way that companies are realizing it is not all "take" and no "give" to universities. Another telling indicator is that 40 percent of the donations have come from small companies.

Against this backdrop of AEA's broad national activity, I will single out three examples in which we at AEA have played an instrumental role. These should be viewed as a very small sample of the many partnerships in which others are engaged across the United States.

AEA can claim the pride of parenthood for developing the first, state-industry dollar match programs focused on developing new engineering and computer science faculty; and we take at least a share of the credit for gaining acceptance of the second two -- the new University Basic Research Tax Credit and the Microelectronics Innovation and Computer Research Opportunities Program (MICRO).

I. AEA-State Dollar Match Programs -- AEA has used its unique organizational structure -- having legislative programs in six states as well as Washington D.C. -- to help improve engineering education. Our legislative efforts have resulted in two AEA-State dollar match programs -- one in Oregon that ended last year and one in New Jersey which is on-going. AEA dollars triggered through these two programs almost $3 million in state funds focused on the faculty and equipment issues. We look to similar programs next year in Connecticut, New York, Massachusetts, and in California where the statewide fulltime engineering faculty rate is now 22 percent.

II. The New University Basic Research Tax Credit -- Since AEA began tracking donations in 1982, electronics companies have provided well over $600 million in cash and state-of-the-art equipment to U.S. engineering departments -- more than $60 million in 1985 alone.

All here today and a growing number of others now recognize the direct relationship between the excellence of U.S. engineering education and university research and high technology's contribution to the U.S. economy. However, as was previously mentioned, private industry currently contributes only an estimated 4 percent of university research dollars. Though many high-tech companies want to contribute more, many are pressed for resources in today's difficult marketplace.

Therefore, a cornerstone of AEA efforts to improve engineering education has been aimed at enacting tax legislation which provides a tax incentive to industry to contribute more. AEA as part of the Washington, D.C.-based Coalition for the Advancement of Industrial Technology (C.A.I.T.) worked to get included in the recently passed 1986 Tax Reform Act a new 20 percent tax credit for corporations who contract for basic research with universities.

III. MICRO - California Success Story -- A third program is the California Microelectronics Innovation and Computer Research Opportunities (MICRO) program. Established by the California Legislature in 1981, MICRO supports "innovative research in microelectronics technology, its applications in computer information sciences, and its necessary antecedents in other physical science disciplines."

The guiding objective behind MICRO has been to help California electronics and computer industries maintain their leadership by (1) expanding relevant research and (2) supplementing graduate student training and education at the University of California campuses throughout the state. AEA was actively involved in passage and eventual funding of the program.

The MICRO program is under the overall guidance of a policy board of nine members composed of three representatives each from industry, state government and the University of California system. The program has proved extremely successful in linking a California tripartite -- government/industry/education. All three constituencies benefit individually as well.

The University obtains urgently needed financial support for its research and educational missions. Faculty and students gain access to expensive equipment and facilities only available in the sponsoring company.

The State benefits by helping California industry to remain competitive, to hold and create new jobs, and to continue their significant contribution to the state tax base.

Industry gets fresh, innovative product ideas from the research. Also they are able to hire graduate students trained in the frontiers of microelectronics fields. Furthermore, industry sponsors derive specific advantages by being closely associated with on-going projects and by obtaining research results several months prior to when they are published.

Industry participation in the program has grown from 25 companies and 31 projects in 1981-82 to 59 companies and 117 projects in 1985-86. This fledgling program has proved so popular that there is interest in other states, especially Texas, in mounting a similar partnership program.

After focusing on initiatives operating either in the United States or in Japan which might serve as successful models for efforts by the other, I would like to close by spotlighting another new program, developed by AEA, that is simultaneously rooted in both countries -- the AEA Japan Research Fellowships.

One concrete example of the new spirit of internationalization, the AEA Japan Research Fellowship Program was established three years ago in cooperation with the Electronics Industries Association of Japan (EIAJ). Under this program, U.S. engineering and computer science graduate students receive intensive Japanese language training -- this past summer at Cornell University's intensive FALCON Program -- and then go to work in Japanese company research laboratories for nine months to a year.

Nine M.S. and Ph.D level graduate students (six have recently arrived in Japan) have been placed this year in the research labs of some of the finest Japanese corporations, such as Sony, Hitachi, NEC, Fujitsu, Toshiba and others. To date, twenty-two U.S. companies have contributed support for the program in the U.S. Also, we receive welcome support under a two-year NSF "Challenge" grant that matches U.S. industry dollars contributed for language training and program management.

This model program is a first step in creating a new generation of engineers with firsthand literacy in Japanese language, culture, and technology. For the foreseeable future we see Japan as both a major competitor and an enormous market opportunity. We at AEA, therefore, consider it part of our industry leadership role to encourage U.S. universities to offer Japanese language training and to help students experience first-hand research practices in Japanese companies. We believe this is a small but symbolic example of how we can help increase U.S. international technical literacy -- a growing and important component if we intend to remain competitive. This program exemplifies, I suggest, our new U.S. view of "internationalization."

CONCLUSION

Perhaps a more appropriate metaphor for understanding -- and enhancing -- the U.S.-Japan relationship for the next quarter century ought to be of the two strangers who meet on the road. They do not seek nor expect full-scale conversion experiences. Rather, they honor each other best by learning to respect each other's differences and then, continue on, enlightened perhaps, neither imposing nor imposed upon. "Internationalization" at its best captures this cooperative spirit.

PARTICIPATION OF FOREIGN RESEARCHERS IN JAPANESE RESEARCH ACTIVITIES

Genya Chiba
Director, Research Administration
Research Development
Corporation of Japan

INTRODUCTION

Japan, as you have surely noticed, is changing in several ways. No change ever occurs in Japan unless a consensus for it has been formed. A national mood for change must precede any movement towards change. Movements toward change start very inconspicuously in the form of discussions and experimentation, which consume a considerable amount of time. Once a consensus is reached, however, change takes place rather rapidly and smoothly. The consensus building now taking place in Japan is leading to radical changes similar in importance to those of the Meiji Restoration and of the immediate postwar period.

These changes are occurring in government, in education, in industry, and in Japan's international role. The word "internationalization" is used very frequently by politicians, business leaders and the press. Concrete changes in the role of government are being promoted under the slogan, "min-eika" meaning "privatization." Examples of this are the privatization of Japan Telegraph and Telephone Corporation, of Japan National Railways, and of some other government-owned enterprises. Educational reform may take place at all levels from primary schools to universities. In the industrial sector there is more emphasis on high-tech industries than on heavy manufacturing industries. Japan is seeking ways to transform her export-oriented economic structure to a two-way trade structure. It is making trial-and-error probes in the area of internationalization. To put it succinctly, past frameworks are no longer adequate. Japan is searching for new frameworks for its socio-economic structure.

This is especially true for science and technology. In the past, Japan modernized by importing advanced technology from the West. Technology was more important than science. Education emphasized the training of engineers rather than scientists. The large proportion of engineers graduating from science and engineering departments of Japanese universities is a carryover from this past framework. In this framework, universities and national research institutes have served well as transmitters of Western technology.

Since the beginning of the 1970s, some changes have become apparent in this technology-oriented framework. The "Japanization" of imported technology, just like the one that took place 1200 years ago in the Nara period, has begun to take place. Japanese-style management, quality control, miniaturization, and so forth are all examples of the fusion of Western technology and Japanese culture and sensibilities. Such fusion helped Japan survive the two oil crises.

Having survived these oil crises, Japan finds herself to be a technological and economic power. The fusion of Western technology and

Japanese culture is, I think, the key to the Japanese success story. This success means, however, that there are no longer models for us to emulate as we have done since the Meiji period. This is producing a new trend in the science and technology of Japan of the 1980s. We are gradually realizing that scientific and technological growth is the mainstay of Japan. In other words, we must create new science and technology as our contribution to the international community. The slogan, "creative basic research and internationalization," describes this quite well. It encompasses administrative, educational, industrial, and social reforms.

PRESENT STATUS

The fact that "internationalization" has become a household word indicates that the Japanese people feel that internationalization of the country is a difficult process and that much effort must be made to achieve it. Even within the field of science and technology there are many problems of internationalization on individual, organizational and social levels. Many problems remain to be solved by the academic, private and government sectors. But quite a few of these problems might be solved by the exchange of researchers and administrative people.

Even if we narrow our attention to the problem of exchanges of engineers, there is an unbalance between Western countries and Japan. Reasons for this unbalance may be found on both sides, but there are problems which should be solved unilaterally by Japan.

According to the statistics compiled by the Ministry of Justice in 1985[1], 32,000 Japanese researchers (including students) went to the U.S. and European countries, while only 6,000 researchers went to Japan from the U.S. and European countries. During the same year, in comparison with 9,000 Japanese researchers who went to countries other than the U.S. and European countries, there were 33,000 non-U.S. and non-European researchers who came to Japan. The ratio of the non-Japanese researchers to the Japanese researchers is reversed from 1/5 to 3.5/1. These figures tell something about the relationship of the U.S., European countries, non-U.S. and non-European countries, with Japan. A more detailed breakdown shows that 20,000 Japanese researchers went to the U.S., 3,000 to England, and 2,000 each to France and West Germany in 1985. The growth rate from 1980 to 1985 for the Japanese going to the U.S. and European countries is about 60 percent, but that for the American and European researchers coming to Japan increased by 120 percent. This tendency has been accelerated and the gap in numbers is expected to be narrowed.

It is a fact that much effort is being made in various sectors in Japan to remedy the above situation. Examples are efforts to make government laboratories, traditionally known for their closed nature, open to foreign researchers. The Ministry of Education, Science and Culture has now made it possible for national universities to hire foreign scholars as regular faculty members, and the Science and Technology Agency, in cooperation with other ministries, has contributed to the enactment of legislation to open national laboratories to foreign researchers. Many national laboratories and national projects already have foreign researchers working there or are planning to accept foreign researchers. Dr. C.T. Owens of NSF reports that, based on his 1985 survey, about 50 percent of Japanese companies which responded to his inquiries said that they already had foreigners working in their companies or were ready to receive them. The internationalization of Japanese society and the accompanying changes in attitude have made it easier for foreigners to participate in Japanese activities.

ERATO, A SOCIOLOGICAL EXPERIMENTATION

An example of the new science and technology policy of the Japanese government is the ERATO program[2] inaugurated by the Science and Technology Agency in 1981. This program has also served as an effective pace setter for the promotion of internationalization of scientific and technological research in Japan. This program which is administered by JRDC[3] is based on an operating principle which is the complete opposite of those social elements in Japan which have brought its success (such as consensus, organization-orientedness, centralization and permanent employment).

The purpose of this program is to engage in basic research, the results of which may provide clues for future developments in science and technology. Each project under this program is made up of young researchers from Japan and abroad, who are engaged in open-ended research on some specific topics for a period of five years. The relationship among JRDC, project directors and researchers is analogous to that of the producer, director and performers of a play.

Up to now about 200 young researchers have participated in the program, 60 percent of whom are on loan from Japanese companies, the rest coming from universities and national laboratories and as postdoctoral participants without home institutions. About 30 foreign postdoctoral participants have come from twelve countries including the U.S., Canada, England and West Germany. Foreign participants in the on-going projects are given some preferential treatment concerning travel and housing allowances, but otherwise they are treated like any other Japanese co-workers and not as guests, as has often been the case previously. The average age of foreign participants is about 30 years old, and they have displayed excellent adaptability, which has pleased senior Japanese researchers in the program. Some speak good Japanese, and many do not speak Japanese at all. Language does not seem to be an obstacle, though, as far as research is concerned.

The ERATO program was opened to foreign participation from the very beginning partly because of the demands of the time, but partly because it was thought desirable to form a heterogeneous group with different values and viewpoints, which would serve as the seed for many more such groups in the future.

Five years have elapsed since the program was formed, and it is regarded as the most active and productive program in Japan. The program was never intended to be an educational institution, but many people regard it as the best educational institution for postdoctoral people. There are, of course, problems with the program, but on the whole my feeling is that it has been much more successful than anticipated at the beginning. Several programs inaugurated subsequent to the ERATO program are being administered utilizing the experiences gained through the administration of the ERATO program.

PROBLEMS FACING INTERNATIONALIZATION

It is obvious that internationalization must be promoted vigorously in various aspects of the world community in order to develop a well balanced and cooperative relationship among nations, and to create a new culture born out of interaction between different cultures. It is also clear that factors which retard efforts towards internationalization exist in every country, and they can only be removed by mutual effort. It will take some time before internationalization really takes root.

Take for example the relationship between Japan and the U.S. Both sides are inclined to think that their ways of doing things are the standard ways. Language, customs, and various procedures are examples of such ways of doing things. Such presumptions originate from the lack of interest, information and understanding on both sides. The fact that the amount of information about Japan possessed by Americans is less than that about the U.S. possessed by Japanese is an obstacle to better understanding between the two countries. The situation is rapidly improving, however, as the need to know more about Japan on the part of Americans is increasing. Japanese language courses for scientists and Japan Centers at several American universities are good examples of such improvement.

I would now like to point out some of the specific problems on the Japanese side which are obstacles to the exchange of researchers between Japan and U.S. and Europe.

Permanent Employment and Company Loyalty

There are various merits to the system of permanent employment, but it is a negative system as far as the mobility of researchers is concerned. Japanese companies plan, train researchers and invest in research over a ten year period. Excessive mobility of research personnel does not fit into this pattern of operation, and makes employers skeptical about their employee loyalty to their companies, and may result in a conservative employment policy.

In the ERATO program a term employment system of five years maximum has been adopted. This permits companies to loan their employees to ERATO projects without the fear of losing them. If U.S. companies allowed a long term leave of absence, participation by their researchers might become easier. There are no large pay differentials (but there is a difference in purchasing power for some items), but salary is not necessarily a problem in the employment of American researchers.

Language and Customs

As far as research is concerned, English is sufficient in most cases. Most Japanese researchers can handle English, but most of them cannot carry out in-depth discussions on research and other topics in English. It is obvious that knowledge of the Japanese language would be extremely helpful. In order for researchers from abroad to enjoy life in Japan, it is extremely desirable for them to know conversational Japanese. If they only speak English, they will be treated as "guests" rather than colleagues. It is important for them to get a feeling for the Japanese way of thinking and Japanese sensibilities. This cannot be done without knowing the language.

Housing

The housing situation in Japan is rather problematic and there is no easy solution to it. However, if a researcher is posted in a non-central city, housing difficulties are eased somewhat. Many institutions maintain their own housing for employees, and researchers may be able to take advantage of it. Foreign researchers participating in ERATO projects receive a housing allowance and choose their own housing. They consider living in cramped quarters and commuting in crowded trains as part of their Japan experience. Perhaps they can tolerate or enjoy it because they are young.

Exchange of Administrative Personnel

Exchange of research personnel tends to be emphasized more than that of administrative personnel, but I think it is very important and necessary. Unless administrative people involved in the actual business end of a research program have knowledge of how business is conducted on the other side, the exchange of research personnel or cooperative research projects will not work smoothly. Exchange of young administrative personnel should be considered as an educational process and is as important as the exchange of research personnel.

Information Communication

Information is at the base of the exchange of personnel and cooperative research. Thus it is necessary to establish a system to communicate information concerning research and other employment opportunities in Japan, and the procedure for securing jobs. The reverse case is sometimes true. Many Japanese companies, for example, complain that even though they wish to hire people from the U.S. and Europe, they do not know how to go about it. The exchange of personnel at present is mostly based on individual contacts.

CONCLUSION

And now, permit me to express some of my personal views. I understand that a Japanese novel, Five Rings (a samurai novel) was popular among American readers a few years ago. The translator of this novel, Charles Terry, an expert on the Japanese language, had a terrible time translating it into English. The problem stemmed from the fact that many Japanese ideas and expressions do not have ready equivalents in the English-speaking world, and vice versa. Of late, there are an increasing number of foreign residents in Tokyo who speak fluent Japanese. They are not language experts but are engaged in administrative, business or technological work in Japan. They are the people who must comprehend ideas expressed in Japanese that cannot be directly translated into English.

This sort of phenomenon indicates that a qualitative change is taking place on a higher level in the relationship between Japan and the rest of the world. What is expressed in words relates to the life of a given culture. Thus, the harder it is to translate an idea into another language, the closer that particular idea may be to the heart and core of that culture. In this sense, we may say that the meeting of East and West is taking place on a more genuine basis.

Science and technology has a philosophical foundation; namely the concept of nature and man; which is deeply rooted in the cultural heritage of a nation where it has been developed. In particular, creative ideas are often the fruit of different cultural heritages that meet each other.

Postwar America attracted a large number of energetic and talented youths from all over the world. In particular, meetings between leaders of European academia and young champions of American pragmatism have generated new and innovative scientific and technological breakthroughs which became a dominant force in the world. I would not be surprised if a similar situation should arise from a meeting of America, Europe and Japan.

We can regard Japanese production technology as a result of the meeting of industrial technology transferred from the West and the Japanese agricultural tradition. Some people compare the basis of the highly regarded Japanese quality control to Japan's traditional rice transplanting method, and that of the Japanese management system to the Edo society. The new age of science and technology may have come from deeper encounters between East and West.

The Japanese concept of the relationship between "nature and man" is different from the West. The Japanese emphasize harmony between nature and man, which serves as the basis of the Japanese concept of beauty. In architecture, art and music, the concept of space is also different between the two cultures. Japanese cherish empty space. Also, Japanese tend to give "personalities" to inanimate things. For example, a marked contrast between Japan and the West may be noted in the way robots are utilized. Some people say that, in Japan, robots are treated as if they are people.

In the coming age of science and technology, we must search for ideal relationships between nature and man, and machinery and man. I am hopeful that these relationships will emerge out of meaningful encounters between the Japanese cultural heritage and the cultural heritage of the West. There is an old saying, "A bridge must be built from both sides."

NOTES

1. Annual Report of Immigration Control, 1983, Ministry of Justice.
2. The Exploratory Research for Advanced Technologies is one of the three programs administered by JRDC. It has a budget of $20 million for fiscal year 1986.
3. The Research Development Corporation of Japan was founded in 1960 as a public corporation under the jurisdiction of the Science and Technology Agency.

Appendix I

Exchange of Researchers

(Unit: Person)

	Outgoing				Incoming			
	1980	1983	1985	85/80	1980	1983	1985	85/80
U. S. A.	12,468	15,271	20,069	1.61	1,565	2,591	3,250	2.08
England	1,556	1,906	3,021	1.94	355	778	1,017	2.87
France	1,685	1,702	2,151	1.28	149	256	416	2.79
W. Germany	1,523	1,724	2,153	1.41	176	301	340	1.93
Others	2,348	3,098	4,416	1.88	412	974	984	2.39
U.S.A. } Europe	19,580	23,701	31,810	1.62	2,657	4,900	5,962	2.24
Others	3,569	5,356	9,313	2.61	7,713	24,002	32,839	4.26
Total	23,149	29,057	41,123	1.78	10,370	28,902	38,801	3.74

Source: The Ministry of Justice, Annual Report of Immigration Control

The purposes of travel; research; study; technical training

Disciplines covered include social sciences