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ABSTRACT

This colloquium was held with the purposes of promoting cooperation and collaboration among engineering education institutions in the Mekong subregion and establishing the linkage with engineering institutions in France; to promote university-industry collaboration in the field of engineering and technology education; to establish a network of engineering and technology education in the region; and to plan for further cooperation between France and SEAMEO RIHED (Southeast Asian Ministers of Education Organization and Regional Center for Higher Education and Development) in the future. This report serves as a source of information not only for engineering and technology institutions and the educators who work there, but for the private sector as well. The report is divided into four sections: (1) Introduction and Opening Speeches; (2) Papers (from France and Canada); (3) Country Reports (Cambodia, China [Yunnan], Lao PDR, Malaysia, Singapore, Thailand, Vietnam); and (4) Recommendations. The Keynote Address, by Professor Roger G. H. Downer, provides insight into the problems and issues involved in the provision of quality engineering education in the region, and suggests remedies to be pursued. The papers are as follows: "Pan-European Training: the Case of Cesi" (Monique Le May); "Trends in Engineering Education" (Jean Francois Mela); "How To Become a Qualified Engineer by Apprenticeship" (Christian Rumelhard); "The Challenges of Cooperative Engineering Education" (G. E. Schneider); "Thai-Canadian Collaboration in Human Resource Development" (S. A. Boctor); "Quality Assurance in Engineering Education: Engineering Accreditation in Canada" (F. Hamdullahpur); and "University-Industry Linkages in Environmental Engineering" (L. Otten.) Two annexes contain a program and a list of participants. (AEF)

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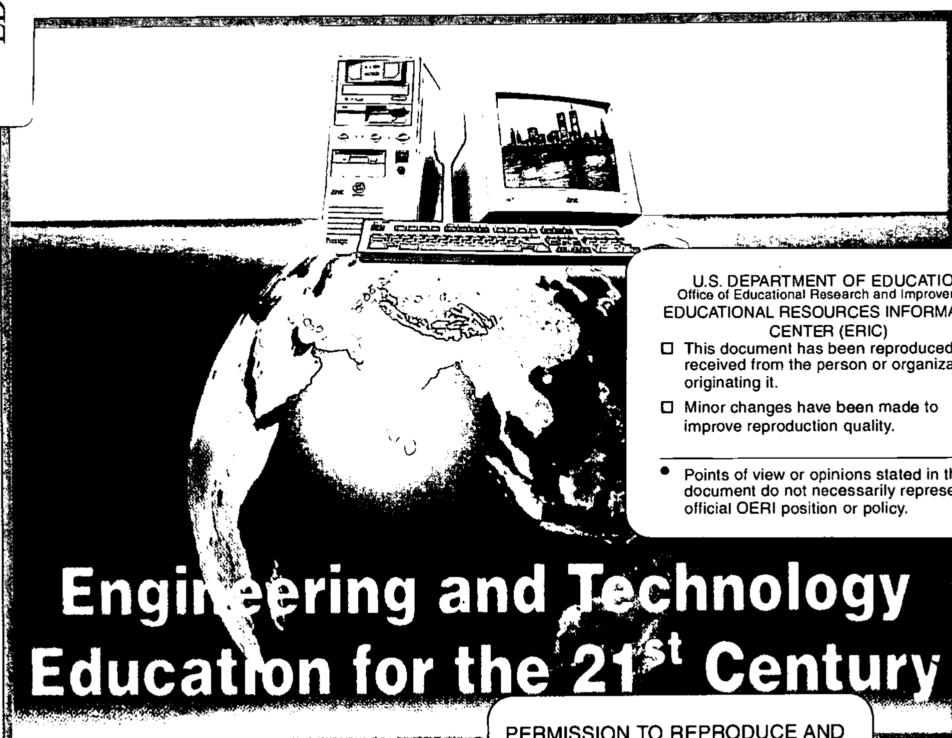

Engineering and Technology Education for the 21st Century

A report from the
REGIONAL COLLOQUIUM ON ENGINEERING AND TECHNOLOGY EDUCATION FOR THE 21ST CENTURY

held at
Suranaree University of Technology
from 11-14 February, 1997

organized by SEAMEO RIHED and AUAP with the support of the French Government

Edited by Kevin C. Kettle

SOUTHEAST ASIAN MINISTERS OF EDUCATION ORGANIZATION
REGIONAL CENTRE FOR HIGHER EDUCATION AND DEVELOPMENT

Engineering and Technology Education for the 21st Century

Editor: Kevin C. Kettle

SEAMEO RIHED

SEAMEO Regional Centre for Higher Education and Development
5^{th} floor, Ministry of University Affairs Building
328 Sri Ayutthaya Road, Rajthevee, Bangkok 10400, Thailand.
Tel: (662) 644-9856-63, 644-5418, 644-5491, 2461106-14 Ext. 518, 523
Fax: (662) 644-5421
E-mail: rihed@mis.mua.go.th

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edited by Kevin C. Kettle

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Section One: Introduction and Opening Speeches

Introduction by Dr. Tong-In Wongsothorn, Director, RIHED

Introduction

The "Regional Colloquium on Engineering and Technology Education for the 21st Century" was organized by Suranaree University of Technology (SUT), AUAP, and SEAMEO RIHED, with the support of the French Government. It is recognized that quality engineering education is needed in national development processes, especially in SEAMEO Member Countries. Engineering education institutions in these countries are at different stages of development and there is thus a great need to share resources and experiences among these institutions, so that quality engineering education can be promoted. Furthermore, the need for these institutions to establish linkages with industries is necessary in order to make higher education relevant to the world of work.

This Colloquium was a follow-up activity to the "Colloquium on Engineering and Technology Education for Southeast Asia in the 21st Century", held from 9-10 January,1995, which was organized by the Ministry of Education and Culture of Indonesia, RIHED and SEAMES; and the "Colloquium on University-Industry-Government Cooperation in Quality Engineering and Technology Education for Southeast Asia in the 21st Century", held from 27-28 July,1995, which was organized by Suranaree University of Technology (SUT) in collaboration with UNESCO, UNISPAR and SEAMEO RIHED.

The Colloquium was thus a continuation activity and a response to the need to improve the status of engineering education in the region. The support of the French Government was sought as France has an advanced technology and engineering education. The active involvement of AUAP was essential as AUAP embodies the spirit of cooperation among universities of the Asia - Pacific region; and the sharing of resources among the engineering institutions in the region will enable the achievement of international standards. The link between engineering institutions and industries is essential and in this area SUT is a pioneer in Thailand, developing cooperative education in the engineering curricula. In the implementation of continuing education, SUT is well placed to collaborate with SEAMEO RIHED and AUAP, to meet regional needs.

Thus, SUT, AUAP, and SEAMEO RIHED , with the support of the French Government , held the Colloquium with specific purposes in mind. They were : to promote cooperation and collaboration among engineering education institutions in the Mekong subregion and establish the linkage with engineering institutions in France; to promote university-industry collaboration in the field of engineering and technology education; to establish a network of engineering and technology education in the region; and to plan for further SEAMEO RIHED- French cooperation in the future.

The objectives outlined above have already been achieved. Following the recommendations (see section 4 of this report) of the Colloquium , future activities are already planned. SEAMEO RIHED - French cooperation will be realized on "A Regional School on Mathematics for Applications in Science and Technology"; SUT and AUAP are cooperating on short training courses; the network APCEEN (Asia- Pacific Continuing Engineering Education Network) has been approved by the AUAP Governing Board; and another colloquium with the focus on university-industry linkage will be hosted by the government of Malaysia, in early 1998. RIHED will cooperate on this colloquium as well.

The Colloquium was thus a resounding success which resulted in quick and positive actions. This report is in four sections. Section one includes the opening addresses, which help further explain the rationale behind the Colloquium and the part each collaborator can play. The Keynote Address by Prof. Roger G.H. Downer, provides insight on the problems and issues involved in the provision of quality engineering education in the region, and suggests remedies to be pursued. The valuable inputs from the French and the Canadian experts are included in section two. Section three covers the country reports, and section four the recommendations.

It is hoped that this report will be of great interest and a source of invaluable information not only for engineering and technology institutions, and their educators who work there, but for the private sector too. Furthermore, this report can act as the basic manual upon which to further develop the process of the provision of quality engineering education, the promotion of university-industry linkages, and the promotion of collaborative inter- institutional efforts.

Dr. Tong-In Wongsothorn.
Acting Director. RIHED
October 1997

Speech of H.E. Mr. Montri Danphaiboon, Minister of University Affairs of Thailand

Speech of H.E. Mr. Montri Danphaiboon

Prof. Dr. Wichit Srisa-an,
Rector of Suranaree University of Technology and
President of the Association of Universities of Asia and the Pacific,

Mr. Jean Claude Terrac, Cultural Counselor of the French Embassy,

Prof. Dr. Roger Downer,
President of the Asian Institute of Technology,

Dr. Tong-In Wongsothorn, Director of SEAMEO RIHED,

Professors and Speakers from France,

Professors and Speakers from
the Canadian Universities of Technology Consortium,

Distinguished Participants and Guests,

Ladies and Gentlemen,

It is a pleasure to be with you this morning through the wonders of modern communication technology of teleconferencing. It is with regret that previous commitments in Bangkok prevent me from joining you in Nakorn Ratchasima.

I am indeed delighted to have some moments with the distinguished speakers and participants to share ideas and challenges of the very important topic of engineering and technology education for the 21st century.

I, therefore, would like to congratulate the organizers Suranaree University of Technology, SEAMEO RIHED and the Association of Universities of Asia and Pacific, of which the Secretariat is at SUT. I commend very highly their efforts in organizing this colloquium on a very timely theme.

May I warmly welcome the delegates from Cambodia, Canada, France, Indonesia, Laos, Malaysia, Philippines, Thailand and Vietnam.

I would like to express my great appreciation to Mr. J. C. Terrac and Professor Georges Camy of the French Embassy for the support given by the French Government and for the participation of French experts in this colloquium.

Equally, I would like to acknowledge the invaluable contributions of colleagues and friends from the Canadian Universities of Technology Consortium headed by Prof. Dr. Roger Downer of the University of Waterloo but now the President of the Asian Institute of Technology.

Ladies and Gentlemen,

The great and rapid scientific and technological advances in developed countries have underscored the need for improved engineering and technology education in the Southeast Asian region. If we want to attain the same degree of economic growth and development, we need a highly standardized international quality engineering education in our region.

Thus, if attainment of technological self-sufficiency is to be the goal of Southeast Asian countries in the next century, then universities in the region must provide high quality engineering and technical education now.

The other problem we have is the university-industry linkage. In our region, this linkage is still weak. We need to strengthen this linkage. I would like to commend Suranaree University of Technology for integrating cooperative education into the third and fourth years of the engineering curricula.

It is pleasing to see representatives from the private sector in attendance at this colloquium here today as this will lead to a better understanding of university-industry linkages. From their valued inputs, it will be possible to create strategies as well as policies for the continuous quality improvement of engineering and technology education; and the strengthening of university-industry education collaboration.

I am happy to learn that the colloquium will discuss ways and means to improve continuing education for engineers. This is very important for professional growth and development. It is also necessary for maintaining one's competitive advantage. This needs close collaboration between universities and industries. Such continuing education could be local, national, and international.

It is in the implementation of continuing education that universities like SUT and KMIT can collaborate with regional organizations like SEAMEO RIHED and AUAP in meeting regional needs. Collaboration can also be extended beyond the region in the same way as France and Canada.

In closing, I would like to reiterate my warm welcome to all the speakers and participants, my congratulations to the organizers and appreciation to the French government and the CUTC for their support. I wish you a pleasant stay at Suranaree University of Technology and in Nakhon Ratchasima. I join Dr. Wichit Srisa-an in recommending the tourists sites of Thailand, especially in the Northeastern region. I am confident that the discussions will be most fruitful. The Ministry of the University Affairs eagerly awaits the documentation of this colloquium.

Thank you.

Opening Speech of Prof. Dr. Wichit Srisa-an, Rector of Suranaree University of Technology and President of AUAP

Opening Speech of Prof. Dr. Wichit Srisa-an

H.E. Mr. Montri Danphaiboon,
Minister of Ministry of University Affairs of Thailand,

Prof. Dr. Roger Downer,
President of the Asian Institute of Technology, Thailand,

Dr. Tong-In Wongsothorn, Director of SEAMEO RIHED,

Mr. Jean Claude Terrac and Dr. Georges Camy of the French Embassy,

Dr. Francois Mela, President, University of Paris 13,

Colleagues from the Canadian Universities Technology Consortium,

Distinguished Speakers and Participants,

Ladies and Gentlemen,

On behalf of Suranaree University of Technology, as well as of the Association of Universities of Asia and the Pacific or AUAP and myself, I would like to extend a warm welcome to all the participants and guests from Canada, Cambodia, France, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand and Vietnam.

The organizers, SUT, AUAP and SEAMEO RIHED are grateful to H.E. Mr. Montri Danphaiboon, Minister of the Ministry of University Affairs of Thailand for honoring us by his presence in Bangkok and with his address which will be delivered via teleconferencing mode.

Our gratitude also goes to Prof. Dr. Roger Downer, President of the Asian Institute of Technology for accepting the invitation to deliver the keynote paper.

It is also my pleasure to welcome our colleagues from the Canadian University of Technology Consortium or CUTC for coming to share with us their experiences in engineering education.

Last, but not least, is our great appreciation and gratitude to the French Embassy, specially Mr. Terrac and Dr. Georges Camy, for the financial support and the invitation to Prof. Dr. Jean Francois Mela, President of University of Paris 13 and other speakers from France.

Ladies and Gentlemen,

Since Suranaree University of Technology admitted its first batch of engineering students only four years ago, we should have one of the most recent engineering curricula in the country. However, with the information explosion and the fast changes in the various fields of engineering and technology, revisions in engineering curricula would still be inevitable if we want our graduates to effectively cope with the ever increasing and varied challenges of the 21st century.

Quality engineering and technology education must be provided if industrialization and the socio-economic gains the region are now enjoying are to be sustained, if not enhanced.

Therefore, in the spirit of cooperation among universities of the Asia-Pacific region as embodied in AUAP, there is a great demand for sharing resources and experiences among schools of engineering so the engineering education of international standards could be achieved in the region.

Engineering and technical education must be closely linked with demands of industries and for engineering education to be relevant to the world of work. Suranaree University of Technology has pioneered in Thailand the inclusion of cooperative education in the engineering curricula. SUT is quite successful in placing the third and fourth year engineering students not only in local industries but also abroad like in Canada, Germany and the Scandinavian countries. With the establishment of the TECHOPOLIS, SUT is able to partner with industries in research and in some other joint ventures. University - industry linkage must still be enhanced in the region.

Education is also no longer a one-time event in the life of an individual. It is a life-long process. Continuing education of professional engineers must be provided jointly by universities and industries if they are to maintain their competitive advantages in the present international business environment. New skills and knowledge must be acquired to prevent professional obsolescence. SUT, together with other members of AUAP, therefore plan to provide such continuing education courses in engineering.

Thus, this Colloquium aims to tackle and discuss issues on revision of engineering curricula to meet the demands of the next century, suggest strategies for enhancing university-industry linkages and partnerships, as well as plan provisions for life-long or continuing engineering education. SUT and AUAP are happy to be part of this discussion.

Finally, I wish you a pleasant stay at SUT and Nakhon Ratchasima. I hope our foreign guests would find time to enjoy also the cultural and tourists attractions of the country. I look forward to receiving the suggestions and recommendations from what I am confident will a very successful and fruitful meeting.

Thank you.

Speech of Mr. Jean Claude Terrac, Cultural Counselor of the French Embassy in Thailand

Speech of Mr. Jean Claude Terrac

His Excellency, Minister Montri Danphaiboon,

President Prof. Wichit Srisa-an, Dr. Tong-In Wongsothorn,

Distinguished Speakers and Participants,

It is a great pleasure and honour for me to participate in the opening ceremony of this Regional Colloquium on Engineering and Technology Education for the Twenty- First Century.

On this occasion I would like to remind you that the President of the Republic of France, during his official visit to Singapore on 1 March 1996, expressed his great interest in improving linkages between France and Southeast Asian countries.

As a matter of fact, France has already demonstrated its keen interest in cooperating with the countries of this region in the field of higher education . We could mention for instance the cooperation with the Franco- Singaporean Institute or with the Institute of Technology of Cambodia or here in Thailand, with the Thai-French Innovation Centre.

In December 96, we already organized, in cooperation with SEAMES, a regional seminar on the same subject and I would like to remind you of some of the recommendations which came out from this exercise.

It was recognized that the cooperation between France and SEAMEO Member Countries should now rely on a real partnership rather than an assistance.

It is of great importance for SEAMEO countries to create a high standard of training in engineering in order to answer to their social and economic needs.

A possible strategy could consist of twinning French and Southeast Asian engineering institutions and to get support from French industries established in the region, as well as from other institutions already supported by France. The cooperation prospects should include research activities developed with the contribution of young French scientists.

Simultaneously, a cooperation should be developed to facilitate a better public understanding of science and technology in the various fields of cooperation, priority should be given to the needs of SEAMEO countries, and the themes and fields of excellence in French universities.

Starting from these recommendations it is expected that this Colloquium will constitute an active forum leading to the establishment of strong linkages between engineering institutions in France and in SEAMEO member countries.

Before ending this speech, I would like to express my sincere thanks to all the organisers of this Colloquium and particularly to Dr. Tong-In , Director of RIHED, and to Dr. Wichit, President of Suranaree University of Technology, for his warm hospitality.

Finally, I wish you all, distinguished participants, the best success in your work during these two days.

Thank you for your attention.

Keynote Address by Prof. Roger G. H. Downer, President of the Asian Institute of Technology

The Education of Engineers for the 21ST Century

Prof. Roger G.H. Downer

I would like to begin by indicating my great pleasure at being present at this Colloquium and assuring you that I am honored to be invited to present this Keynote lecture. I have heard much about Suranaree and its distinguished President and I am delighted to visit both it and him. It is said that "every clown wants to play the role of Hamlet" and, by similar reasoning, let me state that "every scientist wants to play at being an engineer". Today, you have given me that opportunity.

I emphasize my lack of formal training in engineering because I am speaking today from the perspective of an informed outsider - someone who is not a professional engineer but who has been fortunate enough to have been thrust into leadership roles in two institutions with strong programs of teaching and research in engineering - namely the University of Waterloo and the Asian Institute of Technology. Thus, I have had cause to reflect upon the topics of this Colloquium and it is these personal reflections that I wish to share with you today.

However, at the outset, it is useful to recognize the importance of the exercise in which we are engaged and, in this regard, for the next few minutes I will confine my remarks to the teaching and training of engineers for Thailand. A 1992 study reported that of all university graduates in Thailand, only 13% graduated in fields related to Science and Technology. By contrast, the figures for Taiwan and Malaysia were 56% and 47% respectively. Things are improving somewhat, but it is evident that Thailand must make a much greater effort to increase the number of engineering graduates especially when we see the enormous national effort of countries like Malaysia to produce more engineers. This shortage of engineers is emphasized by the fact that between 20-30% of advertised positions for engineers in Thailand remain unfilled. An even more disturbing finding is contained in a 1993 study conducted by the world Economic Forum which examined the quality of engineering graduates in 15 newly industrialized nations and placed Thailand in 10th place and behind all other SE Asian countries. Thus, the topics of this Colloquium are of central importance to the long-term economic growth and future of this country and new universities like Suranaree University of Technology have a pivotal role and responsibility to ensure that there is a cadre of well-trained, competent engineers to meet the needs of Thai industry.

With this justification for our existence, let me proceed to reflect on the first of the three themes of the Colloquium-engineering education for the 21st century. My selection of this theme is quite ambitious because, in my career I have had much involvement with continuing education and extensive experience in building sound university-industry interactions but very little experience in the design of curricula for engineering. Thus, I have chosen to speak on the topic about which I know least. My hope is that, as a result, my views will be somewhat original and perhaps even controversial.

I will introduce this topic with a personal analysis of the historical background of engineering in universities and, in researching this, I was assisted greatly by two sources-a series of essays by Lord Ashby titled "Technology and the Academics" and several conversations with and some personal notes of Dr. Douglas Wright, a distinguished structural engineer and former President of the University of Waterloo.

The central thesis advanced by these scholars is that engineering was not readily accepted as an academic discipline and, for much of its history, university engineering had to work hard to justify its existence. Ashby and Wright suggest that this is because the industrial revolution in the 19th century did not originate in the universities. The Arkwrights and Dardys had little or no formal education-they were amateur inventors and self-made men. Thus both science and technology developed independently of universities. Indeed, it is suggested that the traditional sources of power in the British universities-the Church and the landowners-resented the new wealth produced by industry. Thus, when science was, somewhat grudgingly, accepted by universities, it had to be "pure", a matter of scholarly enquiry and certainly not to be used to further advantage the new industrial rich. This attitude unquestionably affected the nature of the engineering curriculum in British universities-it reflected a culture that was somewhat hostile to research and technological change. Indeed, it is highly significant that when Ruther Ford discovered that radio waves could be modulated and, therefore, could form the basis of transmitting information, he dismissed the finding as not of great academic interest-it was left to Marconi to develop and exploit this discovery.

I do not mean to suggest that engineering education was poor. Far from it, and there are many sterling examples of university research in engineering which has led to important practical advances. But I feel that the trend in the 60s and 70s towards engineering science, driven in part by advances in finite mathematics and the power of the computer, has resulted in engineering education in the UK being dominated by analysis with less emphasis on synthesis and creativity in design and productivity which are, in my judgment, the basis of the engineering profession. This emphasis on analysis, I am sure, resulted from the legacy of engineering's acceptance by the universities and the desire to legitimize the field as a worthy academic enterprise.

Before leaving this somewhat simplistic historical perspective, I would be remiss in a colloquium sponsored in part by the Government of France, if I did not refer to the difference between the United Kingdom and France. It was Napoleon who introduced "Les Grands Ecoles" including L'Ecole Polytechique which were dedicated to the training of an elite. This concept was widely adopted in continental Europe and, indeed, the first university-level engineering school in the US, bore the French name "Polytechnique" - Rennselear Polytechnic in Troy, NY. In these schools, engineering was seen as an appropriate general education for a career in an industrialized society. Thus, in the US engineering graduates were seized by industry and held senior positions in industry whereas, as recently as the 1950s in the UK, the machine tool industry which was still a major supplier to the world, hired only two engineering graduates.

It is with this historical background that I now propose to venture into a consideration of what is needed for engineering education in the 21st century and I will address this within the context of a classic engineering flow chart which can be applied to any production process.

Let us consider briefly, each of these elements in the production of a graduate engineer for the 21st century.

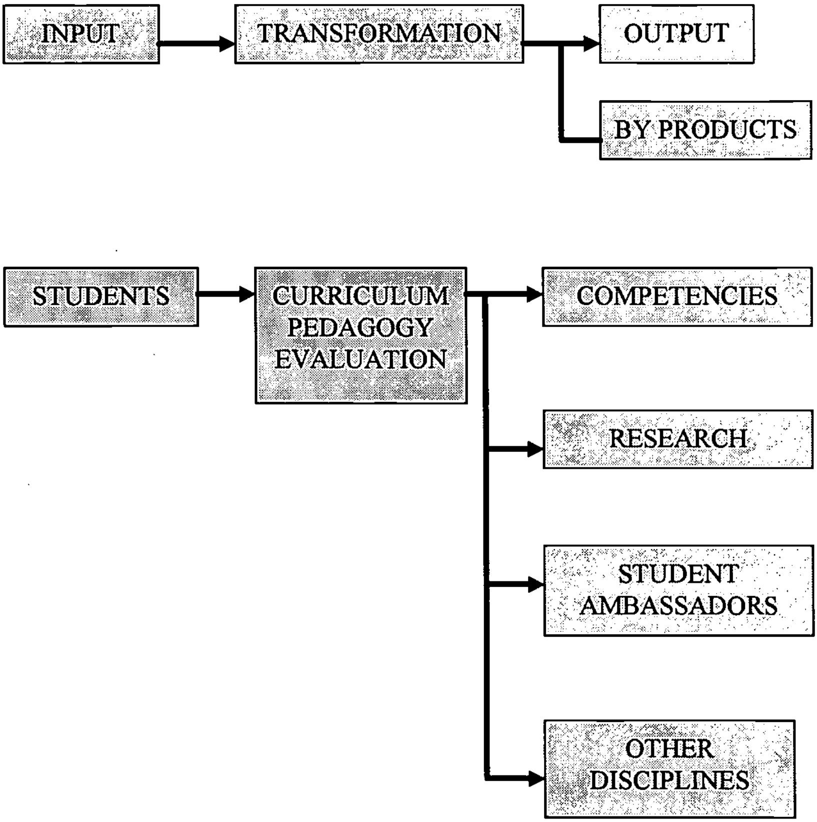
I am sure you will agree that the first consideration for any production engineer is the supply and quality of the raw materials that will be transformed into the final product. Any university that is involved in the training of engineers must be equally concerned about the supply and quality of the students who are entering the Institution. I do not have a great deal of background upon which to base my comments on this topic but, from the conversations that I have had with professors in a few Asian universities, I believe that there is room for improvement.

I am told that the students' background in science, mathematics and English is not adequate and that they have been educated in a system which stresses rote learning and memorization of facts rather than in one which encourages assimilation and problem-solving ability. If these criticisms are true, then universities have a problem which should be addressed. Indeed, I would suggest that universities have a responsibility to work with the secondary schools in order to raise the quality of education provided to pre-university students. Universities have a responsibility also to ensure that the best students are encouraged to pursue careers in science and technology - the earlier statistic reporting only 13% of graduates had chosen S&T suggests that there is much room for improvement in this regard. In particular, it is important to ensure that young women are encouraged to think of S&T as an appropriate field of study. I would suggest that universities send their most exciting and dynamic teachers to the schools, stage summer engineering camps for the brightest students, organize weekend lectures, produce news bulletins in simple, easy-to-understand language and work with teachers to improve their access to and understanding of latest developments. In other words, universities should be a partner and resource for schools, not only for curriculum development but also for promotion and raising public awareness of the importance and excitement of S&T. In this regard, it is important to recognize that, although most people in this room tend to view technological development in a positive light, this view is not universally held-particularly among young people. Rather than it being a positive force in improving the quality of our lives, many equate technology with such evils as Chernobyl, nuclear war, acid rain, pollution, destruction of the ozone layer. Technology is viewed as a menace rather than a salvation. Therefore, it behoves those of us who are involved in technological research and the training of engineers to spend some time improving the image of science and technology, demonstrating its virtues and, thereby, identifying it as an attractive career option for bright, talented young men and women.

Having talked about the quality of incoming students-the input-let us turn now to the transformation; how do we turn this raw material into the type of highly trained engineer who will be a valuable, contributing member of our society in the future.

You will see that I have identified three elements in the transformation process-curriculum, pedagogy, and evaluation-and, as you might expect, I will deal with them sequentially. (Figure 1)

FIGURE 1 : PRODUCTION FLOW-CHART



CURRICULUM *:* Clearly, given my background, it would not be appropriate for me to attempt to deal with the technical subjects that should be part of the curriculum in Departments of Chemical, Civil, Electrical, Mechanical or any of the other sub-disciplines of engineering. This falls within the purview of the professional engineering community and, indeed, is beyond my competence. However, there are some general observations which I will offer and which I feel should be considered in the design of curricula.

The first I have already alluded to in my historical perspective and that is the need to recognize that the practice of engineering requires practical knowledge. I do not dismiss the importance of analysis and, of course, the rigorous computer-based analyses which have characterized much of academic engineering research in the last decade has increased greatly our understanding of, and our confidence in, engineering principles. But we must never forget that most of our students will become practicing engineers and they have to do, as well as, theorize.

The second observation about curriculum is fueled by a recent article in the January 1997 issue of "Engineering Australia" in which Dr. Knuth Henneke (VP, Human Resources for ABB of Germany) comments on the increasing importance of globalization in the practice of engineering. He states emphatically that industry needs young engineers who have been exposed to industrial experience, to principles of sound management and to the realities of economics. Furthermore, they should have some knowledge and experience of international business and an understanding of the myriad of factors that can be influenced by technological development.

Obviously we cannot think of everything. No one could have predicted the impact of the automobile. When Henry Ford pioneered the production of a car that was available to the masses, it was thought of as a more convenient way to go to the store and to church than the horse and buggy. People did not anticipate how it would change the nature of their villages and towns, lead to the creation of cities, expand trading horizons, open up the world to exploration, pollute the air and become the backbone of Western economy.

Although, we cannot expect our young engineers to be so far-seeing, they must at least have an awareness of social and environmental considerations in the implementation of new technologies and this awareness must be provided through an undergraduate curriculum which exposes students to more than simply the technical aspects of engineering.

Finally, in my general observations about curriculum, I wish to make a strong appeal for the inclusion in modern engineering curricula of entrepreneurism. I make this plea with some trepidation because I am not entirely certain about how to teach or to create entrepreneurs. However, I believe strongly that the opportunities for bright young engineers to develop new businesses which create new jobs and wealth are greater now than at any time in the last fifty years. The reason is based in what has come to be called the New Economy. Ever since the middle of the 19th century, industry has been highly capital-intensive with a considerable investment required in order to set up the mill or the production plant. Thus, the drivers of industrialization for most of this century have been capitalists who employed engineers as salaried employees.

However, within the last decade, it has been possible once again for bright engineers to create and grow new types of industries which do not require large initial capital investments. Such industries can rapidly produce wealth and large market capitalization values. They are easy to start and are the essence of the new economy. The reason, of course, for the lack of need for start-up capital is that these businesses are knowledge-based and the principal product is information.

The economic impact of these industries is considerable and if you question this statement, let me give you an astonishing fact. Last year, the total world GDP increased while there was an economic depression in energy and natural resource commodities-the first time in the history of the world that this has occurred. For the first time, human resources and knowledge are more important than natural resources and, of course, this is why some of the most successful economies in the world-Switzerland, Germany, Japan-are resource poor but technology rich.

This is why I stress that our engineering curricula must expose our students to the principles of entrepreneurism-provide them with case studies, explain the development of business plans, the importance of market surveys, competitive advantage and basic accounting procedures. I am convinced that from the pool of young Asian engineers there will emerge another Bill Gates and a multi-billion dollar company that was started on a shoestring in a basement room.

PEDAGOGY : Having recruited the brightest students and determined the content of the curriculum that they should be taught, let us now turn our attention to the manner in which this curriculum should be taught.

The first point that I will make in this regard should come as no surprise to those of you who are aware of my extensive involvement with the University of Waterloo. This university is strongly committed to experiential learning and, indeed, operates the largest cooperative education in the world with about 10,000 undergraduate students alternating terms in the classrooms and laboratories of the university with on-the-job practical experience in the public and private sectors. As a result, when students graduate they have a great deal of practical experience to complement the theory that they learned in university. They can appreciate much more the applied aspects of what they have learned in the classroom and, of course, they enhance the quality of classroom tutorials by being able to share their experiences with teachers and other students.

I suppose a simple analogy would be to try to learn to play golf by studying books and videos and swinging clubs in the back garden; but it is only by stepping onto the first tee and playing a round that you really become a golfer.

Thus, my first point in pedagogy is that experiential learning is the preferred way of training engineers and the Waterloo model is worthy of emulation. This, by the way, is clearly evidenced by the high demand by industry for Waterloo graduates e.g. the aforementioned Bill Gates of Microsoft hires more students from Waterloo than from any university in the world.

The second comment that I would make about pedagogy is the importance of encouraging students to think and solve problems. If I have a major concern about much of the university teaching that I see, it is that there is an over-emphasis on facts and a neglect of assimilation and synthesis of ideas. Don't misunderstand what I am saying. Facts are important and, of course, form the essential core of information on which the discipline is based, but what is of key importance ultimately is how those facts are used. I would prefer to see much of the factual material in many courses presented through videos and CD ROMS so as to allow professors to spend time interacting with students in tutorials and discussion groups. Students must be encouraged to ask questions, to seek creative solutions to problems and to present their views in a clear, logical manner. As we all know, the engineer who is unable to communicate effectively with clients and peers in both written and oral form is severely disadvantaged professionally.

EVALUATION : The points that I have made about pedagogy impinge also on evaluation. All too often, I feel that we evaluate our students on their ability to remember facts and restate established dogma. This is, of course, important but, as I have tried to indicate, there are other important qualities associated with being a successful engineer. At the very least, each student should be evaluated also for her/his problem solving abilities and his/her communication skills. The university which insists on a high degree of competence in these areas will readily establish respect and confidence among prospective employers and the currency associated with their degree will rise in value.

BY-PRODUCTS : Any successful manufacturing process will endeavor to ensure that, in addition to the primary product, there are marketable or desirable by- products which add value and enhance the cost-benefit analysis of the operation. I believe that the production of engineering baccalaureates is no different and I have suggested three by-products which can result from a properly organized School of Engineering.

RESEARCH : One of the most frequent complaints that I hear from faculty is that, "I don't have time to do research" and one of the saddest comments that I hear from undergraduates is that "I didn't know Prof. X did research". Professors who spend time telling their students about their research are usually rewarded with great interest and, often, some very good ideas. The students, of course, are usually caught up in the excitement of the professor's enthusiasm for his subject. Often students will volunteer to provide the extra pair of hands in the laboratory and indeed can become valuable contributors to the research endeavor. Therefore, I urge you to recognize the research potential of undergraduate students.

STUDENT AMBASSADORS : The former President of the Universite de Campeigne in France once described the importance of students in disseminating research ideas in a delightful phrase. He said "Students are to research what mosquitoes are to malaria". In other words, students who travel between the university and industry are vectors who spread news and ideas and carry them in both directions. This role of students is particularly evident under the format of cooperative education where students go into industrial laboratories and tell about the ideas that they have learned from their professors and then return to the university to tell about what they saw and experienced in industry. Many major industry-university collaborations have resulted from this type of ambassadorial role.

OTHER DISCIPLINES : The final by-product which I will mention is of more significance to broadly based universities in which engineering is only one of many disciplines. However, it is important enough to include in this address. The Oxford Dictionary still refers to a liberal education as the education that befits a gentleman. It is still an acceptable definition as long as we understand that the role of a gentleman has changed. The gentleman is no longer a member of the leisure class-more often, he works 70-hour weeks and needs expert knowledge on a great many topics, including technology. Therefore, a strong case can be made for the inclusion of technology as an essential component of all university education - indeed it could be the cement between humanism and science. Thus, just as I argued earlier for some breadth, diversity and generalism in the education of engineers, so I will suggest that engineering subjects can enhance greatly the quality and value of undergraduate courses in the Arts and Humanities.

COMPETENCIES : All of this leads us, of course, to the final product - the graduate engineer of the future. What kind of skills and abilities do we want him/her to have. I have indicated many of my preferences during this talk and, of course, this is really where we should have begun. Because, it is difficult to design a production line if you do not know what it is that you want to come off the other end.

At the outset, we want our graduate to be knowledgeable in the technical aspects of the engineering profession and this is what I have left to you the professional engineers. What I am advocating are the value-added components. Those features which will make our product more competitive in the market and more capable of representing their company and their country in the international market places of the future.

The value-added components that I would like to see include :

Flexibility- We do not know what the technologies or the needs of the future will be : few of us, fifteen years ago in 1981 would have predicted the impact of the PC, the fax machine, the CD ROM, the mobile phone and we are just as unlikely to be able to predict what the important technologies will be sixteen years or even ten years from now. Our graduates must be flexible, adaptable, capable of embracing new technologies and adjusting to change-hence my emphasis on assimilative and problem-solving abilities and creativity.

Entrepreneurism- Whether our graduates are entrepreneurial and create new businesses for themselves or whether they are intrapreneurial and create opportunities for their companies, our graduates must be opportunistic, recognize business opportunities when they surface and pursue these aggressively in order that the potential is fully realized. This ethos of opportunistic entrepreneurism must be instilled in our graduates and they must be provided with the knowledge to capitalize upon the opportunities that become available.

Confidence- if our graduates are to compete successfully in the international market places of the future, they must have the confidence to take on the rest of the world and challenge them to be better. This confidence comes from excellent training during which students are encouraged to speak and challenge dogma and propose new ideas.

Communication- I emphasize again the importance of communication skills for the modern engineer. Although such innovations as E-mail and voice-mail are tending to reduce the quality required for some forms of communication, there will always be a need for the preparation of good accurate reports and compelling oral presentations. I would stress also that, in the light of my earlier comments about globalization, the importance of a competency in English and perhaps even another foreign language should not be underestimated. The successful global businessman will function in several languages.

Thus, I offer you the successful engineer of the future. Technically competent, highly adaptable, entrepreneurial and instilled with the confidence and communication skills to be a major player in the highly competitive but extremely lucrative, global business environment of the 21^{st} century.

I will conclude with one more observation and this concerns universities which, from my perspective as a biologist, are among the most successful institutional species that the world has ever seen. It is salutary to reflect that of all the institutions and organizations and constitutions which existed in Europe 400 years ago, less than 70 have survived to today in more or less unaltered form. Those that have include the government of the Isle of Man, the Roman Catholic Church and over 60 universities. Universities survive because they are able to change - but in a carefully controlled manner and in response to a change in the role that they have had to play. Thus :

Early Universities of Bologna and Salerno functioned to train professionals in theology and medicines;

Later Oxford and Cambridge provided education for gentlemen, statesmen and administrators;

Then Gottingen and Berlin became the centers for research and scholarship ;

More recently Zurich and MIT became staff colleges for technological experts.

I am supremely confident that the relatively minor changes which I am advocating in the training of engineers will be made and that, as a result, the universities of SE Asia will produce the kind of graduates required to ensure economic growth and an improved standard of living for the Region. I look forward to working with you to achieve this worthy goal.

Section Two: Papers

FRANCE

Pan-European Training : the case of cesi

by Monique Le May,
International Project Manager, cesi

Pan-European Training : the case of cesi

Monique Le May,
International Project Manager, cesi

HISTORY AND EVOLUTION

In 1958, thirteen years before training became a legal requirement for French companies, five French industrial groups (Renault, Telemecanique, SNECMA, CEM and Chausson), decided to join forces in training their engineers by founding **cesi**.

cesi has since become one of the largest private training organizations in France. It is managed by a board which is made up of representatives of Renault, Air France, Pont-a-Mousson, IBM France and Rhone-Poulenc, and in addition, senior representatives of the five trade union confederations in France as well as CNPF and UIMM, both French employer's associations.

While staying faithful to its founding principles and being aware of companies needs **cesi** has broadened its scope of activities by developing complementary areas of expertise. In this way it has achieved international status. Today **cesi** is a ***Pan European training group***.

REGIONAL, NATIONAL, INTERNATIONAL

France

- A large network in France and overseas : 30 local regional branches, close to the clients whom they serve and to their socio-economic environment.
- 35 years experience of training adults.
- 5 million manhours of training each year.
- More than 480 employees and 3,000 associated experts or business professionals, to ensure a continuous response to market needs.
- A research and development centre for education technology which is recognized at international level.
- A national organization for consultancy and training in the sectors of healthcare.
- A recruitment consultancy : Resources S.A.

Europe

- A Spanish company, COFOR S.A., specializing in consultancy, training and recruitment.
- A Belgian company, AGENOR S.A., which runs the European Community's FORCE Programme (Continuing Training in Europe) jointly with its Spanish, German, and Greek partners.
- A German company EWA GmbH in partnership with BULL Germany, to develop training programmes in the five new German Landers.
- A Department of European Studies, in charge of developing research and consultancy.

PROFESSIONAL QUALITY

The **cesi** group is an active member of the following French organizations :

- UNORF (National Federation of Training Organizations).
- Conference des Grandes Ecoles (Association of "Grandes Ecoles").
- AFREF (the French Association for the Promotion of Training).
- ADITE (the French Association for the Promotion of Educational Technologies).
- ARDEMI (a Regional Consortium for the Development of Multimedia Training Material).
- " Reseau Formation ", a professional training magazine.

At European level the **cesi** group is also a member of :

- IEFP (the European Institute for Vocational Training),
- SEFI (the European Society for Engineering Education),
- SATURN (the European Association for the Promotion of Open Learning in Europe),
- EITA (the European Information Technology Association).

cesi is accredited by the OPQF, (Professional Office for the accreditation of training organisations); many **cesi** institutions have been certified under ISO 9001, others are in the process of certification.

SERVICES OFFERED BY THE CESI GROUP

Training, surveys, consultancy and project monitoring are the services the **cesi** group provides each year for large, medium and small companies, and organizations in sectors such as metal working, construction, civil engineering, chemical engineering, electronics, the aircraft industry, information technology, banking and finance, insurance, health care, civil service, transport and the defence industry.

Management training is the core service offered by the **cesi** group. In this field, **cesi** is number one in France. To face the current challenges of economic development, the training services offered by the **cesi** group are organized into four areas of activity :

1) cesi Engineering School

cesi's Diploma of Engineering (a master's degree) is certified by the French examining body "Commission du Titre d' Ingenieur". It can be obtained through various courses :

A further education course with two different sections : "F1" a general course of engineering and "F31" a specialized course in the industrial applications of information technology (CIM, CAD/CAM, robotics...). The length of both courses is two years, full time. They are targeted at technicians who generally hold a first degree. Five years professional experience is a prerequisite. These courses are run in the following **cesi** regional centres : Arras, Evry, Lyon, Rouen, Bordeaux, Toulouse and Nancy. (Table 1)

A special three-year "sandwich" course through "apprenticeship" contract with a company, for young people under 26, who already hold a first technical degree. These courses are carried out in partnership with professionals, and take place in CEFIPA (Centre de formation d'ingenieurs par l'alternance) at Gentilly, EIA at Angouleme and at Auch. (TABLE 2,3,4)

Training of engineers through education courses, given by the Institute for Industrial Engineering Technics, is organized for company technicians with at least five years experience and a professional qualification.

The training is carried out both in companies themselves and on **cesi** premises located at Limoges - for the "Option in Mechanics" - and at Evry for the "Option in Maintenance". The duration is about 2 years or 1,500 hours.

Engineering master's degrees can be taken in Industrial Data Processing at Bordeaux and Rouen, Architecture of Industrial Data-Processing Systems at Evry, and Administration of Export Projects at Nancy.

The course is of 12 months duration with 6 months in a **cesi** centre and 6 months in a host company.

Various tailor-made courses for technicians' and engineers' career development, designed and run according to needs of companies, public sector, industry bodies and other professional organisations.

Table 1: Two-Year Full-Time Schedule

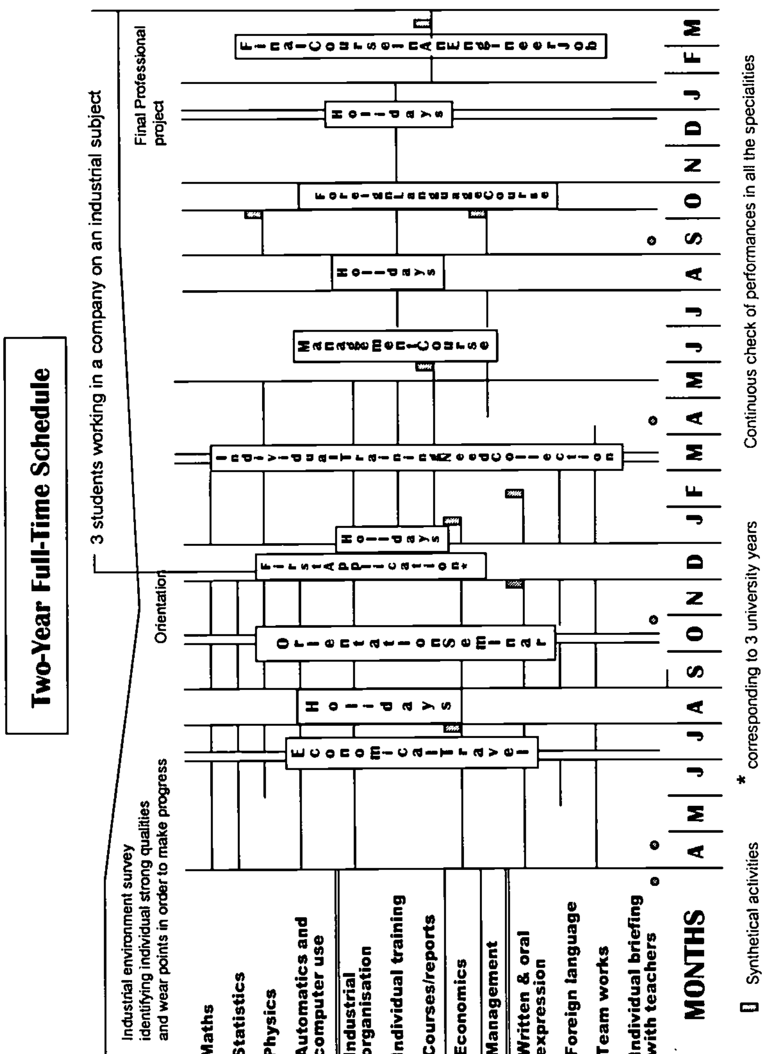


Table 2: Three-Year Alternate Schedule

	at work
	at CESI School

1st Year

First six month period		OCT				NOV					DEC				JAN					FEB					MARCH		
	week n°	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13

Second six month period		APRIL				MAY					JUN				JULY					AUG					SEPT		
	week n°	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39

2nd Year

Third six month period		OCT				NOV					DEC				JAN					FEB					MARCH		
	week n°	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13

Fourth six month period		APRIL				MAY					JUN				JULY					AUG					SEPT		
	week n°	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39

Including 3 days at work

3rd Year

Fifth six month period		OCT				NOV					DEC				JAN					FEB					MARCH		
	week n°	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13

Sixth six month period		APRIL				MAY					JUN				JULY					AUG					SEPT		
	week n°	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39

Including 4 days at work

Table 3: The principle of alternance: shared training in co-responsibilities

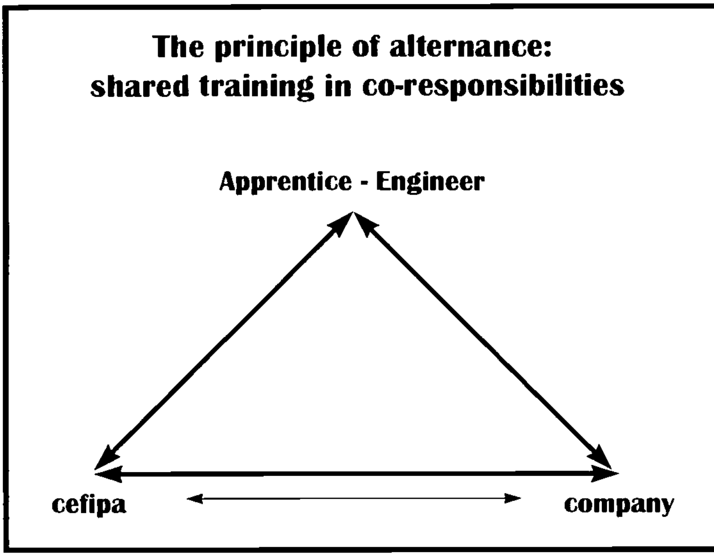
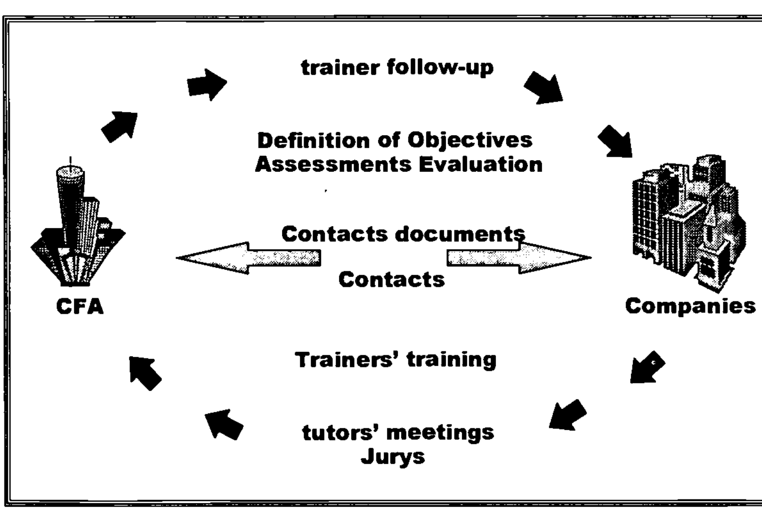


Table 4: Relations CFA-Companies



Trends in Engineering Education

A Summary of the Paper
Presented by
Prof. Jean Francois Mela,
University of Paris 13

Trends in Engineering Education

A summary of the paper presented by
Prof. Jean Francois Mela,
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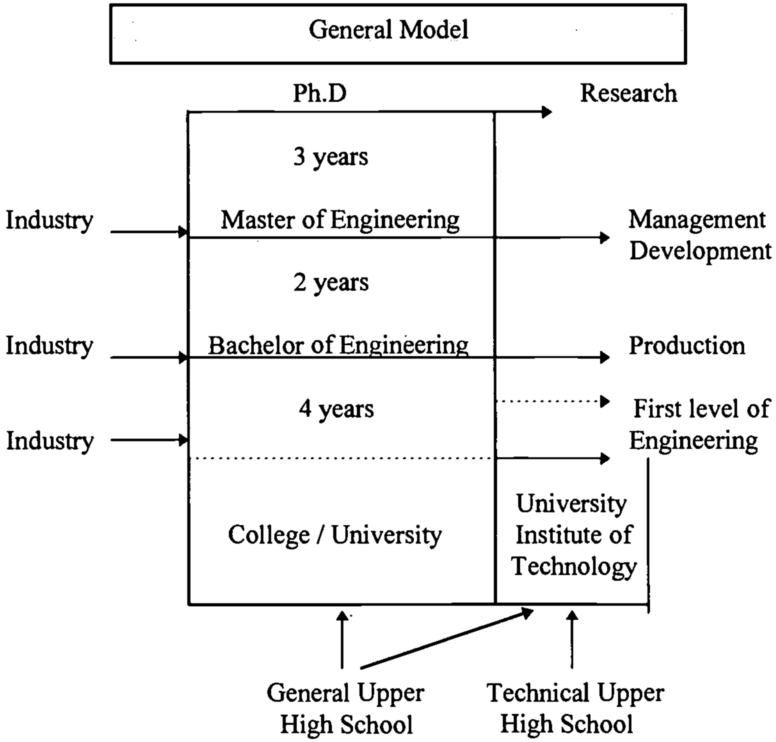
The following is a brief summary of the paper presented by Prof. Jean Francois Mela. First, he outlined the general model of engineering education, as shown below.



- Different terminal levels corresponding to different qualifications.
- Integrated training program with access at different levels (continuing education).

Three Ways of Training Engineers

The three ways of training engineers were summarized as follows :

1. Initial Education

- Direct access from upper high school (relies on a strong basic education in science and mathematics at the upper high school level).
- Access from College or Technical College (with strong general scientific curriculum).

2. Continuing Education

- Classical (evening courses….)
- Distance learning.
- Free periods for training, allocated by the companies (legal requirement in France).
- Professional skills taken into account for obtaining a degree.

3. Apprenticeship / Dual System

- Alternation of academic training and professional training.
- Initial Education or Continuing Education.

Training Engineers : MAIN TRENDS

Prof. Mela went on to examine the main trends occurring in the training of engineers ; they are listed as follows :

- Importance of a strong basic education in science and mathematics at the upper high school level and during the first years of higher education.
- Intensive use of computers for scientific computation, documentation and communication through networks.
- Multidisciplinary curriculum (including management, foreign languages, communication, quality assurance) to train people to deal with the different aspects of a company-like the ability to conduct projects.
- Connection to research : academic staff must be involved in research centres.
- Involvement of professionals in the teaching process.
- Training periods of long duration in the companies.

College Level:
The Model of French University Institutes of Technology

At the college level, Prof. Mela presented the model of French University Institutes of Technology. He firstly examined the general organization and then the weekly organization :

GENERAL ORGANISATION

- 2 years (+1 year in alternation).
- Selective access.
- 150 students by department.
- Each department covers a specific area (Mechanical Eng., Electrical Eng., Chemical Eng.,).
- Curriculum established by a national committee involving representatives of industry.
- 13 industrial specialties.
- 8 specialties for services.
- 10 weeks of training periods in industry.

WEEKLY ORGANISATION

- Theoretical courses : 6h.
- General culture : 5h.
- Tutorials in small groups : 9h.

  (26 students per group)
- Practical work on equipment : 10h.

  (12 students per group)
- Individual projects : 5h.

Reinforcement of general scientific background.

Half of the graduates go directly to industry.

Half of the graduates attend engineering courses of upper level.

Training Engineers at the University (Initial Education)

Example : Engineers in Telecommunications (University Paris 13)

As an example to illustrate the process of engineering education, Prof. Mela outlined the stages followed by Engineers in Telecommunications at the University of Paris 13 :

GENERAL ORGANISATION

- 3 years after College (or Institute of Technology).
- + 1 year (optional) : "Degree of Technological Research".

LEVEL : MASTER'S OF ENGINEERING

First Year :

- Theory : 470h.
- Practice : 300h.
- Language and social sciences : 100h.

Second Year :

- Theory : 370h.
- Practice : 240h.
- Project : 120h.
- Language and social sciences : 125h.

Third Year :

- Theory : 150h.
- Practice : 75h.
- Project : 120h.
- Language and social sciences : 100h.
- Specialisation : 120h.
- +4 months training period in industry.

Fourth Year :

- Technological research project in a company or a research centre with a period at the University (graduate level).

Hints for Action

In conclusion, Prof. Mela suggested that the following hints for action should be carefully considered :

- Twinning of French engineering departments and departments of local universities.
- Creation of engineering departments mixing French professors and local staff, delivering degrees with common certification.
- Teaching in English.
- Complementary training in French language with an intensive session at the end.
- Organisation of summer schools for tightening the links of local staff with the international scientific community.
- Extra-teaching for raising the level of the students/ candidates.
- Welcoming of the best students in French postgraduate programmes.
- Promoting research cooperation between French and local institutions.

How to Become a Qualified Engineer by Apprenticeship

by Prof. Christian Rumelhard,
CNAM - Conservatoire National Des Arts et Metiers

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How to Become a Qualified Engineer by Apprenticeship

Prof. Christian Rumelhard, CNAM

ABSTRACT

Among the many different ways which are possible to become a qualified engineer in France, the most recent is apprenticeship. This paper describes the main characteristics of the training offered by one of the organizations promoting this way : Engineers 2000 and its associated engineering school : ESCPI. These new organizations are based on a two centuries old training institution having many contacts with business and industrial activities : the CNAM, which is also quickly described.

INTRODUCTION

In many European countries, there is a training giving the engineer qualification. This diploma corresponds to five years training after the "baccalaureat", that is to say at least one year more than the Bachelor's degree. In France, many schools or institutions working in parallel with or within universities deliver this qualification. Among the different possibilities offered to students to get this degree, the most recent is the apprenticeship way. And the objective is that a part of the engineering qualification in France will be obtained by this way in some years.

One of the organizations delivering this new qualification is "Engineer 2000", which was created recently to develop this type of training and generated a new Higher School for Industrial Design and Production. The Engineer 2000 organization was the result of an association between CNAM and several French industrial societies. So it is necessary to begin with the presentation of CNAM which is an institution dependent on the Ministry of Education with extensive experience in continuous training.

THE NATIONAL CONSERVATORY FOR TRADES AND ARTS

The National Conservatory for Trades and Arts (Conservatoire National des Arts et Metiers or CNAM) was created two centuries ago, in 1794, to promote the presentation of new technical or scientific equipment which was necessary for the development of the industrial revolution in Europe. It offers study programmes for adults who have already begun their professional career and delivers the Engineer qualification as well at the doctorate level. It is a public institution of higher education under the tutelage of the French Ministry of Higher Education and Research. In fact it is a network of 53 associated French regional centres including, Polynesia, French Guyana, Guadeloupe, New Caledonia, Reunion and West Indies. There are learning centres in more than 120 cities all over the country.

There are 90,000 students amongst whom 60,000 attend evening courses and 30,000 attend courses given by specialized Institutes. The mean age is 28 years. Each year, 700 engineering degrees are obtained in evening classes.

There are seven departments : Computer Science; Work and Work Place; Physics and Electronics; Mechanical and Material Engineering; Chemistry, Biology and Nuclear Physics; Economics and Management; Mathematics. The multimedia technique is used to teach from a distance: several experiments in this field are tested in regional centres.

A strong activity is realized in basic and applied research in connection with business and industry representing for instance 240 doctoral students in 1993.

The type of training delivered by CNAM is expanding in several countries like Germany (Darmstadt), Greece (Athens), Lebanon (Beirut), Rumania (Bucharest) or Spain (Barcelona and Bilbao). The Engineering degree delivered by CNAM can be easily transformed to a European Chartered Engineering Degree.

ENGINEER 2000 AND THE HIGHER SCHOOL FOR INDUSTRIAL DESIGN AND PRODUCTION

In 1991, CNAM, six industrial societies (Thomson, Schneider, SNECMA, Usinor-Sacilor, Renault, EDF/GDF) and an association of metallurgical industries created the organization Engineer 2000 to promote apprenticeship training for engineers in France. Again in cooperation with CNAM, this organization created a new school to develop this activity : the Higher School for Industrial Design and Production (Ecole Superieure de Conception et Production Industrielle or ESCPI).

In this school, there are five years of training after the technical or scientific level A. Each year is divided in two 6 month sessions : the university (or academic) session and the industrial session. Students are closely followed by two tutors : a university tutor and engineering tutor.

During the university session, two thirds of training is dedicated to scientific or technical subjects. At the present time, these subjects are divided in three streams : Mechanical and Production Systems Engineering; Electronics and Computer Science Engineering; Electrical Engineering or Electrical Systems Design. One third of training is devoted to management, communication and languages (2 to 3 months of the industrial session is completed outside of France).

The industrial session is also dedicated to learning with the engineering tutor in the environment of a firm. The students are employees closely associated to the firms. At the present time, 80 firms are training 240 trainee-engineers enrolled at this school and working on 140 different industrial sites.

The first batch of students went out last September and these new engineers are considered as having an experience of one or two years.

AN EXAMPLE OF INTERNATIONAL ACTIVITY FOR ESCPI

The ESCPI also has international activities. As an example, an apprenticeship programme was started in October 1996, in Hungary. The local university is the Technical University of Budapest and the companies are ANNAFER and a Hungarian roundtable of industrials. This project is supported by the Education Ministry in Hungary, by the French Ministry of Foreign Affairs and an European contract called PHARE. Three streams are starting : Mechanics, Electrical Engineering and Civil Engineering. Starting with students having two years of training after Baccalaureate, the Hungarian school offers two years of training. The ESCPI is consultant of this project and at the same time, Hungary is opening a network of regional centres associated to French regional centres of CNAM.

DIFFERENT OFFERS FROM ESCPI AND CNAM

Based on their experience in France and in an international environment, different activities listed hereafter can be offered by ESCPI or CNAM :

- Visit of professors
- Training of students coming to France
- Training of professors

- Acting as a consultant to launch a programme like the one in Hungary
- The help of CNAM professors in many domains is very useful to establish technical programmes
- The CNAM network of regional and international centres can be used to organize a project.

CONCLUSION

This paper presented a new way to become a qualified engineer : the apprenticeship way. The recent creation of the association Engineer 2000 and of an engineering school (ESCPI) to promote this new way to become an engineer was described. All these creations were based on a traditional institution created two centuries ago and having a long experience in education : the CNAM. It was shown also that CNAM, Engineers 2000 and ESCPI are quite able to develop these activities in an international environment.

CANADA

The Challenges of Cooperative Engineering Education

by Dr. G. E. Schneider,
University of Waterloo

The Challenges of Cooperative Engineering Education

Dr. G. E. Schneider,
Associate Dean of Engineering
Undergraduate Studies, University of Waterloo

INTRODUCTION

The challenges of the cooperative system of engineering education will be discussed. Our concern will be with the usefulness of the system with respect to the purposes of education, although some mention of organizational, administrative, and financial issues will be included.

Cooperative education has been widely praised as a highly effective system of education, particularly by those institutions that have adopted the system. However, there is no system that cannot be improved in some way and the claimed advantages of the system do not come without some associated cost. A true measure of cost-effectiveness has yet to be realized; thus, much of this article will necessarily be qualitative in nature.

Cooperative education has been remarkably successful at the University of Waterloo. It is largely responsible for raising the institution to be a major force in Canadian (North American) higher education within the short span (in university measures) of 40 years. Waterloo employs the conventional, alternating work and academic terms, cooperative program that is mandatory for the 3,600 undergraduates enrolled in the Faculty of Engineering at Waterloo.

In the following pages, some background for cooperative engineering programs at Waterloo will be provided followed by some of the issues and challenges affecting this system of study in an engineering education environment.

BACKGROUND

Cooperative education was introduced into Canada with the organization of the University of Waterloo in 1957. Seventy-five students were enrolled in that year in a mandatory cooperative engineering program in Chemical Engineering. The program expanded rapidly in enrolment and into disciplines other than engineering. At present the cooperative enrolment is approximately 9,000 students comprising about 60% of the total undergraduate enrolment. Of these, 3,600 are enrolled in engineering, making Waterloo the largest engineering school in Canada. The cooperative program at the University of Waterloo is the second largest in North America.

Waterloo uses the conventional system of alternating periods of on-campus academic study interspersed with practical work experience at employer organizations. There are eight academic terms and six cooperative work terms. Engineering students enrol in the cooperative program in September and complete their first academic term on campus. The freshman intake is about 750 students per year. Beginning in the following January, approximately one-half of the students begin their first four-month work term in a business, industry, or government setting while the remaining students continue on-campus to complete their first year of studies. In the following May, the two groups of students exchange the nature of their activity and this establishes the alternating academic/work term sequence on a year-round basis. This alternating schedule is maintained until the fourth year of academic studies. The fourth year students entering 4A (the first academic term of fourth year) in the fall term continue for eight months in their academic studies. All students are again on campus for their 4B (final) term of academic studies.

Students must successfully complete a minimum of five (of the possible six) successful work terms in order to graduate. Employers complete a performance evaluation for the student (s) to the university for entry on the students cooperative record file. In addition to the requirement for five successful work terms, students must submit at least four work-term reports that are graded satisfactory or better. These work-term reports must report in detail on some technical aspect of their work term and are judged for analysis and design as well as for communication skills including layout, organization, grammar, spelling, and clarity of presentation.

The administration of the work terms at the University of Waterloo is performed by the Department of Cooperative Education and Career Services (CECS). Although faculty members are not directly involved in this aspect of the program, close ties are maintained between CECS and the Faculty on a personal level and via committees within the Faculty on which CECS has contributing and voting members. Examples of such committees include Engineering Faculty Council, Engineering Faculty Undergraduate Studies Committee, and Engineering Examinations and Promotions Committee. Much of the formal communication between the Faculty and CECS has traditionally been undertaken through the Associate Dean of Engineering for

Undergraduate Studies; however, recently a Director for Liaison with CECS and the PEO (Professional Engineers of Ontario) has been appointed who reports to the Associate Dean. Close contact and liaison between the Faculty and CECS is deemed to be sufficiently important to warrant such a dedicated position, albeit not a full-time one.

At Waterloo, assignment of students to jobs takes place during the on-campus academic term immediately prior to the work term at hand. It is expected that a student will return to his/her employer for at least a second term if a job is available. Each term, approximately 1,500 engineering students require cooperative employment, including those that will be returning to their employer for a second (or third, etc.) work term. Traditionally, 85-90% of the students obtain jobs in the private sector with the balance being employed in various federal, provincial, or municipal agencies, governments, or organizations. Of approximately 2,500 potential employers of engineering students contacted each term, about 450-500 actually hire students. While there are about 12 employers who hire more than 20 students each term, the majority hire fewer than three students and about 60 % of employers hire only one student. In the Canadian (North American) economic climate, the trend is to have increasingly more employers each of which is hiring, on average, increasingly fewer students.

THE CHALLENGES

In the following, some of the challenges facing cooperative engineering education will be presented. These will be presented in brief form, with the issues identified and succinctly described. In some cases, the issues will be culturally dependent as to their importance; some issues related to local economy and culture may have been missed entirely. A discussion of all of the challenges of cooperative engineering education is highly perspective dependent. Nevertheless, some of the important challenges are presented below.

INDUSTRIAL LINKAGE

It is crucial to form strong links with industrial and government concerns. The nature of this linkage must reflect a commitment from the industry to the continued participation in the cooperative program. There are responsibilities that the industry must fulfill including student performance evaluation, job description preparation, interview participation, and co-ordinator interview participation. This commitment must in turn reflect the recognition by the industrial "partner" that this is not a student aid or training program;

the industrial partner must be convinced of the actual benefits that accrue to it through the program. The remuneration package must be an appropriate full-time rate for a student engineer. In some countries this will represent a cultural barrier that must be overcome.

INSTITUTION COMMITMENT

The university must demonstrate commitment to the concept of cooperative education. This requires a significant infrastructure within the university, some of this being physical and much of this being human resource in nature. The "co-ordinators" are required to interact with the students both on campus and on the job. Job development personnel are required to continuously develop (secure) jobs from partner industries and government offices. Internal record-keeping is required for promotion, evaluation, communication and discipline purposes.

MEANINGFUL JOBS

The jobs that are offered as part of the cooperative engineering education program must be meaningful and appropriate for the student and for the employer. A cooperative job is not just a job! The job must provide a meaningful learning, employment, and a contributing environment for the student yet it must also provide a return on investment for the employer. The employer should want to participate because it recognizes the benefit to itself.

RESPONSIBLE STUDENTS

The admissions process must develop a student population that has a strong work ethic, understands the cooperative education process, and understands the students' responsibility in this process. The student must be willing to accept that not all jobs will meet his/her expectation but that this is part of the process. The student must act responsibly on the job and contribute to the goals of the employer. The student must understand that the purpose of the cooperative work term from his/her perspective is to produce a superior engineer on graduation and not to simply finance his/her education. Here again, there may be some cultural barriers to overcome.

FACULTY COMMITMENT

Individual faculty members must be committed to the concept of cooperative engineering education. They will be involved in marking work reports, their classes will be disrupted by students coming from and going to job interviews, some students will want special arrangements for job-related matters, etc. Where faculty members do not appreciate the benefits of the cooperative education environment, they will become resentful and impose barriers to the smooth and cooperative implementation of the program.

GOVERNMENT COMMITMENT

There are additional expenses involved in running a cooperative education program in excess of those required for a "regular" program. These expenses are not insignificant and place an additional financial burden on the university. Where government funding is used to operate the university, it would be very useful if the university grants recognized these additional burdens in a tangible way. Unfortunately, government recognition generally does not come in the form of additional financial support.

GRADUATE STUDENT POPULATION

Engineering graduates from a cooperative engineering program generally are far better prepared to enter the work force and begin contributing in a meaningful way than are the graduates from the "regular" programs of conventional universities. Industry is generally eager to acquire these graduates, offering them very attractive salaries. As a result, graduates move directly into industry under the temptation of high salaries and do not consider graduate school as a option. It can be argued that we lose some of our best students to industry in this manner.

ACADEMIC TERM DYNAMICS

The nature of a cooperative program of study is one of constant interchange between the work term and the academic term. Students must frequently travel significant distances in making the transition, and when they arrive on campus, because of their short- term time, there is no time to spare. Students and instructors must move into high gear immediately. Exams must occur every four month term, and as a result the "teaching time" is further reduced so that the time on campus must be used very effectively.

UNIVERSITY IDENTIFICATION

Normally, a four year residence at university builds identification and loyalty. The residency is not only an important learning experience for the student but is an important bridge for the university to alumni support. Cooperative students, with their frequently interrupted attendance at the university considerably hinders their ability to identify with the university. A strong group identity does develop in the cooperative program but it is restricted to the group or stream with whom students make their way through the program. A lesser identification occurs with the program as a whole, and an even lesser identification occurs with the university.

SOCIAL ISOLATION

A problem analogous to the one above is that of developing contacts with students in other disciplines besides engineering. Movement between the work- term job and the campus and frequent changes in housing arrangements hinders the building of long-term friendships based on a living group, on clubs, or on other student activities. In many cases clubs and student government offer students invaluable training in leadership and administration but the intermittent presence of the students on campus makes it difficult for cooperative students to take on officer positions. University athletics poses a similar problem.

CONCLUSION

The foregoing presents some of the challenges facing the implementation of a cooperative engineering education program. As can be seen, they are many, so the task is not an easy one. However, the benefits are great. Benefits to the student and to the university include the following : increased learning through the experiences that the students bring to the classroom ; increased learning through the interactions of students with each other ; research ideas and challenges that come to the university from the student's work experiences; increased student maturity through the work-term experience; increased student maturity through the requirement to change venue every four months; research funding and opportunities through the employer-student identification of potential need/expertise alignment; innovation that results from the non-conservative cooperative environment; in situ sensors of change in the workplace in the form of students; and, soon to be realized in Ontario, reduced experience requirements for professional registration as a result of the work experience gained on cooperative work terms. As noted in the introduction, however, a true measure of cost-effectiveness has yet to be realized.

At Waterloo we are firmly convinced that the benefits of cooperative engineering education far outweigh the costs of implementation.

Thai-Canadian Collaboration in Human Resource Development

Presented by Dr. S.A. Boctor,
Ryerson University Polytechnic

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Thai-Canadian Collaboration in Human Resource Development
The SUT-CUTC Project

Dr. S.A. Boctor, Ryerson Polytechnic University,
Dr. W. Caley and Dr. F. Hamdullahpur,
Technical University of Nova Scotia

INTRODUCTION

In 1991, CIDA decided to provide $10M to support ten HRD collaboration projects between Canadian universities and corporations and their Thai counterparts, intended to enhance the development of human resources in Thailand, particularly the Engineering, Business and Technology related disciplines, and encourage long-term collaboration between the Canadian and Thai partners in these fields. Dr. Wichit Sris-an and the Ministry of University Affairs were the projects' main driving force in Thailand, and through their excellent coordination and planning the ten projects were launched in 1993.

THE SUT/CUTC PROJECT

One of the first projects to be launched was the SUT/CUTC project, with a total budget of about $6.0 M, of which CIDA's contribution is about $1.0 M. The Thai partner is the newly established Suranaree University of Technology, and the Canadian partner, the "Canadian Universities Technology Consortium" which consists of four institutions : Ryerson Polytechnic University, University of Waterloo, Technical University of Nova Scotia and the University of Guelph. Over the five-year duration of this linkage project, the approved activities and deliverables are designed to provide mutual benefits and ultimately result in sustainable and enduring institutional relationships, particularly in the field of human resource development.

The Project Activities and Deliverables

To achieve the goals of this novel institutional linkage and technical cooperation project, three specific programs were designed to provide the project deliverables.

I Institutional Capacity Building Program

To support the institutional development and capacity building of SUT, four major activities were implemented :

1. *Development of Academic, Administrative and Management Framework at SUT*

Customized programs were designed for five SUT academic administrators in the areas of academic planning, policy development, system of governance, curriculum planning and development, research administration, academic standards and promotion, and admissions procedures. The exposure of the SUT personnel to these areas of academic activities at the CUTC institutions provided them with various ideas to assess the benefits of implementing similar or modified management procedures at SUT.

2. *Development of Academic Programs and Curricula at SUT*

Seven academic chairs and coordinators visited the CUTC partner institutions on customized programs to assess the curriculum development and planning activities, laboratories, equipment, computer facilities, and research programs in various areas of applied science and engineering disciplines.

3. *Development of Institutional Support*

Customized training programs were designed for 10 SUT personnel in the areas of library automation, computerized management and information systems, and maintenance of scientific equipment, at the various campuses of the CUTC partner institutions. Also, Canadian consultants visited SUT to assess and provide recommendations about library automation, management information systems (MIS) and computer support systems.

4. *Establishment of ESL Centre at SUT*

Two SUT professors in ESL visited various ESL centres in Canada, and a Canadian consultant assessed and provided planning and curriculum related recommendations about the establishment of the ESL centre at SUT. This centre has now been in operation for about three years and provides valuable language proficiency services to all of SUT's students.

II International Academic Program

Three major areas of activities constitute the novel components of this program :

1. International Applied Science and Engineering Programs (IUP)

Curriculum planning and implementation activities were undertaken by CUTC professors in collaboration with SUT professors to design and deliver four international undergraduate engineering and applied science programs in the fields of Mechanical, Electrical and Chemical Engineering, and Food Technology. These programs anticipated serving international students from Southeast Asian countries in those critical engineering areas which are essential in support of the expansion of industrial developments in Southeast Asia. The language of instruction in all of the curriculum course material is English. The curriculum design takes into account the opportunities available to the undergraduate students in these programs to transfer to the CUTC partner universities to complete their degree requirements, either after the first or the second year (s) of their undergraduate programs. Hence the curriculum for at least the first two years was mostly transplanted from the partner Canadian universities. This also implied that those transfer students could then earn Canadian bachelor's degrees and become eligible to be licensed as Professional Engineers in Canada.

This is the second year of implementation of these IUPs. As many as twelve Canadian professors have been assigned to SUT to help in the delivery and curriculum development of the different course material. Thai students in Mechanical Engineering have already transferred to Canadian universities. And another group of Electrical Engineering students are expected to transfer this year.

We expect that these programs once they overcome the growing pains, will have long-term impact on the human resource development in Thailand and the Southeast Asian countries. This is also an area of enduring and sustainable relationships.

2. Joint Research and Ph.D. Programs

Junior faculty members at SUT will the support of scholarships from the Thai Ministry of University Affairs, are given the opportunity to pursue their graduate studies to obtain their Ph.D. degrees at the CUTC partner universities. At present, three such doctoral candidates are enrolled at the Technical University of Nova Scotia (TUNS) and it is anticipated that another three candidates will take part in this aspect of the project. To strengthen the collaborative nature of these activities and its long-term sustainability, the Canadian graduate supervisors will visit

SUT to discuss and explore the long-term continuation of such research activities with their Thai counterparts. Further, four postdoctoral scholarships were provided to SUT faculty members, to renew and expand their research activities at the CUTC partner universities. We expect that such postdoctoral research opportunities will also lead to on-going sustainable research collaboration in the future. Also, three senior professors from the CUTC partner universities will provide consultancies to SUT to support, and collaboratively plan the development of postgraduate engineering programs at SUT.

3. *Cooperative Student Exchange Programs*

Through this program 8 Thai and 8 Canadian students will be assisted by the project in securing cooperative placements in Canada and in Thailand respectively. The objective of this activity is to provide seed funding to convince industrial and governmental institutions of the viability and benefits of cross-cultural and cross-technological exposure of undergraduate students in both countries to the international development occurring in their fields. To date, seven Canadian students and four Thai students have completed their cooperative assignments.

III University-Industry Linkage Program

SUT, through its newly established Technopolis and its Centre for International Affairs, has established many university-industry linkages, particularly in the areas of continuing education and specialized industrial seminar series and conferences. Canadian professors from the CUTC partner universities and industrial consultants have contributed to these activities and provided seminars and lectures in such fields as university-industry linkage projects, water resource management, environmental management issues, internationalization of higher education, computer integrated manufacturing, etc. This is another area that promises sustainable and mutually beneficial long-term collaboration.

Project Management and Project Review Committee (PRC)

An important aspect of the project was the unique management structure adopted in the early stages of the project design. Each of the partners, SUT and the CUTC, established a steering sub-committee. Frequent dialogue and on-going communications between these sub-committees, together with the annual meeting of the whole PRC (in

Canada and in Thailand) helped overcome perceived and anticipated difficulties even before they arose. Through these PRC meetings, review and assessments of completed activities were discussed, and planning for implementation and/or minor changes in the project deliverables and activities took place in a collegial and friendly atmosphere. This open and frank dialogue helped immensely in steering the project towards its successful completion.

CONCLUSION

The authors wish to express their pride in taking part in this exciting, stimulating and gratifying project, and also wish to express their sincere thanks to CIDA, SUT and the Thai Ministry of University Affairs for making this project a reality. The achievements of this project and its goal of mutual benefits and sustainable institutional relationships provide an excellent viable example for international cooperation and collaboration. We hope to see many such linkage projects established in the near future, ushering in a new century of open markets, global exchanges and communications and maybe one day a borderless world.

Quality Assurance in Engineering Education : Engineering Accreditation in Canada

Presented by Dr. F. Hamdullahpur,
Technical University of Nova Scotia

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Quality Assurance in Engineering Education : Engineering Accreditation in Canada

Dr. S.A. Boctor, Ryerson Polytechnic University,

Dr. W. Caley and Dr. F. Hamdullahpur, Technical University of Nova Scotia

INTRODUCTION

The practice of the engineering profession in Canada is governed by legislation at the provincial level. Like most professional fields of endeavors that involve public liability issues, society needs to be assured of the quality, qualifications and ethical conduct of those people practicing the profession. Each of the ten provinces in Canada has its own Professional Engineering licensing body. In order for a graduate engineer to be able to practice his/her profession, he/she must be a member of and licensed by the provincial body where he/she expects to be employed.

Instead of a system involving provincial licence examinations in each of the engineering disciplines, as is the case in the United States, the Canadian provincial engineering associations formed the Canadian Council of Professional Engineers (CCPE). One of the four standing boards of the CCPE is the Canadian Engineering Accreditation Board (CEAB). The main objective of the CEAB is to conduct cyclical assessments of the 33 colleges of engineering, at the various Canadian universities and undertake a thorough review of each of the engineering programs offered at the various Faculties. The successful evaluation by the CEAB of the engineering programs at a specific university provides an indication to all of the provincial licensing bodies that the graduates of these "accredited" programs are eligible for licensing, after an internship period (three to four years) and after successfully completing the "Professional Practice and Ethics" examination. A new engineering program is usually assessed for the first time while the final year of the program is being implemented, i.e. just before the graduation of the first class of students. The quality assurance assessment conducted by the CEAB and the exhaustive parameters used for these evaluations are of prime importance to all of the Faculties of Engineering at the various Canadian universities; particularly in the design of the undergraduate engineering curricula and in the establishment of the engineering education environment.

This paper will briefly discuss the evaluation parameters and the procedure used to assess the quality of engineering programs in Canada.

ACCREDITATION CRITERIA

These criteria, which fall under three categories, are formulated to ensure that the graduates of a specific program are provided with an academic education that meets or exceeds the professional registration requirements, placing special emphasis on the quality of the graduates, the academic and support staff and the educational facilities (such as laboratories, library, computer centre, etc.).

I - General Criteria

- The engineering undergraduate program must develop an individual's ability to use appropriate knowledge and information to convert, utilize and manage resources optimally through effective analysis, interpretation and decision making (i.e. the design process).
- Overspecialization in curricula is discouraged, exposure to fundamental knowledge of other branches of engineering and innovative education development is encouraged.
- The graduate must be adaptive, creative, resourceful and responsive to changes in society, technology and career demands. The graduate must also be aware of the role and responsibilities of the professional engineer in society and must be able to communicate effectively within society at large.

II - Curriculum Content

Judgment is applied to both the qualitative and quantitative aspects of each of the criteria used to assess a specific program's curricular content.

An accreditation unit (AU) is used to assess quantitatively the various components of the curriculum. One AU is one lecture hour, or two tutorial or laboratory hours. For example, a three-hours lecture/two-hours laboratory per week, in a course offered over a 13-week semester, would be equivalent to 52 AU. An activity that is not properly described by specific contact hours, like Thesis Projects and Design Assignments, can be evaluated by multiplying the credit units assigned by the university to such activity by a mathematically derived proportionality factor, to arrive at the equivalent AU units. The minimum content of each curricular category is defined as follows :

Mathematics : 195 AU, including algebra, differential and integral calculus, differential equations, probability and statistics and numerical analysis.

Basic Science : 225 AU, including elements of physics, chemistry, life and earth sciences. These subjects are intended to impart an understanding of natural phenomena and relationships.

Engineering Science and Engineering Design : 900 AU of the combined subject matter, but no less than 225 AU in each category. The remaining 450 AU could be any combination of Engineering Science and Design as deemed desirable by the specific program and institution. Engineering Science subjects have their roots in basic science and mathematics but carry the knowledge further towards creative applications, like modeling and numerical techniques, simulation procedures, materials, fluid mechanics, thermodynamics, electrical and electronic circuits, computer science, soil mechanics, control systems, aerodynamics, transport phenomena, environmental studies, etc.

Engineering design integrates mathematics, basic and engineering science and complementary studies to develop systems, elements, processes to meet specific needs. Such activity is characterized by its creative, interactive and often open-ended nature.

Appropriate content requiring the application of computers must be included in this component of the curriculum.

Complementary Studies : 225 AU, covering studies in humanities, social sciences, literature, management, economics and communications, that complement the technical content of the curriculum. Considerable latitude is provided in the choice of suitable courses, but this category must include studies in engineering economics, the impact of technology on society and must develop the students capability to communicate effectively.

The remaining 235 AU can be assigned to any category as deemed appropriate and desirable by the program. The entire program must include a minimum of 1800 AU. Laboratory experience must be an integral component of the engineering curriculum. The total instructional AU content of a given course does not include final examination and can be split between different categories (normally two).

III- Program Environment

The emphasis here is placed on the qualitative evaluation of the program's environment, including :

- Quality of students, faculty, support staff, teaching assistants, administration of the program, the laboratories and computing facilities, library resources and other supporting facilities.
- The morale, commitment, experience and engineering competence of the faculty members. The majority of the faculty must be full-time to assure adequate levels of student-faculty interaction, curricular counseling and development and control of the curriculum.
- Faculty teaching workload should allow time for adequate participation in research and professional development activities.
- Faculty members teaching the engineering science and engineering design component of the curriculum are expected to have a high level of competence and dedication to the engineering profession. This criteria is assessed through faculty qualifications, experience, level of scholarly activities, participation in professional and learned societies and registration as professional engineers.
- The Deans and Chairs of engineering programs are expected to provide effective leadership and to have achieved a high standing in the engineering community. They are expected to be professional engineers.
- The Engineering Faculty Council, or equivalent, must have effective control of the engineering programs and their curricula.
- The academic admissions, promotion and graduation policies adopted by the Engineering Faculty must verify that the students have demonstrated competence in the courses taken. The definition of competence should be acceptable to the CEAB.

ACCREDITATION PROCEDURES

The CEAB reassesses all of the accredited programs (about 210) at intervals not exceeding six years. At the invitation of an institution to the CEAB, by January 1 of the year in which the visit is to take place, the CEAB sends documentation to the institution, including structured questionnaires, documents required by the visiting team, schedule of events and procedures to be followed before, during and after the accreditation visit. A visiting team chair, usually a board member of the CEAB is selected, and the chair selects his team, which normally includes a board chair and a program visitor specialist for every program to be assessed at the specific institution. One of the team members is specified by the Professional Engineering Licencing Association in the province of the assessed institution. All members of the visiting team must be professional engineers. At least six weeks before the date of the visit (usually in October or November), each member of the team must receive the appropriate documents requested from the institution.

The Accreditation Visit

The accreditation visit normally takes two days. The team members assess qualitative factors such as environment, morale, professional attitudes, quality of students, staff and faculty; and may request clarifications regarding certain issues raised through the questionnaire submitted by the institution. The activities undertaken by the visiting team include :

a) interviews with the President, the Vice President (Provost), the Dean of Engineering and the Chairs of the engineering programs being assessed;
b) interviews with faculty members, staff members and students;
c) tour of the facilities such as labs, computing facilities, libraries, etc.;
d) review of recent examination papers, laboratory manuals, student transcripts, sample student work, reports and projects, course outlines (management sheets) and textbooks used in the various courses of the programs' curriculum;
e) before the end of the visit, an exit interview is conducted between the team members and the Dean and Chairs of Engineering, to review the perceived strengths and

weaknesses of the programs and to indicate areas of concern.

Reports and Decision

Six to eight weeks after the accreditation visit, the chair of the visiting team sends a written report, including the individual findings of the team members, to the CEAB and then to the Dean of Engineering at the institution. The Dean and the Chairs could respond to the team's report and may advise on improvements being implemented in the current academic year.

The CEAB board meets normally in June, to assess the institution's dossier, including the original submission, the visiting team's report and the institutions response to the report. The Dean is invited to respond to any questions from the (13) board members and may make a presentation to the board if he/she wishes. The accreditation decision is then made at the conclusion of the board meeting, regarding each of the programs being assessed.

If the CEAB board has no concerns, the program is deemed to meet the accreditation criteria and is granted the maximum six-year accreditation term. Accreditation for a term less than six years, normally three, is granted to programs when the board feels that certain concerns need to be overcome. A reassessment visit may then take place near the end of the accreditation term. Depending on the nature of the concerns, the board may require a report (instead of a visit) to be submitted to the CEAB at the end of the three-year term and upon favorable review, the board may extend the accreditation term for another three years before the revisit occurs.

If the CEAB judges that significant weaknesses currently exist in the program being assessed, either a limited term termination notice or denial of the accreditation decision is made. Before the end of the term termination notice, an institution may write a report to the CEAB explaining the major improvements made to the program (s). The CEAB, upon reviewing such a report, may then re-initiate a new cycle of assessment visit, or may decide to terminate the accreditation on the end date of the termination notice.

The accreditation decision is conveyed by letter to the Dean and the President of the institution whose programs are being assessed. The Dean could then convey the CEAB's decision to the faculty, staff and students.

CONCLUSION

For over 30 years, the experience of the Canadian universities with the engineering education quality assurance process provided by the CEAB accreditation procedure has been favorable. At times, some institutions may have confronted some difficulties. However, through feedback and discussions, the process has been fine-tuned over time and does indeed provide a very valuable service to the profession.

University-Industry Linkages in Environmental Engineering

by Dr. L. Otten-University of Guelph

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University-Industry Linkages in Environmental Engineering

Dr. Lambert Otten,
Director & Professor,
School of Engineering, University of Guelph,

ABSTRACT

Linkages between university and industry in environmental engineering is presented in terms of education programs and research activities. The current state of the environmental industry and the driving forces for the demand of environmental products and services are also reviewed. Government is found to play the most important role in creating the demand and also provides most of the research funding for environmental research, which is becoming increasingly a multi-disciplinary effort.

1. INTRODUCTION

Before considering environmental engineering linkages between university and industry in Canada, it is useful to look at the environmental industry itself. It is important to realize that the environmental industry is only about ten years old even though environmental issues have been addressed in different industries for many decades. It should also be understood that environmental engineering as a discipline is relatively new and much of the environmental activities are still found in traditional engineering disciplines, such as civil and chemical engineering. They deal mainly with the environmental aspects of the pulp and paper industry, petrochemical and related industries, mining industry, manufacturing industry, and the municipal sector. Although the evolving environmental engineering discipline and industry cover the same areas, they are interested in a broader spectrum of environmental concerns, including the redemption of past mistakes and the introduction of new environmental management process and technology. For this reason environmental engineering has a significant multi-disciplinary component.

Environmental attention of many product manufacturers, such as the consumer product industry, has shifted from production processes to the product itself. Today, product R&D has to take into account a large amount of government regulations and market requirements, such as the recycling and re-use of packaging, efficiency and emissions standards in use, and take-back guarantees at the end of service life. An excellent example is the disposable diaper industry which has been forced to redesign the product to make it more environmentally acceptable. The industry has spent millions of dollars on life-cycle analyses to determine the cradle-to-grave impact of the diapers and on the development and promotion of recycling methods, such as composting.

2. ENVIRONMENTAL INDUSTRY

The Canadian environmental industry consists of about 5,000 companies which provide technologies, processes, products and services. Although there are some large multinational corporations, the majority of companies are small to medium-sized, employing less than 50 people. However, like many growing industries with a large number of small companies, the environmental industry is undergoing restructuring and consolidation as smaller companies are being bought up by larger ones. The total employment is probably in excess of 150,000 engineers, scientists, technologists and technicians.

Canada's domestic market for environmental goods and services in 1994 was about $11 billion and is expected to increase at a rate of 10% per year to $22 billion by the year 2000. About 70% of environmental companies sell services, such as waste handling and facility operation, consulting services, environmental pollution and related field services, environmental research, natural resource conservation and protection. Waste handling and environmental facility operations is the largest component of the service sector, accounting for 65% of the total service sector income of $5 billion in 1994. Consulting services and construction contribute about 20% and 10% respectively.

The other 30% of the companies represent the environmental manufacturing sector with yearly revenues of $6 billion. Equipment for water pollution control accounts for 40% of the equipment manufacturing income, followed by air pollution control equipment (25%) and solid waste management/recycling equipment (25%). The remaining 10% includes the production of monitoring, chemicals (especially chlorine for water treatment plants), laboratory equipment, noise control equipment, and equipment for natural resource conservation.

Canada's share of the world market for environmental products and services was 3.5% in 1994 but is growing rapidly. The primary market for Canadian exports is the United States. In general, the total world market for the environmental industry is expected to reach $600 billion by the year 2000, with the U.S. market alone being $200 billion. However, the fastest growing markets (perhaps an average of 1.5% per year) during the next few years are expected to be the industrialized nations of central and eastern Europe, Latin America, The Pacific Rim and Southeast Asia.

3. DRIVING FORCES

The driving forces for the demand of environmental goods and services can be summarized as follows :

1. Compliance with ever increasing federal, provincial and municipal legislation and policies.
2. Economic growth, which creates the need for environmental goods and services at new industrial plants to meet environmental standards.
3. Population growth, which generates the demand for water and waste water treatment, and solid waste management facilities.
4. The increasing demand by consumers for environmentally-friendly "green" products.
5. Increased corporate environmental consciousness resulting from a public relations need to show a strong environmental record.
6. The general acceptance of the concept of sustainable development which forces governments and industry to consider long-term environmental implications of economic and social growth. (Brundtland, 1987).
7. Improved competition, such as resulting from ISO 14000.
8. Increased profits due to minimization of waste and waste treatment, recycling, reduction in packaging, energy savings, etc.

Currently, compliance with legislation and policies is probably the most significant reason for the growth of the environmental industry. The manufacturing sector will benefit from legislation regarding air pollution control, such reduction of No_x and VOC's, control of green house gases, SO_2 emissions from major point sources, and other toxic emissions. Water pollution control will require equipment and technologies for the implementation of "closed loop" systems, water separation technologies, water filtration, mobile pretreatment of water before final disposal, run-off from parking lots, on-site solvent reclamation in case of spills, UV treatment of water as an alternative to chlorine, water treatment services and membrane separation. Integrated solid waste management will require equipment and technologies for soil remediation, material recovery facilities, composting facilities, and recycling plants. Additional needs will be for computer software and hardware, incineration equipment, solid waste collection, handling and disposal equipment and systems.

Of course the service sector will grow accordingly. Consulting services are expected to grow significantly, especially in the areas of environmental audits, impact assessment, integrated solid waste management master plan development, public consultations and education, emergency response systems, geographic information systems, software development, energy conservation, site remediation studies, and project management.

4. EDUCATIONAL UNIVERSITY-INDUSTRY LINKAGE IN ENVIRONMENTAL ENGINEERING

Education and training programs to serve the environmental industry have increased considerably in the past decade but are still in a developmental stage. Depending on the requirements, the education and training can be obtained at universities, colleges and technical institutes, contract training, and in-house training programs.

4.1 Undergraduate Education

At the undergraduate university level there are four types of programs where environmental expertise can be obtained; namely, civil and chemical engineering programs, environmental engineering programs, environmental science programs, and course electives found in engineering, physical or biological science programs.

Most traditional civil and chemical engineering programs have environmental options. Civil engineering mostly covers the areas of municipal wastewater treatment, sediment transport, landfill design, and urban water supply. Chemical engineering generally addresses industrial environmental problems, such as air pollution control and industrial wastewater treatment using chemical processes. Many such programs have introduced new environmental electives and minors to broaden the scope of environmental training.

However, in the past few years engineering faculties at the Universities of Guelph, Regina and Windsor developed new environmental engineering programs accredited by the Canadian Engineering Accreditation Board (CEAB). The enrollment at these three institutions in 1995 was 243, 127 and 75, respectively (CCPE, 1996). The objective of these programs is to develop engineers with a scientific appreciation of the ecosystem and a broad understanding of the social-legal-economic environmental framework. In addition to the usual prerequisite courses in mathematics, physical and engineering sciences required by all accredited engineering programs, environmental engineering students are provided with a background in environmental sciences such as biology, microbiology, analytical and/or organic chemistry. In subsequent courses the students concentrate on the conceptualization, model development, and application of engineering solutions to environmental problems. The courses cover such topics as water resource engineering, contaminant and pollution transport in the environment, hazardous waste management, solid waste management, wastewater treatment, hydrogeology and ground water flow management, and municipal engineering. Broader perspectives of environmental management are obtained through courses in environmental impact assessment., environmental law, environmental planning, ecology, ecotoxicology, and environmental resource management.

4.2 Cooperative and Internship Programs

An important direct educational link with industry is through the placement of students enrolled in cooperative educational programs or a variety of internships. The cooperative students spend four to six work terms in engineering jobs, depending on the university's cooperative program. A 1993 survey showed that about 20% of the environmental companies participated in cooperative educational programs. Both the Guelph and Regina environmental engineering programs have cooperative opportunities.

Internship programs work on a similar principle except that the student may be on a work assignment for a summer semester or a full year.

4.3 Graduate Programs

Because the environmental industry is growing rapidly, the demand for new employees with new skills is outstripping the supply of people in the short term. Several engineering programs have responded by developing graduate level environmental programs. In addition to the research-based programs which normally lead to a M. Sc. or Ph.D. in Engineering, there are programs based on coursework which often result in M. Eng. degrees. These programs are particularly popular with practicing engineers and scientists because they allow them to upgrade their environmental engineering knowledge and skills on a part-time basis. The School of Engineering of the University of Guelph has both thesis-based and coursework degrees in environmental engineering.

In many instances the graduate programs are offered in cooperation with university centres or institutes. For example, the Waterloo Centre for Groundwater Research accepts a limited number of students with a scientific and engineering background. During their studies they learn to apply hydrogeological principles to the management of groundwater systems.

Another well-known non-thesis graduate program with specialization in environmental engineering is the M. Eng. Pulp and Paper Program offered at the University of British Columbia and McGill University in association with the Pulp and Paper Research Institute of Canada. The Institute represents Canada's largest resource-based industry.

4.4 Special Short-Courses and Training Programs

Companies with interest in environmental issues have several other avenues of satisfying their specific training needs, such as association training, on-the-job training, outside trainers, industry seminars and conferences, internally-developed training programs, and equipment supplier/vendor training programs.

Industry associations often offer courses to their members. For example, The Air and Waste Management Association has a Training Institute in Calgary to provide some 32 courses on a broad variety of environmental topics. Similarly, the Environmental Services Association of Alberta has a program to retrain technically-skilled workers from the oil and gas industry for work in the environment.

University engineering and science faculty with special knowledge often contribute as teachers in the associations' initiatives, as outside-trainers or as seminar speakers. They normally provide these services as consultants. An important spin-off of these involvements is that they frequently lead to research projects funded by member companies.

It is expected that distance education through video conferencing or similar methods will play an increasingly important role in making university courses available to industry for on-site training.

5. ENVIRONMENTAL RESEARCH

In considering research linkages between universities and industry it should be kept in mind that research is often done in traditional engineering programs as well as in the newer environmental engineering programs, and increasingly involves interdisciplinary groups. This is particularly true for the environmental research at the University of Guelph where most of the focus is on non-industrial areas, with the exception of the food processing industry. For example, a one-year pilot project involving composting of source-separated organic waste from 15,000 metro Toronto households involved environmental engineering, soil science, and microbiology faculty and staff.

The actual linkages between environmental research at universities and industry can be summarized as being either direct or indirect. In direct cases individual companies provide funding though grants or contracts to individual faculty or group of faculty. Usually this type of involvement is due to the specific expertise of the researcher or the need of company to find a solution to a specific problem.

In indirect instances a number of companies fund research of general interest to all of them through an association, research institute, centre, or similar industrial organization. Again, the grant or contract may be with individual faculty or group of faculty. It is also possible for the industrial organization to provide funding to a University Research Centre or Institute. These will in turn fund the work of individual faculty or groups of faculty.

Another indirect linkage is developed though the funding of Research Chairs, usually with additional funding from government sources. The Chair is usually for a limited duration, normally five years, during which time research is conducted on behalf of the industry. The Natural Science and Engineering Research Council normally funds 50% of industrial chairs.

Figure 1 shows the structure of one industry/university organization - Environmental Science and Technology Alliance Canada (ESTAC). In 1995 ESTAC consisted of the member companies shown, each contributing an annual membership fee ranging from $25,000 to

$100,000 based on Canadian-Made Sales or Total Sales in Canada, and universities, each contributing $10,000 per year. Additional funding in the amount of $5 million over 5 years is provided by Industry Canada to carry out environmental research & development. It is expected that ESTAC will grow to 50 companies and 20 universities by 1999.

Research projects are conducted through interactive networks of company personnel and university faculty.

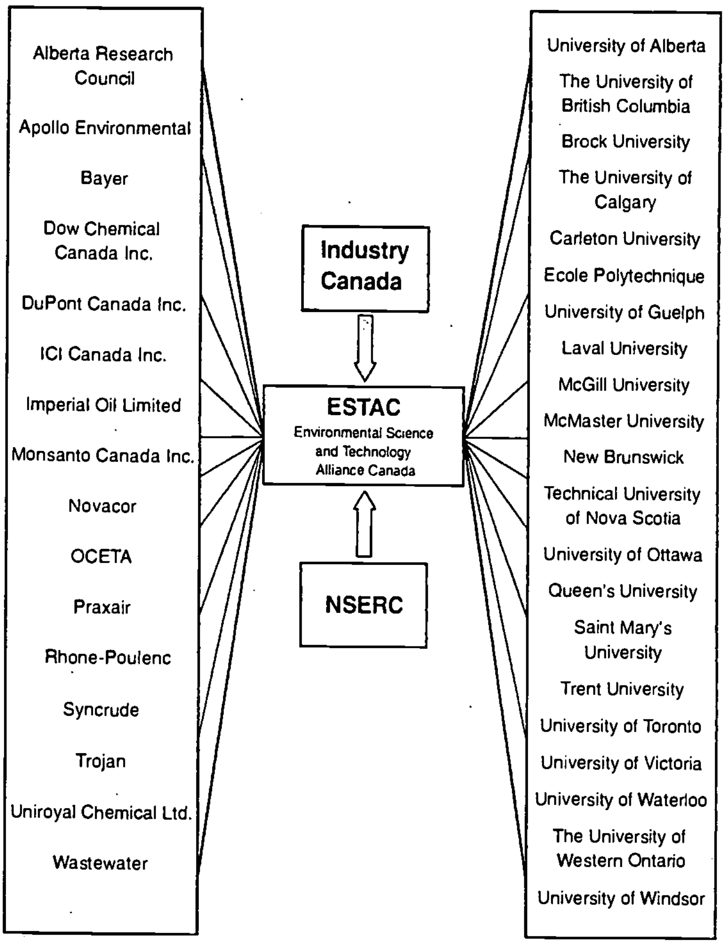

Figure 1. Environmental Science and Technology Alliance Canada

The MEND program (see Table 1) is a cooperative effort financed and administered by the Canadian mining industry, the Canadian government through Energy, Mines and Resources Canada (CANMET), Environment Canada, and Indian and Northern Affairs Canada, and the governments of British Columbia, Manitoba, Ontario, Quebec and New Brunswick. MEND's objective is to develop knowledge and technology that will substantially reduce the concerns and the environmental problems related to acid mine drainage caused by bacterial oxidation and acidification of sulpfide minerals contained in copper, nickel, gold and uranium orebodies and tailings. In Ontario alone some 20 out of a possible 2000 sites have been documented to contain 55,000,000 tones of reactive sulpfide tailings over a surface area of 830 hectares. The cost of stabilizing some sites has been estimated to be as high as $400,000 per hectare, while the average cost is expected to be $200,000 per hectare.

In the past two years there has been a significant shift in funding of environmental research. In the past almost all of the environmental engineering research at universities was funded by grants or contracts from federal, provincial and municipal governments. However, governments have either significantly reduced or completely eliminated their direct grant programs. The present situation is that researchers must have industrial or commercial sponsors before they can apply for matching government funding. In most cases this still means that government provides most of the funding but the research tends to be more applied and problem oriented. NSERC has a number of special programs, including cooperative research grants, shared equipment and facilities, industrial research chairs, and senior and visiting industrial fellowships to promote research.

The Canadian Pulp & Paper Industry has recently launched a $88-million closed cycle research drive. The objective of the five-year program is to shift the emphasis from pollution treatment to prevention, while boosting the industry's global competitiveness. The program is a follow up of the $5-billion investment in new bleaching technology and secondary treatment facilities from 1988-1995, which effectively eliminated dioxins and furans and sharply reduced pollutants in effluent streams. The new research effort is expected to contribute significantly to the various university pulp and paper centres and other environmental engineering efforts.

Table 1: Examples of Industrial Research Funding

Industrial Research Funding Groups	Typical Research Projects
Associations	
Canadian Chemical Producers' Association	hazardous waste; air & water pollution; bioremediation
Petroleum Association for the Conservation of the Canadian Environment (PACE)	plant decommissioning; soil redemption, air & water pollution; hazardous waste, environmental impact of explorations
North American Recycle Rubber Association (NARRA)	recycling tyres; incineration; reclamation; reprocessing;
Alliance of Manufactures and Exporters of Canada	packaging
Ontario Restaurant Association	organic waste disposal : land application, composting
Institutes	
Environmental and Plastics Institute of Canada	hazardous waste; packaging; toxicity; recycling; waste disposal; life-cycle analysis; solvent substitution
Pulp and Paper Institute of Canada (PAPRICAN)	wastewater treatment; biological treatment; sludge management; biodegradation; deinking; recycling; bioconversion; oxygen bleaching; closed cycle technologies
Other	
Soft Drink Manufacturers	recycling, packaging; life-cycle analysis
Food and Consumer Products Manufactures of Canada (FCPMC)	packaging, recycling, waste management; life-cycle analysis
Mine Environment Neutral Drainage (MEND)	land reclamation, acid mine drainage control, groundwater and surface water pollution

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Table 2: Examples of University Centres with Environmental Research Interest

University Centres	Typical Research Projects
Pulp and Paper Centres : University of British Columbia, University of Toronto, McGill University, Ecole Polytechnique	deinking, chlorine dioxide production, anaerobic fermentation, composting, biodegradation of resin acids, monitoring of contaminants in pulp mill discharges, treatment of newsprint mill whitewater; dour removal and control, bioprocessing of solid waste residue, wastewater sludge management.
Waterloo Centre for Groundwater Research	Groundwater quality; oil remediation; risk assessment; environmental impact assessment

6. EXAMPLES OF RESEARCH LINKAGES

As mentioned before, the scope of environmental research is considerable and involves traditional engineering fields, environmental sciences, chemical and biological sciences, toxicology, sociology, mathematics, computer science, etc. Table 3 was constructed to provide some specific examples of the types of projects funded directly or indirectly by industry in the last few years at the School of Engineering. It does not show the research funded directly by different levels of government, which still accounts for at least 80% of all environmental engineering research funding for the School because of its roots and connections with the agricultural and food sciences.

It is interesting to note that several of the projects involve biological treatment of contaminated sites and waste streams. Biofiltration and composting of organic wastes are major areas of research, only a fraction of which is funded by industry. Nevertheless, industry has provided some $300,000 for these projects in the past few years.

7. CONCLUSION

There has been a rapid growth in the environmental industry, both in equipment production and services sectors, in response to a number of driving forces. The most important one being the need to comply with new environmental laws and standards. Most engineering faculties have responded by either increasing the number of environmental options available to the students or, in a few cases, by introducing accredited environmental engineering programs.

Research linkages in environmental engineering between universities and industry are less common than government sponsored research. Furthermore, most projects that are funded by industry also have a significant contribution of government funds. It is however expected that industry will play a greater role in research funding as governments are cutting back more and more to reduce their enormous deficits.

Table 3: Examples of Industry Funded Environmental Engineering Research Project at Guelph (1994-1996)

Project Title [Sponsor]
Formation of chlorinated organic compounds by commercial bleach discharges to sewers [Chlorox]
Quality of storm water runoff. [Gamsby and Mannerow Ltd]
Enhanced biofiltration of waste off-gas streams. [Canadian Petroleum Products Institute]
Biofiltration pilot study for CGT's dry laminator emissions. [Canadian General Tower Limited]
Composting of source-separated municipal solid waste. [Procter & Gamble Inc.]
Fate of disposable diapers in composting systems. [Procter & Gamble Inc.]
Biological degradation of slaugtherhouse waste. [J.M. Schneider Limited]
Soil remediation using supercritical extraction. [GASRep]
Chemical spill behaviour. [Imperial Oil]
Stripping and volatization in wastewater facilities. [Water Pollution Control Federation Institute]
VOC emissions from industrial drops and drains. [Dupont Chemicals]
Gasoline volatilization from wet soil. [Imperial Oil]
Biological remediation of diesel fuel contaminated soil. [Bell Canada]
Hydrocarbon flux measurement : method development and application. [Bell Canada]
Infiltration into permeable concrete block pavement. [Unilock Ltd.]
Thermal enrichment of stormwater runoff by paving. [Unilock Ld.]

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Section Three: Country Reports

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CAMBODIA

Cambodian Report

Mrs. Phoeurng Sackona,
Head of Food Chemistry Dept.,
the Institute of Technology,
Phnom Penh, Cambodia

1. SOME LANDMARKS

The history of the Institute of Technology or ITC is the history of Cambodia : good times, bad times, important dates. To help better understand the challenges which face ITC, we will start with some landmarks in the history of the Institute.

The inauguration of the Khmer-Soviet Friendship Institute of Technology (ITSAKS) by Prince Sihanouk, as a result of a cooperation agreement between Cambodia and the Soviet Union.	20 Sept. 1964	
ITSAKS trains hundreds of graduates, teaching in French.	1964-1975	
	17 Apr. 1975	The Khmer Rouge enter Phnom Penh.
	1975-1979	The premises of the Institute serve as a transit centre.
	7 Jan. 1979	The Khmer Rouge regime is overthrown.
ITSAKS trains, teaching in Russian, the 1980-1991 specialists which the Cambodian economy so desperately needs.	1980-1991	

After the departure of the Soviet experts, the Institute maintains a minimal level of activity, thanks to support from the UNDP.	1991-1993	
	23 May 1993	Under UN supervision, free elections mark the birth of the new Cambodia.
A cooperation agreement is signed by Cambodia and France; responsibility for the renovation of the Cambodian Institute of Technology is entrusted to AUPELF-UREF.	10 Sept. 1993	
The first three-year plan confirms the renaissance of ITC.	1993-1996	
	1996-1999	The second three year plan will consolidate ITC's regional importance.

2. PRESENT SITUATION

When we are talking about the formation of engineers and technicians in Cambodia, we must start with ITC. ITC is the only institute in Cambodia charged with training technicians and engineers for industry. In addition, it has established a close relationship with the industrial sector to ensure that its training meets national needs.

After the free election on May 1993, ITC possessed a clear vision of its role and its future, and has been fortunate enough to receive the financial assistance necessary to begin implementing the vision without any loss of time. To implement the agreement signed between Cambodia and France on 10 September, 1993 for the development of ITC, AUPELF-UREF (Association des Universites Partiellement et Entierement de Langue Francais-Universite des Reseaux d'Expression Francais) was designated as operator under supervision of the Ministry of Education, Youth and Sport. The objectives are :

- to train the technicians required for the reconstruction and development of Cambodia,
- to train the engineers who will contribute to the development of Cambodia and of the other countries; this training will be open to candidates from throughout the neighbouring countries,
- to train Cambodian engineers to research level, and
- to train the new generation of engineers to a communicatively competent level in English.

At present ITC has two programmes :

- a 3 year course leading to a Diploma of Technology (DUT)
- a 5 year course for engineers

The students in these two programmes are recruited by entrance examination from high school graduates. (See Table 1). After their first year of study students select one of the five specialist departments at ITC: Civil Engineering(GCI), Food Technology and Chemical Engineering (GCA), Energy and Electrical Engineering (GEE), Industrial and Mining Engineering (GIM), and Rural Engineering (GRU). (See Chart 1).

Table 1: Enrolment for Entrance Examination at ITC

	Engineer course/ for 30 places	Technician course/ for 150 places
1994	738	770
1995	391	243
1996	2917	1934

Enrolment of female students increased from 3% (1995) to 15% (1996)

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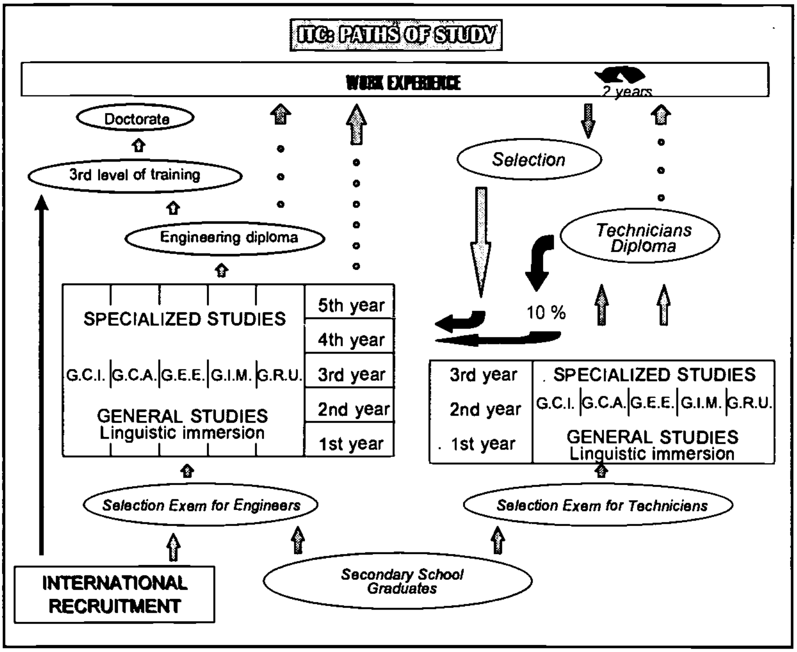
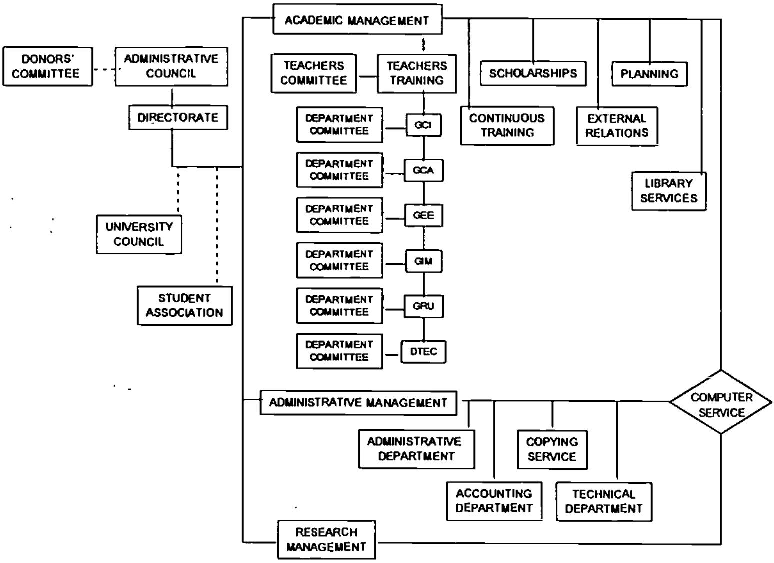
Chart 1: ITC : PATHS OF STUDY



The 3 year technicians' course is taught in both Cambodian and French, while only French is used for the engineering course. At a later date French-speaking international students from the Asia-Pacific region will also be able to enrol for this course. ITC maintains links with Francophone countries and with equivalent educational establishments in various countries of the region, including Thailand, Laos, Vietnam and New Zealand.

The support given through a committee representing the donors is also international, with representation from AUPELF-UREF, Belgium, Cambodia, France, New Zealand, UNDP, UNESCO and soon, Quebec-Canada, as well as from industries active in Cambodia and abroad. Similarly, the Administrative Council consists of members from Belgium, Cambodia, France, the Lebanon, Quebec-Canada, and Tunisia.(See Chart 2).

Chart 2 : Administration at ITC



Since the reopening of the Institute in 1994 the first priority has been the renovation and refitting of the buildings, classrooms, laboratories and workshops, and a restructuring of the administration and teaching programmes to meet the demands of the new system. This also explains why ITC needs to recruit personnel from abroad, while simultaneously improving the skills of those already working at the Institute.

1996 was a watershed year for the Cambodia Institute of Technology-marking the end of the first phase of renovation (1993-1996) and the beginning of the second (1996-1999), which will carry the Institute to the brink of the twenty-first century.

3. PROBLEMS

ITC has restored a balance between the training of engineers and technicians (1/3 engineers, 2/3 technicians) that reflects actual demand. However in spite of some efforts, ITC has faced some serious problems.

- The lack of human resources. This is related to the precarious financial situation of the teaching staff which is caused by low government salaries; the result of which is that the best teachers have left their jobs to go to another organisation or NGO. Also, of the 78 full-time technical teaching staff, only some of them are Ph.D graduates. The rest have Master's Degrees. Most of them studied in non-Francophone countries, in Russia, Germany, Czecho slovakia and thus we do not share a common technological language. Even the Khmer translation is not uniform. One solution found is to use French language but the French language is new for certain teaching staff too, and now when the teachers are required to teach in French, they can not assure the courses. At present, in ITC the majority of courses are assured by foreign and part-time teachers. We have to find a rational solution to replace foreigners and part-time teachers with our own teaching staff. (See Table 2). Under the circumstances of the first two decades, teachers were trained to follow instructions. However , the demands of today require that all the members of the team must take initiatives and be prepared to take on leadership roles.

- The Cambodian students do not like the technician courses. It is a belief of Cambodian people, not yet to see the important role of technicians in the economic development of the country. The result is that students either drop out of technical courses before they have finished or they study expecting that they can get a master's degree in another subject and in another establishment.
- The problem of language. As Cambodia is a neighbour of ASEAN countries, most of the demand for jobs is in English, and an academic programme with the French language imposes difficulties on graduates.
- In spite of these difficulties, ITC has established new training programmes that conform to the socio-economic reality of the country. The following areas are regarded as priority areas by the marketplace :
    - building and public works
    - prospecting for producing and distributing energy
    - processing agricultural produce and food technology
    - providing clean, safe water
    - industrial maintenance
    - telecommunications

- irrigation and agricultural hydraulics
- electronics
- computer training
- impact on the environment.

Table 2: Staff Statistics of ITC, 1997

Direction / Dept. Service	Teachers		Laboratory staff	Administrative staff		Foreign staff
	Full time	Part time	Full time	Full time	Part time	
Director						1
Director Administrative				1		
Administration				8	15	1
Technical service				19	21	1
Financial management				8		1
Direction of Studies				5	1	2
French language	8	18	1			5
Library				3	1	
Information Technology	2		1		1	2
Physical Education	1					
TC	7		3	1		3
GCI	12		3	1		3
GCA	11	2	5	1		1
GIM	13	1	3	1		1
GEE	11		2	1		3
GRU	10		2	1		1
In training	6		2	1		
Total	**87**	**25**	**22**	**50**	**39**	**27**

- FULL TIME = 159
- PART TIME = 64
- FOREIGNER = 17

TOTAL = 250

Student performance in the world of work has changed as government policy has changed :

- In July 1994, 164 engineers graduated. All were employed within the civil service.
- In July 1995, 210 engineers graduated. Only some were recruited into the civil service.
- In July 1996, 261 engineers graduated. The graduates are not guaranteed employment within the public sector. But more than 20% were employed in the private sector.

But to solve some problems, ITC has a strategy to face these difficulties :

- Adoption of a system of salary supplementation based upon actual performance. Send the teaching staff abroad for training long- term and short-term. Allow overseas scholars to continue to come. Develop links between each department and other establishments in France, Belgium, Canada and other regional or international countries.
- To change the beliefs of people is very difficult, but to make the technician courses for young Cambodians more acceptable, we need general information. We must wait until July 1997, when the first group of technicians will graduate and perform in the market of jobs, after that the problem will be partially resolved.
- ITC has reviewed the academic programme and set -up English courses to assure that the graduates are able to communicate with companies and industry in English.

4. FUTURE PLANS

The ambitions of ITC for the 1996-1999 period are to consolidate its leading position as a provider of higher education in Cambodia and to bring international recognition to the Institute. In order to succeed, two strategies are required.

- First, it is necessary to reinforce the achievements of the first phase at the level of initial training.

- Second, it is necessary to implement new actions so that ITC in the year 2000 becomes a truly multilateral establishment with a regional vocation.

The primary role of the Institute is to train its students up to regional and international standards.

To achieve this, the programmes provide a solid general training with work experience in industry, allowing the students to specialise towards the end of their studies. But today knowledge and know-how by themselves are not enough to assure future employment. Among the keys to success today are the capacity to communicate, and flexibility.

To satisfy this objective, four elements must be brought together :

- open access for all
- partnership with industry
- teaching resources with high calibre
- a physical environment conducive to learning

Today, the development of the skills of the teaching staff have become the major commitment. A three- pronged strategy will allow us to achieve this goal.

First Focus : improvement of basic skills

Short courses at ITC
Teaching assistance and advice by teams of visiting specialists
Further training and re-qualification of teachers
Distance education

Second Focus : development of new skills

Involvement in research and continuing training
Learning of foreign languages
Development of inter-university exchanges

Third Focus : increasing motivation and broadening horizons

System of performance-based remuneration
Involvement with private sector professionals
Training in industry

ITC's principal role is the training of engineers and technicians, but it must also become a provider of goods and services.

From being a centre for training, it must move to become a centre for resources. It must be achieved in the following ways:

- Continuous training : The organisation of training courses open to industry is a natural activity for a Resource Centre. It must respond to the urgent needs of professionals involved in current projects who are hampered by the insufficient training of their employees. The participation of the teaching team in continuous training sessions will also enrich the teaching at the initial training level. These activities will also be a source of income for ITC, allowing the support of other activities within the Institute. They can also be offered off-campus, so that ITC's reputation can spread throughout region.
- Help in establishing production units : ITC can assist in the planning, establishment and future support of production units in such areas as food technology, energy, maintenance.
- Expertise working with businesses : ITC propose technical support of applied research projects, projects that aim to optimise production and those that experiment with new materials.
- Development of a Junior Enterprise Club: can lead to a diverse range of experiences for the students.
- Teachers training expertise: ITC can supply programmes for training trainers and other teaching services.
- Development aid : ITC is able to make its expertise and resources available to communities for specific purposes.
- Developing a third level of training.

5. SUGGESTIONS

One of ITC's objectives is to participate in the development of the region where Cambodia is re-establishing itself. To achieve these objectives we have some suggestions:

- Regional and International Exchanges : It is, for instance, possible to arrange a calendar of annual meetings, bringing together specialists in technological fields, both from within the region and from further afield. We need to develop partnerships and relationships with our neighbours in SEAMEO and ASEAN, and to recognise that we are part of the Asian family : we must support each other.

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- A regional, inter-university network : Organisation of colloquiums amongst teaching teams and the promotion of the exchange of students throughout the region whether for initial training as engineers, for continuous training, or for research.

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CHINA (YUNNAN)

Promoting Cooperation, A New Prospect for Engineering and Technology Education in the Mekong Subregion for the 21st Century

Yang Sizhong,
President of Yunnan Polytechnic University

ABSTRACT

New requests are facing us with the development of the Mekong subregion among the engineering education institutes. Because of the function and current state of engineering education in China and in Yunnan Province, because of the importance and active promotion attended to by the Yunnan Provincial Government for the economic exploration and cooperation in the subregion, because of the support, association, and assistance by SEAMEO RIHED ; we can see it is very important for the 21st century to strengthen the collaboration of engineering education institutes in Asia and Pacific. In the subregion, we are sure this kind of collaboration will bring us a brilliant future.

1. THE CURRENT STATUS OF CHINESE HIGHER ENGINEERING EDUCATION

The Chinese higher engineering and technology education has been gradually formed into a complete system with certain scope, multilevels, various subjects and specialties.

Only 28 Polytechnic Universities existed in 1949, they added up to 292 in 1993, making up 27.4% of 1,065 national standard higher universities and institutes. There were only 30,000 undergraduate students in the polytechnic universities in 1949, the number of the students reached 934,000 in 1993, making 36.7% of the total 2,534,000 students. The technical graduate students were not more than 100; the Ph.D. students were 8,155 in 1949 ; however these numbers had increased to 41,234 and 49,389 by 1993, respectively.

In 1949, the national industrial institutes only set up subjects, no majors. However, 379 kinds of majors, and 5,717 major sites in the state had been built up by 1993. They respectively make up 40% and 35.4% of the total state undergraduate majors.

There were only 10,000 professional technical teachers in 1953,but this increased to the total number of 107,166 ; from them, the professors were 7,947; the associate professors were 29,626; these two items totally are 37,573; they separately make up 32.5%, 31.1%, and 21.3% of all the professors, associate professors, and professional teachers in the state.

Before 1949, the graduate and undergraduate students were only 32,000; from 1949 to 1993, they totally reached to 3,074,800. That is 96 times of the total numbers compared with those in 1949.

Additionally, there were 195,200 undergraduate students in the department of correspondence, night school, adult training school. The Occupational College, Broadcasting TV College also had 195,000 undergraduate students on campus in 1993.

The above factors identify that Chinese engineering and technology education has made tremendous progress, playing a role position in the Chinese socialist construction and higher education. The system of Chinese engineering and technology education basically can fulfill the needs of the economic construction of Chinese socialism, international exchange and cooperation.

Figure 1: The number of Chinese standard higher education institutes and engineering institutes :

YEAR	NUMBER OF	
	ALL H.E. INSTITUTES	ENGINEERING INSTITUTES
1949	205	28
1957	229	44
1960	1,289	472
1963	407	120
1971	328	120
1978	598	184
1983	805	215

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Figure 2: The number of undergraduate students at Chinese higher education institutes:

YEAR	NUMBER OF	
	ALL H.E. INSTITUTES	ENGINEERING INSTITUTES
1949	117,000	30,000
1957	441,000	163,000
1960	962,000	388,000
1963	750,000	319,000
1971	830,000	240,000
1978	856,000	288,000
1983	1,207,000	419,000

2. THE CURRENT STATUS OF HIGHER ENGINEERING AND TECHNOLOGY EDUCATION IN YUNNAN PROVINCE

There are two polytechnic universities in Yunnan Province, they are Kunming Science and Technology University, and Yunnan Polytechnic University.

Kunming Science and Technology University is under the administration of The Chinese Nonferrous Metal Corp. It has Geological Engineering, Mining Engineering, Mineral Processing Engineering, Heat Engineering and Power Mechanics, Mechanical Engineering and Automation, Measurement Control and Apparatus, Computer Science, Civil Engineering, Chemical Engineering and Technology, Administration Engineering etc. There are more than 6,000 undergraduate students.

Yunnan Polytechnic University is one of the comprehensive, provincial key universities, which mainly covers industrial education, and is attached to Liberal Arts and Social Science, Economics, and Management. They are namely the School of Mechanical Engineering, the School of Civil Engineering, the School of Chemical Engineering and Light Industrial, the School of Electric Power Engineering, the School of Material Science Engineering, the School of Business Management, The School of Adult Education. They include 23 departments, 35 four-year-study majors, and 15 three-year majors.

Presently, the university has 6,500 full-time undergraduate students; 1,911 faculty members; 384 of them are professors and associate professors.

Yunnan Polytechnic University insists on the educational goal of serving Yunnan Province, whatever in terms of the establishment of majors, the structure of fostering capable people, and the target of the scientific research, the university fully considers to serve for the economical construction and social development, for the priority industrials of Yunnan Province, and the preparation of capable people and technology for the long-term development of Yunnan Province.

With the adjustment of subjects and majors at Yunnan Polytechnic University in 1996, Biology Technology, Material Science were added, in addition to these, Social Science, Business Management, Electronics and Information, Motor Engineering and Mechanical Engineering were modified. All of these measures make the structures and the subject goals and technology of Yunnan Polytechnic University closely fit the needs of the economic, scientific and technological development of Yunnan Province, and for the training of qualified, comprehensive capable people for the 21^{st} century.

Yunnan Polytechnic University insists on the rule of serving society. Each school has established close relations with the relevant factories and organizations. We expect that Yunnan Polytechnic University would become the basic site to train the qualified people, to do research for the diversity of the related factories of Yunnan Province. Furthermore, the liaison between departments and factories should become the basis for the student to practice, the resource basis of the student to link to the real world of work, and the basis of service for Yunnan Province. In order to realize this goal, we are ready to take the following items:

1. Building up the long-term cooperative relationship with relevant departments and factories, and signing working agreements.
2. One factory and the university mutually construct a school; for instance, with the combination of the Power Bureau, the Power School is founded. So is the School of Chemical Engineering and Light Industrial, which is combined with the common interest of the Yunnan Natural Gas Company.
3. With the investment of the concerned factory for the school, the relevant lab is set up, and both sides share the equipment.

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4. The research of the new product, new technology and the new technique are able to be processed in the above mentioned lab.
5. The result achieved from the relevant experiment has priority to be used in the partner factories.
6. The university offers the service to train qualified people of different levels and different standards.
7. The factory takes part in the education reform of the university.
8. The factory offers a practical site for the students.

From the above statement, we expect to establish long, steady, and close relationships in academic research, and productivity so as to virtually satisfy all the social needs.

We have already started implementing the above plans. Yunnan Polytechnic University takes account of international cooperation and exchange. So far the university has already established exchange relationships with Columbia University, Carnegie Mellon University, California State University in USA; La Trobe University in Australia; University of Dundee in England; Tokyo Denki University in Japan; King Mongkut's Institute of Technology, Thonburi and Chulalongkorn University in Thailand; and City University of Hong Kong.

3. YUNNAN PROVINCIAL GOVERNMENT'S ATTENTION TO COOPERATION AND DEVELOPMENT IN THE MEKONG SUBREGION

It is well known that the Mekong river is one of the most important international rivers. The first branch of this river rises from Tangula mountain of Qinzan Plateau in China, flows through the east of Tibet and Yunnan Province, this part is called the Lancanjiang River. The second part of the branch, which is called the Mekong River, flows from the board of Yunnan Province through Myanmar, Lao PDR, Thailand, Cambodia and Vietnam, eventually into the South China Ocean. The entire length of the river is 4,800 kilometers, regarded as number 12^{th} in the world, which covers 230 square kilometers in six countries of which the population is 230 million, and the six countries share it. This region is full of rich natural resources and human resources. In recent years, these six countries have rapidly developed their economies, while at the same time, currencies have been kept relatively stable. Presently, the annual increase rate of the national economy in this region is 6%, the GNP has risen to 1,840 billion US$, the average GNP for the people of the six countries is between 225 US$

and 2,450 US$, the average for the region is 805 US$. In accordance with this speed, the GNP in the subregion is predicted to reach to 8,630 billion in the year 2010. Meanwhile, if the increased proportion of the population keeps at 2%, (which means the total population number is 3.14 billion), then the average income could reach to 2,700 US$, which would be three times that of 1994.

The Yunnan Provincial Government considers that the exploration of the subregion extremely reserves potential economic resources, which include the plentiful supply of human resources, water power resources, mineral resources, biological resources, and tour resources. All of these are located in the liaison of three economic circles of Southeast Asia, South Asia, and the South West district of China. The undeveloped transportation, backward facilities in combination with the rich resources, and the impoverished people make this region full of enormous trade opportunities in investment. The diversity of each county's advantage in resources and markets are formulated to complement business. The collaborative exploration will be beneficial for keeping good-neighborly relations, it also can create the better conditions for the continuing development of national and social civilization in the region.

Yunnan Province pays great attention to regional cooperation, regarding itself as one of the key members, actively joining subregion cooperation. Building the land channel and economic corridor, among South West of China, Southeast Asia, and South Asia, pursuing trade with each other is the important strategy of Yunnan Province which is supported by the Central Government.

The Yunnan Provincial Government suggests that the cooperative goals are, firstly : promoting ten linkages; secondly, exploring six resources; and thirdly, controlling the four abuses.

"The ten linkages" means aviation, water transportation, highway, railway, telecommunication, power network, travel network, commerce and trade, finance, and the human resources network and exchange.

"The six resources" means the exploration of human resources, power resources, travel resources, land resources, biological resources, and mineral resources.

"Control of the four abuses" means control of the worse damage inflicted on the natural environment, the realization of continuing development, the control of illegal immigration, the safeguarding of the security of the district, the control of drug abuse, the development of concerned industries, the promotion of the development of the national economy, the control of the spread of Aids, and the matters of evil appearance in society; thus realizing the further progress of social civilization.

In order to join the cooperation of the subregion, the Yunnan Provincial Government does a lot of work under the leadership of the Central Government.

1. Funding the provincial organization - Subregion Cooperative Leadership Office.
2. Actively promoting the construction of aviation, navigation, highway, railway, power etc. and basic facilities. The highway construction from Simao to Banna is under process. The reconstruction of the six airports in Simao, Baoshan, Dali, Lincan, Diqin are under design and will form an air net. The Dian-Myanmar highway, Dian-Vietnam highway, and Dian-Thailand railway, Dian-Myanmar railway are also under construction. Cleaning up the Lantern River, Mekong River, completing the environment protection project.
3. Actively expand the market of the international trade, and make use of the foreign investment. According to the statistics, the volume of imports and exports is 20.76 billion US$.
4. Devoting major efforts to developing domestic and overseas travel, the foreign currency from Southeast Asia took up 35% of the total tour amount in Yunnan Province in 1995.
5. Extensively participant and organize exchange and cooperation internationally.

4. STRENGTHENING THE COLLABORATION, CONTRIBUTING TO THE FUTURE OF THE SUBREGION

The subregion collaborations not only offer appropriate opportunities for the various countries, but also for the higher engineering institutes and universities in the subregion. These institutes should fasten the pace in collaboration and cooperation by pursuing the following:

1. A symposium of Subregion Higher Engineering Institutes should be held at a certain time each year in which, the exchange of information on education reform and how each institute is serving scientific development for the 21st century, can be explored.

2. International exchange and cooperation among the institutes, seeking projects of common interest, should be expanded.
3. There should be an increase in the frequency of the exchange items for students and teachers, thus allowing them to understand the situation of different districts so as to initiate and explore new cooperative subjects and fields.
4. From the bridge of AUAP, the advanced higher engineering institutes can tie-up with the higher engineering institutes of the subregion, which will play an important and significant role in the development of institutes in subregion for 21st century.

LAO PDR

The Faculty of Engineering and Architecture at the National University of Laos (NUOL)- the Department of Communication and Transport

Vixay Chansavang,
Head of Department of Communication and Transport

1. BRIEF BACKGROUND ON DEPARTMENT OF COMMUNICATION AND TRANSPORT (DCT)

The School of Communication and Transport was built by the French Government and officially opened on 22 November 1972 . It was initially named Youth School and then the Road and Bridge School. The first civil engineering students graduated in April 1975. It was in 1975 that the L.P.D.R. Party came to govern Laos in its own right and after a few years the needs of the country for road and bridge works grew. Perceiving this need, the School was expanded (some regional schools were absorbed) and five main branches were established to an intermediate level, namely, roads and bridges, transport, survey, mechanics (automotive) and building.

In 1983 a decision was made that the School needed two new branches (Fluvial-construction and Hydrology) and a higher level certificate than intermediate for the four branches of roads and bridges, transport, fluvial-construction and hydrology. However, in 1987 a further change took place and the branches other than roads and bridges, transport and survey were transferred to other schools. At present the School has a higher level diploma (four-year course excluding the pre-study year) for the roads and bridges and transport branches but an intermediate level (three years) certificate only for the survey branch ; the roads and bridges branch also has an intermediate level certificate. Before enrolment all students are required to have satisfactorily completed secondary school.

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2. NUMBER OF SCHOOL GRADUATES IN 1996

Roads & Bridges (Diploma Level)	1643 (39)
Transport (Diploma Level)	394 (27)
Fluvial-construction (Diploma Level)	149 (8)
Hydrology (Diploma Level)	168 (3)
Roads & Bridges (Intermediate)	799 (92)
Survey (Intermediate)	598 (39)
Transport (Intermediate)	245 (21)
Mechanic (Automotive) (Intermediate)	70 (1)

Total number of graduates:

Diploma Level	2354 (77)
Intermediate Level	1712 (153)

NB. Figures in brackets () indicate female graduates

3. STAFF NUMBERS

The total number of staff is 71 persons, of whom 28 are women.

Teaching staff number 50, including 9 women, and the other 21 are secretarial and support staff.

39 teaching staff have degrees (from Russia, Germany, Vietnam and Laos) and 18 of them work within the roads & bridges branch, 3 in the transport branch and 18 in the basic sciences.

4. PRESENT STUDENT NUMBERS 1996-97

Pre-study year 48 (7)

Branch/level	1st year	2nd year	3rd year	4th year
Roads & Bridges (Diploma)	84(6)	105 (6)	96(7)	109(3)
Transport (Diploma)	30(8)	-	-	-
Roads & Bridges (Inter)	43(6)	23 (7)	42(7)	-
Survey (Inter)	44(7)	45 (6)	43(3)	-
Total number		712 (73)		
Road and Bridge (Higher Level)		468 (37)		
Intermediate Level		244 (36)		

NB. Figures in brackets () indicate female students

5. SCHOOL OBJECTIVES

(a) Pre-study year.

To assist students undertaking a higher level (diploma) course, a one -year pre-study course was introduced a few years ago as the failure rate without the pre-study year was found to be high. The pre-study year includes mathematics, physics, chemistry, politics, English and computer basics.

(b) Roads and Bridges branch.

It is the School's objective that graduates from the diploma course will have gained the basic knowledge to be able, after a few years practical experience under the supervision of experienced engineers, to undertake the following tasks:

- supervise bridge and road construction,
- the design of roads and bridges,
- evaluate the quality of construction materials and make selections on their use,
- estimate construction costs for budget and contract purposes,
- undertake contract administration and control of construction plant, and
- undertake maintenance of road and bridge works.

It is the aim to equip graduates for employment in the government service and in private industry and contracting.

(c) Transport branch

It is the School's objective that graduates from the diploma course will have gained the basic knowledge to be able, after a few years practical experience under the supervision of experienced engineers to undertake the following tasks :

- transport planning (road and water),
- study and arrive at solutions to traffic engineering problems,
- transport economics including bus and truck operations, and
- transport storage and warehousing.

It is the aim to equip graduates for employment in the government service and in private industry and contracting.

(d) Survey branch

It is the School's objective that graduates from the intermediate level certificate will have the basic knowledge to be able, after some years practical experience under the supervision of experienced surveyors and/or survey technicians to undertake the following tasks :

- the work of a survey technician,
- survey for topographic maps,
- calculate survey data and calculate earthworks volumes, and
- undertake road and bridge set-out surveys.

It is the aim to equip graduates for employment in the government service and in private industry and contracting.

6. CURRICULUM

Department	Studies/ Programmes	Duration
1. Road & Bridge	Total hours : 3,801 Divided 5 parts ■ Social Science 576 hrs. ■ Basic Science 780 hrs. ■ Basic of Techniques 492 hrs. ■ Basic of Specialist 681 hrs. ■ Specialization 640 hrs.	4 - year course
2. Transportation Engineering	Total hours : 3,172 Divided 3 parts ■ Social Science 1,378 hrs. ■ Basic of Techniques 496 hrs. ■ Specialization 1,298 hrs.	4 - year course

3.	Road & Bridge intermediate level	Total hours : 2,458 Divided 4 parts ■ Social Science 917 hrs. ■ Basic of Techniques 651 hrs. ■ Specialization 493 hrs.	3 - year course
4.	Surveying intermediate level	Total hours : 2,272 Divided 3 parts ■ Social Science 560 hrs. ■ Basic of Techniques 504 hrs. ■ Specialization 1208 hrs.	3- year course

7. STAFF CONSULTANCY AND PRACTICAL FIELDS FOR STUDENTS

1. Department of Communication - Ministry of Communication, Post, and Construction (MCTPC)
2. Communication Design Institute (CDRI)
3. Some Enterprises whose works involve Road and Bridge construction in Laos (especially in Vientiane Municipality).

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Engineering Education at the National Polytechnic Institute (NPI), Faculty of Engineering and Architecture, the National University of Laos (NUOL)

A summary of the paper presented by
Sengsomphone Viravouth,
Vice Dean, Faculty of Engineering

The problems facing engineering education at the Faculty of Engineering and Architecture, NUOL, and their proposed solutions were outlined and supported with statistical data.

PROBLEMS

Pertinent problems in engineering and technology education :

Quality of the studies and teaching staff.
Lack of practical skills, experience and training (See Table 1).
Continuing Education.
University- Industry Cooperation.

SOLUTIONS

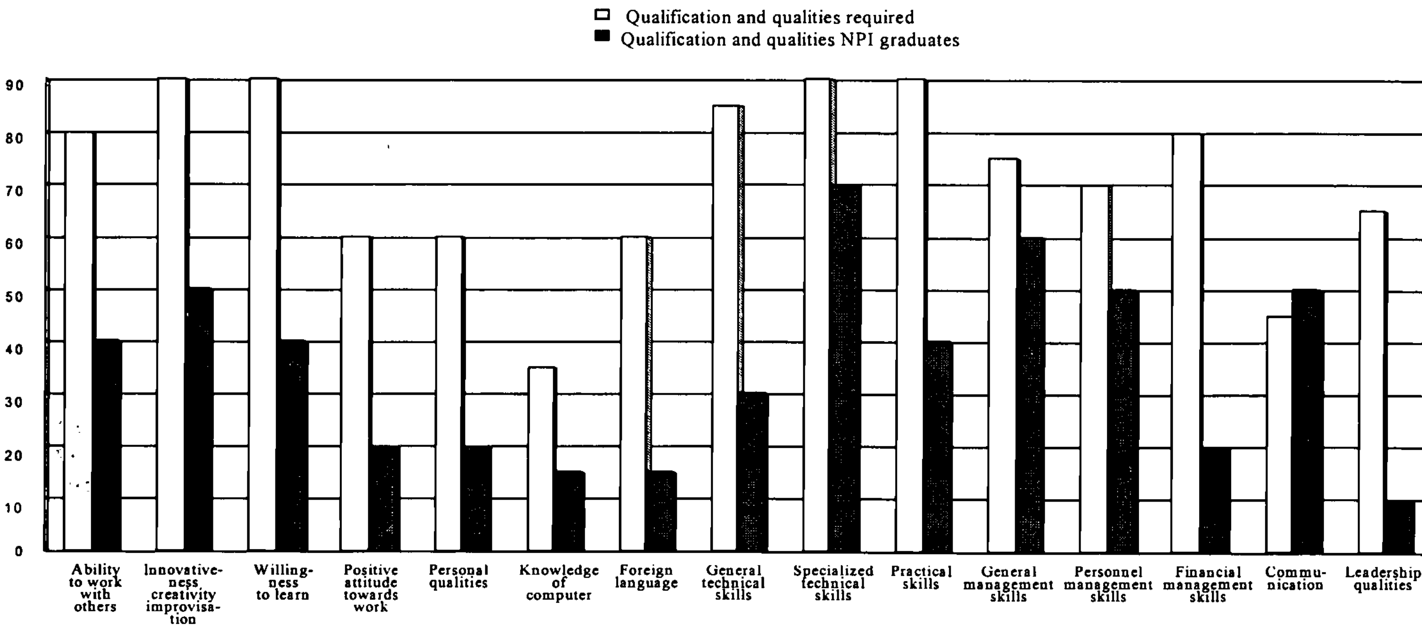
Current attempts to solve some of the problems include:

Implementation of new curricula which must be in accordance with the country's needs; and be comparable to and compatible with the international standards (i.e. a broad engineering background). (See Figures 1and 2)

Preparation of lecture manuscripts.
Training of academic and non-academic staff. (See Tables 2 and 3)

Providing new facilities (laboratories, workshops….) and new equipment, books and didactical materials.
Undertaking institutional development.

Table 1: Expectation of employers and quality of graduates (in percentage)



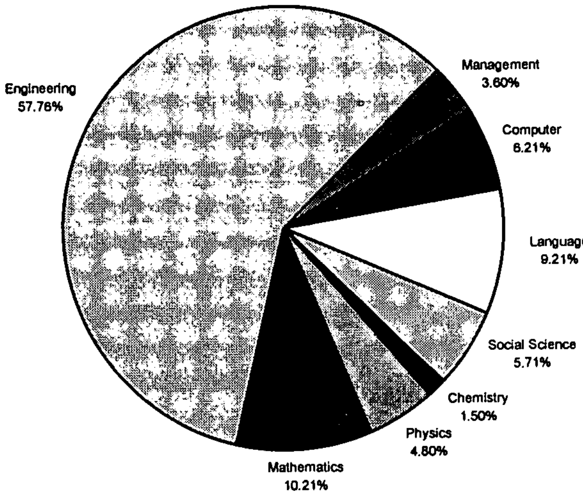


Figure 1: Existing 5-Year Engineering Course Structure for NPI

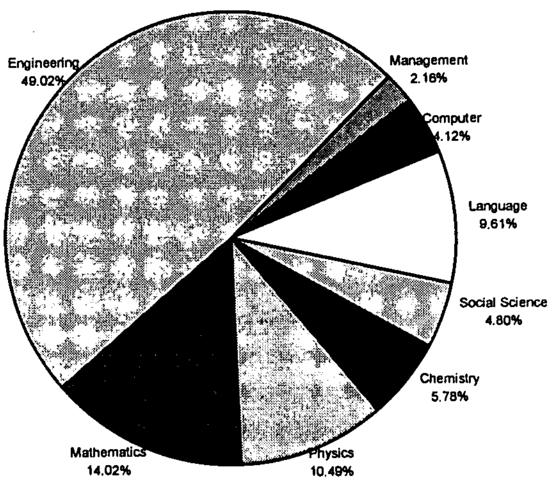


Figure 2: Proposed Engineering Course Structure, Including Pre-engineering, for NPI

Table 2 : Staff Members for 96-97, at the Faculty of Engineering and Architecture

DEPART.	DEPART. of COMMUNICATION and TRANSPORT	DEPART. of CIVIL, ELECTRICAL and MECHANICAL ENGINEERING	DEPART. OF IRRIGATION	DEPART. of ELECTROTE-CHNICS and ELECTRONICS	DEPART. of BUILDING CONSTRUCTION and ARCHITECTURE	TOTAL
STAFF						
ACADEMIC STAFF	50(9)	79(14)	25(N/A)	34(2)	52(N/A)	240(25)
NON-ACADEMIC STAFF	21(19)	43(21)	10(4)	7(N/A)	15(N/A)	96(44)
TOTAL	**71(28)**	**122(35)**	**35(4)**	**41(2)**	**67(N/A)**	**336(69)**

( ) Female

Table 3: Number of Academic Staff in the Faculty of Engineering and Architecture (96-97)

DEPART.	DEPART. of COMMUNIC-ATION and TRANSPORT	DEPART. of CIVIL, ELECTRICAL and MECHANICAL ENGINEERING	DEPART. OF IRRIGATION	DEPART. of ELECTROTE-CHNICS and ELECTRONICS	DEPART. of BUILDING CONSTRUCTION and ARCHITECTURE	TOTAL
DEGREE-LEVEL						
Ph. D	0	1	0	1	0	2
MS. DEGREE	0	14	0	0	0	14
BS. DEGREE	30	63	20	27	42	182
DIPLOMA	15	1	5	5	7	33
CRTIFICATE	5		0	2	3	10
TOTAL	50	79	25	35	52	336

FUTURE PLANS

Future plans for engineering education at NUOL were outlined as follows :

A. Undergraduate Education

There is a need to educate society about the role of an engineer and for NPI to establish itself as the country's only institution capable of producing engineering graduates.

The graduates and the employers indicate the need for improving the curricula. The Institute must be aware of these demands and do its best to upgrade its teaching staff and periodically "fine- tune" its curricula in line with the demands of the country.

B. Continuing Education

There is a great demand for short-term training courses by the practising engineers and by industry. The Institute must develop the potential to offer such courses as part of a "Continuing Education Programme" and start offering these as soon as possible.

C. University- Industry Cooperation

There is the willingness of industry to closely cooperate with the Institute. NPI must do its best to strengthen this cooperation by utilizing the established "NPI - Industry Advisory Council".

There is a great demand for using the NPI testing facilities. When these will be in place and operational, the Institute must advertise the services it will be able to offer. This activity, besides generating revenue, strengthens the professional image and the relations of the Institute.

Industry wishes to use the expertise available at the Institute as a source of consultancy services. This activity is not only financially interesting and strengthens the role of NPI in society, but also would allow the teaching staff to gain experience which can enhance their teaching quality.

Industry is willing to assist NPI by offering practical training places for its undergraduates. With the data already available, relevant data must be established for its utilization by the Engineering Departments.

NPI should take the initiative toward the establishment of an association of its alumni.

RECOMMENDATIONS

A) For the development of the region, different institutions of engineering and technology education should do as follows :

- Exchange of all concerned information in order to know each other better.
- Establish a Regional Linkage Programme or Regional Development Programme Project.

B) Necessary measures for regional cooperation in the development and improvement of engineering and technology education :

- Actively participate in the inter-regional seminars, workshops or conferences.
- Be well- informed about all the inter-regional progress activities.

ADDITIONAL INFORMATION

The attached Tables 4 and 5 indicate the number of graduates in the Faculty of Engineering and Architecture, and the sectors of employment for NPI graduates.

Table 4 : Number of Graduates in the Faculty of Engineering and Architecture (96-97)

DEPART.	DEPART. of COMMUNICATION and TRANSPORT	DEPART. of CIVIL, ELECTRICAL and MECHANICAL ENGINEERING	DEPART. of IRRIGATION	DEPART. of ELECTROTECHNICS and ELECTRONICS	DEPART. of BUILDING CONSTRUCTION and ARCHITECTURE	TOTAL
DEPART-LEVEL						
UNIVERSITY-LEVEL (5-6 YEARS)		470(70)			200(N/A)	670(70)
HIGHER EDUCATION						
4 YEARS	2354(77)		411(N/A)	582(N/A)	1000(N/A)	4347 (90)
3 YEARS	1712 (153)		633(43)	351(N/A)	180(N/A)	4496(196)
TOTAL	**4066(230)**	**470(70)**	**1044(56)**	**933(N/A)**	**3000(N/A)**	**9513(286)**

( ) Female

Table 5 : Sectors of Employment of NPI Graduates

	CE	EE	ME	TOTAL
Central Government	26	1	9	36
Local Government	7	1	2	10
Enterprise	18	26	17	61
Private Company	8	5	2	15
Government & Private Joint Venture	1	2	0	3
Foreign Company	5	2	4	11
N.G.O.	2	0	0	2
U.N./ Development aid	2	0	0	2
Self Employed	4	1	0	5
Army	0	0	1	1
Jobless	6	0	0	8
Other	4	1	4	9
TOTAL	**83**	**39**	**39**	**161**

MALAYSIA

Engineering and Technology Education in Malaysia

Prof. Dr. Mohd. Zulkifli Tan Sri Ghazali,
Dean, Faculty of Civil Engineering,
Universiti Teknologi Malaysia

Assoc. Prof. Dr. Hasanan Md. Nor,
Head of Dept., Faculty of Civil Engineering,
Universiti Teknologi Malaysia

ABSTRACT

This paper presents the scenario of engineering education in Malaysia and the higher education policy with respect to efforts towards achieving a developed nation status. The paper discusses engineering education issues including the concepts of engineering education in the universities and argues that 'relevance' to industry and current needs, within the bounds of the generally accepted criteria of university education, could be enhanced through good industry-university links. Examples of university-industry link programmes are highlighted.

INTRODUCTION

Engineering training and education at tertiary level in Malaysia started in 1956 with the formation of University of Malaya's Engineering Faculty. This was followed by the formation of the MARA Institute of Technology's School of Engineering in 1967, the formation of the Faculties of Engineering of the University of Technology Malaysia (UTM) in 1972, the Engineering Faculty of the Agriculture University in 1975, the Engineering Faculties of the National University and the University of Science Malaysia in 1984 . Latest to join this honors list are the newly formed Faculties of Engineering of the International Islamic University, Sarawak University and Sabah University. Besides the tertiary institutions, there are many polytechnics and colleges which produce sub-professionals in the engineering profession. Although designated to provide courses leading to the awards of engineering diploma and certificates, and thus produce competent technicians and technical assistants, these institutions are also slowly pushing their way through to seek authorisation to produce engineering professionals.

UTM, now the largest engineering tertiary institution in Malaysia, began its history as a Technical College in 1956 producing Diploma holder sub-professionals badly needed by the government technical departments such as the Public Works Department, the Irrigation and Drainage Department, the Telecommunication Department and the National Electricity Department. With the shortage of technical professionals during the formative years of Malaysia as an independent nation fully geared and committed to the task of nation building, the policy of tertiary education then was producer driven as almost all the graduates would be absorbed by the public sector. The scenario now, including that of many other countries has changed. Instead of fulfilling public sector needs universities have to produce graduates to meet the challenges of industry and hence there has to be a paradigm shift from public sector target to industrial sector target ,and from a producer driven philosophy to a market driven one.

The list of tertiary institutions with their engineering courses on offer are shown in Table 1.

Table 1: Courses Offered by the Institutions of Higher Learning

	Institution of Higher Learning						
	ITM	UKM	UM	UPM	USM	UTM	IIU
Civil Engineering	•	•	•	•	•	•	
Materials Engineering					•		
Bioprocess /Biochemistry Eng.		•				•	
Electrical Engineering	•	•	•			•	
Electronic Engineering		•		•		•	
Gas Engineering						•	
Electric and Electronic Engineering					•		
Chemical Engineering		•	•		•		
Mechanical Engineering	•	•	•	•	•	•	
Agricultural Engineering				•			
Petroleum Engineering						•	
Mineral Resources Engineering	•						
Land Surveying Engineering	•						
Computer & Information Engineering	•	•	•	•	•	•	•
Manufacturing Engineering	•	•	•		•	•	•
Mechatronics							•

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Engineering education in Malaysia occurs at various levels such as tradesman, technician and graduate engineer. Engineering education at tertiary level can be obtained through many ways after five years of secondary schooling (equivalent to the G.C.E. O Level of the United Kingdom). Students may choose to enter the four-year degree programme offered by UTM or they may choose to continue their schooling for a further two years (equivalent to G.C.E. Advanced Level) and then choose to enter degree programmes at universities such as UM, UKM, UPM, USM and the International Islamic University. Alternatively, they may opt to do one-year matriculation.

The various approaches towards becoming a qualified engineer are shown in Figure 1.

Figure 1: Various Approaches Towards Engineering Qualification

Age								
13	SC	SC	SC	SC	SC	SC	SC	SC
	SC	SC	SC	SC	SC	SC	SC	SC
	SC	SC	SC	SC	SC	SC	SC	SC
	SC	SC	SC	SC	SC	SC	SC	SC
17	SC	SC	SC	SC	SC	SC	SC	SC
	ITM	UTM	UKM	UM	USM UM UKM	UIA	Polytec. + Uni.	UTM (Dip+ Deg)
18	Deg 1	Deg 1	Mat	Mat 1	Low 6	Mat 1	Cert 1	Dip 1
	Deg 2	Deg 2	Deg 1	Mat 2	Upp 6	Mat 2	Cert 2	Dip 2
	Deg 3	Deg 3	Deg 2	Deg 1	Deg 1	Deg 1	Deg 2	Deg 3
	Deg 4	Deg 4	Deg 3	Deg 2	Deg 2	Deg 2	Deg 3	Deg 3
22	Deg 5	Grad.	Grad.	Deg 3	Deg 3	Deg 3	Deg 3	Dip 4
23	Grad.			Grad.	Grad.	Deg 4	Deg 4	Grad.
24						Grad.	Grad.	

Professional Training (Minimum 3 years)

Professional Engineer

Note : Another approach is through Board of Engineers Malaysia (BEM) examinations divided into Part 1 and Part 2 to graduate.

SC - Secondary Schooling
Low 6 - Lower Six Secondary Schooling
Upp 6 - Upper Six Secondary Schooling

Mat - Matriculation
Dip - Diploma
Deg - Degree
Grad - Graduation

HIGHER EDUCATION POLICY

The National Education, officially accepted in 1988 states that "Education in Malaysia is a continuous effort towards the further development of the potential of the individual in a total and integrated manner to produce man who is in balance and harmony from the intellectual, spiritual, emotional and physical aspect based on the principle of belief and obedience to GOD".

The objective of this policy is to produce Malaysians who are knowledgeable, possess high moral character, who are outstanding , responsible and capable of achieving peace within himself and the family as well as contributing towards the harmony and prosperity of the society and the Nation.

The policy now is mass higher education, and the challenge is not only to increase the numbers receiving higher education but to develop the relevant manpower, not only in the context of Malaysia, but also in the global context. As part of the strategy, distance learning and lifelong learning shall be offered by all universities. Establishment of private universities, illegal before, shall soon be legalised. 40% of places in higher education shall be offered by private universities [1].

The higher education policy emphasises on programmes in science and technology with management and ensures the 'relevance' of these programmes with the current needs. The policy also encourages efforts towards achieving excellence in R & D in order to contribute effectively to the national development.

Recently, changes have been made to higher education through legislations. Hence, education in Malaysia will from now on be governed by five legislations. These are:

i) Education Act 1961.

ii) University and University Colleges (Amendment) Act 1995.

iii) Private Higher Educational Institutions Act 1995.

iv) National Council of Higher Education Act 1996.

v) National Accreditation Board Bill 1996.

The reform measures introduced by the Government will have a very significant effect on the education system. The effects of the new laws are most profound for higher education because it will revolutionise the concept, organisation, mission and delivery systems of higher education.

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The policy now is democratisation of higher education and mass higher education, allowing more people the chance to take-up university training and education. Besides meeting the needs of the population, which is economically of better standing, the policy would help to generate the required manpower for the nation. It is expected that demands for tertiary education, especially engineering and continuing education, would be increased substantially.

ENGINEERING EDUCATION ISSUES

There is a close relationship between the education of engineers and the needs of industry. Industry wants graduates well trained in engineering sciences, natural sciences and non-technical aspects to achieve two goals.

The first goal for engineers in industry is to perform tasks based on a given technology and to develop skills within this technology area. A learning curve orientated education (LCOE) would lead to such a profile. The result is the ability of the graduates to shape the learning curve either by means of process developments or by moderate product innovations. [2]

The second goal for industry is to keep pace with new technologies and new developments which are important to maintain competitiveness either by providing radical new production processes (innovative processes) or by new production possibilities (innovative products). Innovation oriented education (IOE) would help to achieve the respective innovative goals.

A learning curve oriented education contains a deep knowledge of production functions within an existing technological paradigm whereas innovation oriented education includes, in addition to major parts of the LCOE, an intensive training in fundamental and some advanced engineering sciences.

The challenge for the higher education system is to keep an appropriate balance between LCOE and IOE graduates in the right fields of technology. Sometimes calls from industry for a "practise relevant education of engineers" has in fact caused severe set-backs in engineering because it is interpreted as teaching students what people in the average do in industries at the time being. On a short run, this saves training costs in industries. But, of course, this does not meet requirements of a LCOE which is oriented on the state of the art of technology and fails by far the idea of IOE.

Universities, according to some comments, are often training engineers based upon outmoded concepts of what industry is or what it wants [3]. Industry sometimes wonders if universities give the students the proper training for the career they are about to undertake. However, industry accepts that students have been instilled with an engineering mentality-they are problem solvers. Then, why does industry feel that there is a gap in knowledge and that in some cases knowledge taught at universities is not immediately relevant to their own operations?

Has this phenomena got to do with the curriculum and technological change? Technologies learned in universities would not serve an engineer forever. Whilst universities have the concept of providing general and basic engineering education as their philosophy, industry wants ready-made or specialised engineers catered for their individual needs. Hence there has always been a certain tension in engineering education between trade-school preparation and intellectual endeavor. This dilemma has always typified the conflict between learning the trade and learning the extensible academic frameworks.

Accelerating technological development means that professional qualifications quickly become devalued and have to be updated several times during one's professional career [4]. Provided the engineer has acquired good fundamentals and good basic knowledge during his university training, updating does not mean starting to learn a profession or technology again from scratch. Basic knowledge is therefore an important component of an engineering training, which does not become absolute but has to be extended by further training in specialist areas. Hence, engineering courses must ideally provide qualifications which cover a variety of different and changing professional demands; by providing a solid grounding in mathematics, natural sciences and engineering. Some associations of engineers which reflect the industry's opinion, feel that excessive specialisation is detrimental. In general, this specialist knowledge will soon become outdated and consequently the engineer's professional adaptability and flexibility will be reduced.

THE UNIVERSITY DIRECTION AND OBJECTIVES

The engineering education philosophy and curriculum at the University of Technology (UTM), can be considered as the model for engineering education in Malaysia. The philosophy and curricula at other Malaysian Universities does not vary much especially when engineering issues are frequently discussed and coordination does occur through the Council of Deans of Engineering. The engineering ricula of all the Malaysian universities must be accredited by the

Institution of Engineers Malaysia and the Board of Engineers Malaysia, to enable graduates of these universities to register as either graduate engineers or professional engineers. The curriculum structure adopted by UTM is shown in Figure 2.

Figure 2: Curriculum Structure

Year 4	Project Thesis	Electives	Core	Electives	Project Profes-sional
between session			Training		
Year 3	Support		Core		Support
Year 2	Support		Core		Support
Year 1	Basic	Science	and	Maths	

UTM's philosophy is to produce technologists who are competent and responsible to their Creator and mankind. This philosophy is reflected in the university system and the integrated curricula of the various courses offered by the ten faculties of the university. The vision of the university is to make the university as a centre of excellence, a referral centre and an ideal model with focus on science and technology in accordance with its philosophy.

This vision has been translated into the University's focus of excellence, namely Teaching, Research, Publication, Consultancy and Services. UTM being a public sector university, fully funded by the government through the Ministry of Education, carries a heavy social responsibility. It has to scan the global, regional and national environment and should align its goal and directions in line with international and national aspirations. The direction of UTM is to fulfil the vision, especially in efforts to contribute to national growth and the nation's VISION 2020, whilst maintaining the university's academic excellence. [5]

Four issues are considered as critical success goals for the university, namely:

(a) To prepare and produce professional manpower needed for the nation.
How far is the university able to supply professional, technical and managerial manpower required under the Seventh Malaysia Plan?

(b) To develop and advance the state of technology.
What can be the effort by the university to expand the usage and development of advanced technology in line with the strategy of Vision 2020 to meet the requirements of the manufacturing industry?

(c) To assist in creating technological-entrepreneurs.
How far can the effort of the university be put in parallel with the nation's effort to create the commercial and industrial community, especially in the critical technology fields, in accordance with the National Development Policy?

(d) To improve research.
What is the university's action in it's effort to produce a creative and innovative environment which will expand and consolidate R & D towards the nation's wealth creation?

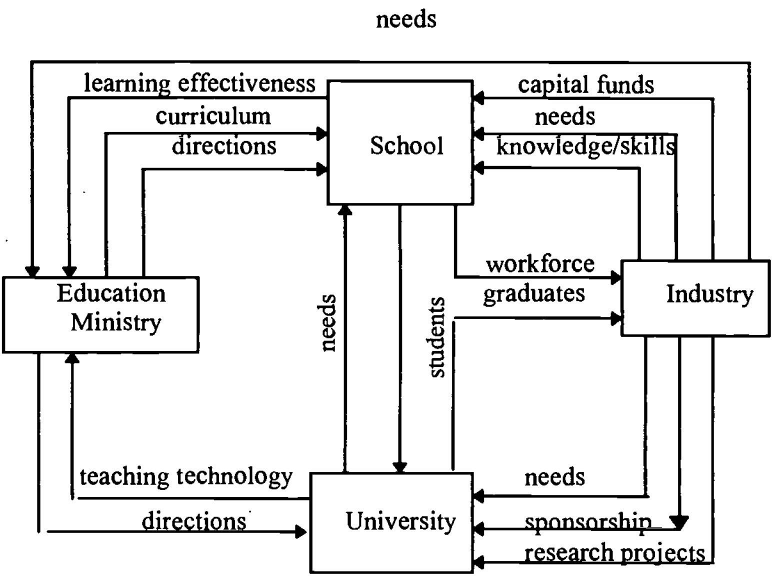
INDUSTRY-UNIVERSITY LINK

In many Malaysian universities, industry-university links are already well anchored. As the philosophy currently shifts from producer driven to market driven and from public sector demands to market driven demands, universities in Malaysia cannot afford to seclude industry-university links from their strategic planning critical success factors. Besides the individual university's industry-university link, there is also the Malaysian Industry-Government Higher Technology group (MIGHT) which also involves the various universities.

The industry-university link can be illustrated by the diagram shown in Figure 3. The interlinkages between the four components with proper feedbacks can provide effective-industry partnership [6]. Both industry and government or public-sector agencies play important roles in the development of engineering curricula in Malaysian universities.

The engineering faculty advisory board includes leading professionals from both the industry and government; hence industry should always ensure that they send good representatives to sit on the board.

Figure 3 : University - Industry Link



At the same time, industry should also open up their operations to the faculty members and to engineering students. This is normally done through the students sandwich practical training, through exchange visits, and forums or seminars. Key industry professionals are frequently invited to give lectures to the students in final year engineering seminars.

The more important industry-university linkage can be summarised as the following [7]:-

(a) Role of industry in the engineering faculty curriculum advisory board, so as to contribute effectively to course design and curriculum review.

(b) Joint research or contract research.

(c) Short input teaching by industry to the students.

(d) Consultancy projects by the faculty for industry.

(e) Collaboration in organising or participation in conferences, seminars and short courses, especially in the relevant field of the industry.

(f) Tailor- made certificate or part-time courses conducted by the faculty for the industry under MOU towards continuing professional development of human resource of the industry.

(g) Teaching Company Scheme :

Joint collaboration of university and industry to run courses or research at the industry and university under the supervision of both.

(h) Teaching Factory Scheme :

Involves skills training and hands on experience of students at a teaching factory sponsored by industry.

(i) Appointment of Adjunct Professorial Chair in the engineering faculty in a particular field of interest.

(j) Industry should provide a Professorial Chair in the engineering faculty in a particular field of interest.

(k) Industry can improve interaction between staff of the industry and faculty by providing opportunities for industrial attachment or places for sabbatical.

(l) Collaboration in retraining programmes for middle and senior managers/engineers using the part-time modular integrated concept.

(m) Cooperation in continuing engineering education (CEE) programmes conducted by the university.

(n) Cooperation in postgraduate programs.

(o) Sponsoring of laboratory or equipment especially those that have direct relevance to the sponsoring industry, which would make the students familiar with the industry's own operation.

(p) Accreditation of the engineering curriculum by the Institution of Engineers Malaysia, which also represents the industry.

(q) Collaboration in setting up research institutes or centres with the universities.

(r) Technology Parks or Science Parks.

In Malaysia, industry is well aware of the importance of industry-university linkages. The Federation of Malaysian Manufacturers for example, carried out a study on R & D industry-university linkage mechanism in the local universities and recommended the enhancing of industry-university linkages through closer collaboration to organise regular dialogues and talks for manufacturers. Universities are asked to identify their niche areas and should regularly channel the latest information on their R & D capabilities and facilities to industry.

Industry also realised that polytechnics and skills training institutes produce technicians and sub-professionals who are practice oriented and possess the necessary "hands on" skills. Industries can further establish good links with these institutions to ensure that some of the output is "ready made" for their immediate use.

Large corporations at their universities produce relevant graduates but also help the nation to provide more higher education places. Such a move would also be in line with the new education policy, and contribute towards the NDP.

EXAMPLES OF SUCCESSFUL INDUSTRY-UNIVERSITY LINK PROGRAMMES

Some examples of industry-university links are [8]:

(1) Integrated Managerial Development Scheme (IMDS) and Integrated Graduate Development Scheme (IGDS) programmes offered by the Business Advanced Technology Centre (BATC) of UTM. The collaboration involves UTM, University of Warwick, United Kingdom, and the participating industrial companies such as SAPURA telecommunications, Malaysian Airline System, TELEKOM, TEN and PNB. Part-time modular courses are run in 3-day modules and participants, who are normally middle or senior managers, will have to take 16 modules and do assignments involving real industrial projects to obtain their post-graduate diploma. The IGDS programme leading to the award of M.Sc in Engineering Business Management, requires 21 modules. The knowledge received during each module is immediately applicable to the industry.

(2) Teaching Company Scheme conducted by UTM and its industrial partners not only helps to provide continuing professional development (CPD) to the staff in the industry but also helps to foster good dialogue and interaction, which in turn contributes to the development of better curricula. The Electrical Engineering Faculty of UTM, for example, runs a M.Sc Course for TNB, a Diploma Course for CELCOM and TELEKOM, and a certificate course for Motorola.

(3) Advisory board on curriculum and the accreditation of curriculum by the Institution of Engineers that engineering education is of good standing and relevant to the needs of industry. All the engineering faculties of the Malaysian universities subscribe to this practice.

(4) Collaboration in conducting CEE Programmes, seminars and colloquiums between industry and university have also been successful in the process of dissemination of knowledge and technology transfer. The School of Professional and Continuing Education set by UTM ensures that quality CEE programmes are abundantly available for the industry, with prominent professors and professionals coming from all over the would. University students are also exposed to these CEE programmes which are normally specialised in nature. This helps to enrich the students and some faculty members with experience, exposure and industrial relevance.

CONCLUSION

In some fields, technology is changing and advancing rapidly. Both industry and university must keep pace with technology in order to survive in this globalisation era. Industry and university should foster good industry-university links for their mutual benefit, which would help the nation achieve the VISION 2020 and enable her to take her place as a developed nation. Good industry-university links would also help to ensure that engineering education in universities is relevant to the operations of the industry. Although current engineering graduates from Malaysian universities do not have problems of seeking employment ,and industries rarely complain of curricula which lacks relevance, good industry-university links must be maintained or further improved to ensure academic excellence. Universities, polytechnics, skills training institutes, and government all have a role to play in ensuring that the linking and matching between engineering education and requirements of industry exist and that engineering education is relevant to the needs of the nation. As the nation is in urgent need of engineers, the universities must play their role in ensuring that manpower demand is met and that the vision to make Malaysia a regional centre of education materialises.

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SINGAPORE

Engineering and Technology Education in Singapore-NTU'S Experience

Assoc. Prof. ER Meng Hwa,
Dean, School of Electrical & Electronic Engineering,
Nanyang Technological University

1. INTRODUCTION

Singapore is a small island country with few natural resources. Its main resource is its people. Since the 1960s, it has developed a more diverse economy and has become a centre of trade, finance and manufacturing. The Economic Development Board was set up in 1961 to promote industry as the key to economic growth. Currently, about 24 percent of employed people in Singapore work in manufacturing. In the beginning, the industrial programme focused on labour-intensive manufacturing to help solve unemployment problems. After this programme succeeded, Singapore moved into higher-skills industries.

By 1979, Singapore's success in industrialization brought new problems. One of these was a growing shortage of labour , especially of skilled and technically trained workers. That year, a high-powered Council on Professional and Technical Education (CPTE) was established. In its studies, the CPTE made a projection that the number of engineers produced annually would have to be doubled to meet the needs of industry. Prior to this, the only university in Singapore, the National University of Singapore, had an annual output of about 300 engineers. The Council recommended that this number be rapidly increased to 1,200. In addition, the majority of these engineers were to be practice-oriented. To meet this increase in enrolment and special requirements in training, a new institute of technology was to be created.

2. PRACTICE-ORIENTED TRAINING

With the passing of the Nanyang Technological Institute Act 1981 by the Parliament, the Nanyang Technological Institute (NTI) came into existence on 8 August, 1981. The target was to have the first intake of students in July, 1982. The existing Faculty of Engineering in the National University of Singapore would continue to provide a traditional course. In terms of standard of the courses and the status of the graduates, both were ranked equal. In the national context, both streams of training were complementary to each other.

Ten years after its establishment, NTI was renamed Nanyang Technological University (NTU) in 1991 with a view to facilitate the introduction of other disciplines complementary to the established courses in engineering , technology and business. The intent was to enrich and diversify the offering of new courses without diluting the strong base in engineering and technology.

The NTU's degree programmes in civil, electrical and mechanical engineering were initially offered by the three founding Schools of Civil and Structural Engineering, Electrical and Electronic Engineering, and Mechanical and Production Engineering. Newer degree programmes, such as Computer Engineering and Material Engineering were introduced by the School of Applied Science in 1989 and 1991, respectively. Depending upon the field of specialization, 'practice-oriented' engineers from NTU are expected to play a key role in the planning , design, development, production/construction, operation/maintenance or management functions of various engineering-related projects.

The desired qualifications of these graduates are specified below under the categories of knowledge, skills and attitudes :

- In terms of knowledge, NTU graduates are required to possess a sound command of the fundamental principles of engineering science and technology, a working knowledge of mathematics, economics, accounting, management, law and marketing in their fields of specialization, the ability of construction practices, production techniques and/ or operating procedures.
- In terms of skills, it is essential that NTU graduates have the ability to perform or direct laboratory project or site work, to analyse problems and synthesize solutions by reference to current practice, to communicate clearly and succinctly and to work in teams and to manage resources effectively.
- In terms of attitude, NTU graduates are expected to develop a sense of integrity and responsibility to society and the engineering profession, a concern for the environment, an awareness of the need to turn to specialists when the situation arises, and a motivation and interest for further learning throughout their professional career.

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3. CURRICULA

The curricula of the engineering and applied science courses was designed primarily on the basis of the needs of the industrial, social and economic development of Singapore and the region, and the academic background and aptitudes of the students. To achieve the main objective of educating practice-oriented engineers at university level, and the specific qualifications desired from the graduates, the curricula was designed to provide a uniform mix of fundamental principles and empiricism throughout the entire span of the courses.

Some of the guiding principles used in the design of curriculum are as follows:

- The main field should be developed as rapidly as possible to allow maximum time for students to gain practical experience.
- The depth of treatment and choice of topics in a subsidiary field should be chosen with reference to the needs of the main field.
- The material for courses in mathematics, computing, communication skills, economics, accounting, law, etc., should also reflect the needs of the main field.
- More emphasis should be placed on design, laboratory, projects and practical work.
- Much attention should be given to the balance of 'breath' and 'depth' of knowledge, skills and attitudes in the curriculum.
- A broader range of knowledge and skills should be introduced in the junior years, whereas more in-depth training of specialized subjects should be given in the senior years.

3.1 Civil, Electrical and Mechanical Engineering Courses

First -year curriculum

The first-year curriculum, common to all engineering students, has been designed to provide a broadly based coverage of mathematics, computer programming, engineering graphics, economics, basic engineering, physics, material science, workshop/laboratory and technical communications.

Through the subjects of basic engineering and physics, students are introduced to such concepts as mechanics, strength of materials, thermodynamics, fluid mechanics, properties of materials, electricity and electronics.

Second-year curriculum

The second-year curriculum introduces the basic core subjects in each of the engineering schools, supplemented by laboratory, design and workshop projects.

The aim is to introduce as many core or main field subjects as possible. The early introduction of basic core subjects will allow maximum time for students to learn engineering applications and to gain practical experience. Further, this will provide more opportunity to motivate students' interest in his or her main field.

Aside from the core subjects, two common subjects, engineering mathematics and computing, and communication skills are introduced in the second year. The contents of engineering mathematics and computing vary among three schools to reflect the needs and emphasis of the respective schools. Communication skills are incorporated in the curriculum to improve the art and practice of written, oral and visual communication useful in engineering. The intention for introducing the subject in the second year is to facilitate effective practice of the communication skills in the subsequent years of study.

A 8-week in -house practical training (IHPT) is scheduled at the end of the second-year course. The training session is planned and supervised by the staff of each engineering school. The intensive training session is ideal for conducting hands-on training, which cannot be effectively implemented during the normal term period. It also provides an excellent opportunity to facilitate staff-student interaction whereby the students' attitude towards the engineering profession can be best inculcated.

Third-year curriculum

The third-year curriculum comprises the follow-on core subjects to apply or reinforce the basic knowledge and skills learnt from the previous years. In addition to the core subjects, engineering economics/ financial accounting is introduced.

In the second half of the year, a 24 -week industrial attachment (IA) is introduced. The purposes of this training programme are: to gain first-hand knowledge of day-to -day operations in the engineering profession, to apply the acquired professional knowledge and skills in

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actual planning, production, construction or operation/maintenance, to acquire first-hand experience of working with people, and to learn about the problems and requirements of industry leading to the choice of field of specialization in the final year.

Final-year curriculum

In the final year, engineering / industrial management, human resources management, contact law, professional ethics, and entrepreneurship are introduced in addition to technical subjects. In this respect, the IA experience in the third year helps the students to gain a firmer grasp of the management subjects by relating theory to real-life practice. Appropriate optional subjects in selected fields of the individual schools are offered so that the student will have more in-depth training of his or her chosen field of specialization. The provision of more optional subjects in the final-year curriculum is considered appropriate because of conflicting demands for more engineering specialization to fit in with graduate degree programmes and the market demand for engineers with a broader inter-disciplinary orientation.

The final-year students are also required to conduct an in-depth project work, preferably within their fields of specialization. Problems encountered by local industry as well as topics relevant to national development and regional needs may form the basis for the final-year projects. These projects are beneficial in several ways:

- In developing students' ability to apply and integrate the acquired knowledge and skills in solving problems arising in modern industry.
- In reinforcing knowledge and skills, both in the students' special field of interest and in fundamental areas.
- In developing the ability to tackle problems independently.

The IHPT in the second year, the IA in the third year and the student project in the final year are some of the special features incorporated in the curricula to enhance students' awareness and ability to tackle real-world problems in engineering practice.

3.2 Computer and Materials Engineering Courses

The curriculum of the computer engineering course is designed to give students an opportunity to acquire in-depth understanding of computer systems and the principles underlying their construction and implementation. Comprehensive training in both the software and hardware aspects of computers prepares the graduates for a professional career in design, applications and use of computers, or to pursue further studies.

The curriculum of the materials engineering course represent a balanced integration of subject matter within the wide field of materials science and engineering. The course comprises the study of the science of the structure, properties, behavior and processing of materials, and their applications in engineering and industry.

Both computer and materials engineering courses are conducted over a three-year period leading to the pass degree of bachelor of applied science. Students may pursue an optional fourth-year course leading to an honours degree. As with the engineering courses, all students in computer and materials engineering are required to undergo a 8-week IHPT at the end of the first year and a 24-week industrial attachment programme in the second half of the second year. These two programmes form an integral part of the respective curricula, with the common objective of providing students with the opportunity to apply their skills and knowledge in real-world applications and particularly in an industrial environment.

4. DISCUSSION ON IHPT AND IA

To reinforce the emphasis of professional orientation, the NTU's curricula deliberately incorporates practical elements, such as the IHPT and IA programmes. These programmes, designed to enhance students' awareness and ability to tackle real-work problems in engineering practice, are resource intensive and require a great deal of planning, co-ordination and monitoring. However, the extra efforts invested in the implementation of these programmes are paying dividends as NTU graduates are highly regarded by industry for their attainment of professional competence soon after graduation. These programmes also form the basis for both staff and students to strengthen their interaction with industry.

THAILAND

Engineering Education in Thailand: a Perspective

Dr. Bundit Fungtammasan,
Faculty of Engineering,
King Mongkut's Institute of Technology North Bangkok
(KMITNB)

ABSTRACT

The socio-economic context in which engineering education has evolved in Thailand is reviewed. The state-of-affairs of Thai engineering education, pertinent problems and issues affecting the delivery of quality engineering graduates are discussed. Plans designed to address these issues are presented and opportunities for regional cooperation in engineering education explored.

HISTORICAL DEVELOPMENT

Engineering education in Thailand dates back to 1913 when the Yantra-Sueksa School which literally translates to "School of Engine Studies" was established as part of King Chulalongkorn's School of Civil Service [1] to serve the needs of the then "Siam's" modernization efforts, primarily in the public service sector. The School merged with the Royal Medical College to form the prestigious Chulalongkorn University. Degree programs in three major disciplines, namely : civil, mechanical and electrical engineering were offered in the initial stage with mining, sanitary, and surveying engineering added later.

The second engineering school to have been established in this country was Kasetsart University's Faculty of Irrigation Engineering, which was transformed from the School of Irrigation of the Ministry of Agriculture [2]. Founded in 1954, the Faculty delivered the type of technical personnel who were to play important supportive roles in Thailand's share of the Green Revolution. The Faculty has now been renamed "Faculty of Engineering" with Irrigation and Agricultural Engineering programs remaining a hallmark of the Faculty.

The latter half of the 1960s saw the establishment of engineering education programs in a number of tertiary education institutions, reflecting the need to meet the demands for technical manpower at the onset of Thailand's industrialization and for rural development. Thus engineering schools were set up in three regional universities : Khon Kaen (1964), Prince of Songkhla (1967) and Chiangmai (1970) ; as well as in the three suburban-based King Mongkut's Institutes of Technology : North Bangkok (1964), Thonburi (1965), and Ladkrabang (1968). It is interesting to note that the three institutes of technology evolved on similar veins, that is, they were all technical colleges prior to their upgrading to tertiary institutions and their education programs were oriented towards the servicing of particular sectors of the economy. Ladkrabang, which was founded on a Technical School of Telecommunications, for example, was aimed at fulfilling the needs of the post and telecommunications state enterprise as well as defense agencies, while the manufacturing sector was well served by North Bangkok and Thonburi with their programs in Mechanical, Production and Electrical Engineering.

During the late 80s and well into the 90s, Thailand experienced phenomenal economic growth spurred by massive relocation of manufacturing bases from more industrialized nations whose labor wages had greatly appreciated and by the coming-on-stream of natural gas from the Gulf of Thailand, which was followed by the emergence of petrochemical and other related process industries. This brought about huge demands for professional engineers, which could not possibly be met by prevailing engineering schools. In response to such a situation, several engineering faculties were founded in both public and private universities, and in both existing and new institutions. Also noteworthy is the founding of international engineering schools-often as joint ventures between Thai and foreign institutions.

At the graduate level, master degree programs were initiated as early as 1941 at Chulalongkorn University [1]. However, because of the war, they were suspended and were not to resume until ten years later. They were followed by the SEATO (South East Asia Treaty Organization) Graduate School of Engineering (now known as AIT-the Asian Institute of Technology) in 1959. Graduate programs in other institutions were also established after 1970. The first doctoral program in engineering in Thai universities was offered in 1982 by KMIT Ladkrabang, in the field of Electrical Engineering [3].

PRESENT STATUS

To date there are a total of 36 universities and colleges-19 public and 17 private-which offer engineering degree programs. According to a recent census report of the Ministry of University

Affairs [4,5], the number of undergraduate engineering students under its jurisdiction in 1995 totalled 54,270, about 70% of which are in public universities. The figure represents only about 7% of the total number of the undergraduate student population. The number of engineering graduates of the same year was 8,696, again 70% of which came from public universities ; and the number represents 10% of the total graduates in all fields. The number of teaching faculty in all engineering schools combined is estimated at about 2,000, with 75% being in public universities.

The range of courses that are being offered cover all the major traditional disciplines as well as other newer areas such as computer and environmental engineering. All the courses follow the US credit system. The Ministry of University Affairs regulations require that an engineering course must conform to the broad guidelines prescribed by the Ministry's Higher Education Standards Division, although the authority to approve courses has recently been delegated to University Councils, except in the case of private universities. Thus at least 30 credit-hours must be devoted to basic general studies which include mathematics and physical sciences, social sciences, humanities and languages ; not less than 90 credit-hours to core courses i.e. the studies of the science and practice of engineering ; and at least 3 credit-hours of free electives. The total number of credit-hours must not be less than 120 and not exceeding 150. Generally, all the programs offered fall in the range of 140-150 credit-hours. In addition, the Commission for the Control of Professional Engineering Practice of the Ministry of Interior also prescribes a set of guidelines to which strict adherence is required if a course program is to be accorded recognition. These guidelines deal with staff qualification requirements and the fulfillment of 39 credit-hours of "core" subjects which are deemed by the Commission as being important for engineering practice in as much as ensuring public safety is concerned. Graduates of such Commission-recognized courses then qualify for a basic professional engineering licence.

The normal criterion for entry to an engineering degree program-normally of a 4-year duration-must be not less than the completion of secondary education in the science-mathematics discipline. In general, admission to the course is based on a nation-wide competitive entrance examination administered by the Ministry. However, a number of universities and colleges also offer 2-to 3-year "continuing" engineering or industrial technology programs, whereby students with a technician diploma are admitted on the basis of an individual university entrance examination. The number of students in this category accounts for about 15% of the total engineering student population.

At the graduate level, master degree courses are offered at 12 faculties (9 public, 3 private) with a total enrolment of 3,044 in 1995. The courses are generally organized in such a way that they conform to the Ministry guidelines, being a combination of taught courses and thesis, with typically 30 and 12 credit-hours respectively. Thesis only programs are also available, but rare. In 1995, there were 326 graduates, representing 10% of total enrolment.

Doctoral programs are offered by only four faculties, namely, Chulalongkorn, Kasetsart, KMIT Ladkrabang, KMIT Thonburi, and more recently KMIT North Bangkok, with a total enrolment of 46. However, only two managed to graduate in academic year 1995. All programs follow the US system which requires the completion of 2-3 semesters of course work followed by dissertation.

Continuing education programs are organized by most engineering schools. The subject areas deal mostly with management and computer related fields as well as other specific advanced technical topics of current interest.

PROBLEMS AND ISSUES

Rapid industrialization and technological change that has taken place in Thailand in recent years has created a number of contentious issues which confront engineering education. The more important ones are to do with quantity, quality and relevancy.

Despite implementation of a number of adhoc and longer-term measures to increase the number of engineering graduates, the shortage is still severe. The September 1996 issue of the Thai Labor Chronical, for instance, reported a projected shortage of 14,000 engineers in the year 2001, which amounts to an average annual shortage of 2,800. The problem is compounded by the lack of a central authority which can provide accurate figures of manpower needs and effectively coordinate the supplying institutions. In any case, with a nation-wide average student-to-faculty ratio already at about 27: 1, it is unlikely that such a demand-supply gap could be filled in the foreseeable future.

The issue of quality came to prominence in recent years due to frequent employer complaints to the effect that some of the graduates do not possess adequate scientific and technical skills for performing basic engineering tasks. Such shortcoming is attributed primarily to the surge of enrolment in engineering programs, resulting in students with less than satisfactory grades being admitted. The inability of the bureaucracy-bound university system to attract sufficient numbers of highly qualified faculty-due to the large wage gap between university and industry, heavy faculty work loads on teaching and administration, and the lack of training equipment both in quantity and quality are also cited as reasons for the decline in graduate quality. Measures to redress the situation include a World Bank Loan program to the tune of 120 million USD which has been negotiated by the Ministry to upgrade undergraduate laboratory equipment, an attempt by the Ministry to institutionalize quality assurance programs in universities, and to seek top-up payment or incentives for lecturers, particularly in engineering and other shortage areas. Rigorous government scholarship programs have also been introduced to upgrade the qualifications of existing faculty and to groom a new generation of well-qualified faculty through education and training abroad. The factors which most significantly affect the relevancy of Thai engineering education today are technological change, environmental degradation and globalization. The advent of information technology, for example, dictates that computer literacy, modern computational and electronic information access skills must be ensured. In this respect, some engineering schools have done better than others depending on resources and commitment. But on other fronts such as telecommunications, microelectronics, materials and modern manufacturing, the response to change reflected in our course content and structure has, in general, been less satisfactory. On environment, some attempts have been made to mandate the inclusion of such subjects as environmental or waste management in all disciplines. The globalization of manufacturing and trade demands that our graduates have not only better language and cross-cultural management skills, but also project management and business fundamentals, and an understanding of the new world economic system. To this end, more international student exchange programs are being pursued, and more management and business oriented electives are being offered in many engineering programs. And the Institute of Engineers of Thailand has been trying to introduce an internationally recognized accreditation mechanism in response to calls by WTO (World Trade Organization) for mutual recognition of professional practices among member countries.

While Thai engineering educators in general are conscious of the desirability to respond effectively to the changing needs outlined above, the efforts to do so have been constrained by the lack of resources (appropriately qualified faculty and equipment), the traditional barriers which exist between university and industry, and by the restrictions on course content and structure imposed by the Commission for the Control of Professional Engineering Practice. However, recent outreach activities initiated by some large corporations, universities and government agencies concerned, involving donations of advanced laboratories and holding of joint-training programs, point to the direction that the situation may be improving.

As regards to postgraduate education, the pressing problem is the inability of the programs to attract high calibre engineering graduates as there are greater opportunities either to remain in industry or to enrol for courses in business and management. And for those few who choose to enrol in engineering programs, many fail to graduate due to lack of commitment by both students and faculty to serious research. Thus the initiatives of the Ministry-through an Asian Development Bank (ADB) Educational Loan Facility-and of the Thailand Research Fund (TRF) in providing attractive scholarships for postgraduate study in local universities and top-up payment for faculty members, are seen as potentially effective measures in alleviating the problem.

FUTURE PLANS

With the multitude of problems facing Thai engineering education, several plans have been mapped out by agencies concerned for remedial action.

To meet the targeted number of engineering graduates of 26,300 in the year 2001 as proposed in the 8th National Science and Technology Development Plan, private and international universities will be urged to play an increasing role, and the so called "Information Technology (or IT) Campuses" in the provinces will be set up. However whether the latter measure, which relies heavily on teleconferencing and related facilities as the mode of instruction, is effective for engineering education in debatable under the present circumstances. At the same time, retired professors and foreign professionals will be hired to make up the shortage of staff.

On the aspect of quality, the government sponsored scholarship scheme for faculty member development will continue until at least the year 2001 ; while the World Bank's five-year loan program for acquisition of basic laboratory equipment will commence early 1998. The Ministry of University Affairs will continue to urge all universities to institutionalize quality assurance programs and to spur competition among faculties of engineering by introducing a rating system whereby faculties will be ranked and perhaps "rewarded" according to their merit. Finally, the Council of Engineering Deans of Thailand, which is a forum of all engineering deans, has also taken quality of engineering education as the top of its agenda. In May 1997, the first Conference on Engineering Education will be held by the Council and efforts to devise a strategic plan for engineering education development for the next 10 years is also being pursued.

On postgraduate education, the ADB Education Loan project, which is aimed at developing excellence in postgraduate education and research, as well as fostering closer university-industry interaction, will last for at least 5 years. The TRF's ambitious Royal Golden Jubilee Project for research scientist development is a long- term project which, hopefully, will see some 3,500 home-grown doctorates in science and technology being added in the next 15 years.

Another key promoter of engineering education and research is the National Science and Development Agency (NSTDA) which has three key national centres under its umbrella : National Centre for Genetic Engineering and Biotechnology (BIOTEC), National Metal and Materials Technology Centre (MTEC), and National Electronics and Computer Technology Centre (NECTEC). Through its many-faceted promotional facilities such as research grants, graduate research and education consortium, and industry research support programs, graduate education and research in selected areas will be enhanced and the door will be opened for industry to tap the technical and scientific resources of engineering faculties.

Of all the programs and plans that are being pursued, perhaps one that is most challenging is "corporatization" or the detachment of universities from the Civil Service bureaucracy. An experiment has already been carried out at Suranaree University of Technology, and a new charter to this effect for KMIT Thonburi is also in the pipeline. It is believed that a "deregulated" university with autonomy in financial, personnel and academic management will have strong impact on the quality and effectiveness of engineering education in Thailand. Indeed, it may be a prerequisite for all other quality improvement programs and plans to take full effect.

PROSPECTS FOR REGIONAL COOPERATION

In recent years, the easing up of political tension in the Indochina subregion, along with the transformation of their economics, and the increasing affluence of the older members of ASEAN, has ushered in a new era of regional cooperation. Thailand, because of her geo-political position, has taken keen interest in advancing relations with her neighbors in many domains. In so far as engineering education is concerned, Thailand has participated in both formal and continuing education programs conducted for the region. For example, through the coordination of the Department of Technical and Economic Cooperation (DTEC), Laotian students have been sponsored to take undergraduate and graduate courses such as communications engineering in Thai engineering schools. Engineering instructors from the universities of the region have also taken short-courses in Thai universities as an upgrading exercise.

Thus, although there may be shortcomings in each country, there is scope for regional cooperation in the development and improvement of engineering education and research, based on diversity in strength and specialties of the region. The challenge for all of us then is the identification of areas of common interest, appropriate modes of cooperation and sources of funding.

To effectively identify areas of interest, channels for dialogue should be opened for concerned parties at the operational level. One possibility which could be explored is the formation of a forum for the Council of Engineering Deans, (or its equivalent) from each country on a bilateral or multilateral basis. Once established, it could be expanded to networking at departmental level. In Thailand, networks of Electrical, Mechanical, Chemical, Civil and Industrial Engineering Departments already exist. Through such networks(s), information on curriculum, research, personnel and service offers can be exchanged. With coordination, such activities would not be unduly time-consuming, particularly in the light that Internet access is becoming widely available and that many faculties and departments already have their own web sites.

The modes of cooperation can take a variety of forms ranging from full-time studies to short-courses and training programs, seminars and conferences, to joint-research programs, post-doctoral fellowships and exchange of student and faculty.

Traditional sources of funding for international cooperative programs are international development agencies and individual donor countries. More recently, countries in the region including Thailand have also begun to make available financial resources for such purposes. Thus it would be worthwhile to find out the type of support that is favored by each of the funding sources. Last but not least, one should not overlook the contributions which may be provided by the private sector, be they multinational companies or local ones.

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VIETNAM

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Higher Education Development for the Year 2000 in Vietnam

Prof.Dr. Tran Kim Lan,
Vice-Director of International Relations Department,
Ministry of Education and Training (MOET)

Prof.Dr. Bach Vong Ha,
Vice-Director of Science and Technology Department,
Ministry of Education and Training (MOET)

I INTRODUCTION

Vietnam has 60 public universities. Among them, 11 are industrial engineering training institutions. Thereto, there are also 9 private universities, which have appeared during the last 5 years.

The 60 public universities may be divided into 7 groups :

1.	Teacher Training Universities	17
2.	Agriculture and Forestry Universities	6
3.	Economics Universities	8
4.	Medicine, Pharmacy, Sport Universities	8
5.	Culture and Art Universities	8
6.	Multi-disciplinary Universities	2
7.	Industrial Engineering Universities	11
	Total :	60

II ENGINEERING TRAINING UNIVERSITIES

1. Hanoi University of Technology
2. Hanoi Civil Engineering University
3. Hanoi Mining and Geology University
4. Hanoi Transportation and Communication University
5. Hanoi University of Water Resources
6. Hanoi University of Architecture
7. Ho Chi Minh City University of Architecture
8. Ho Chi Minh City University of Technology
9. Da Nang University of Technology

10. Thai Nguyen University of Technology
11. Hai Phong Maritime University

These institutions are situated in the 5 biggest cities.

Nowadays, the Vietnamese higher schools are required to meet the new demands of the country's industrialization and modernization with the new challenges of our times. Vietnam is continuing to reform the higher education system ; this reform started from 1987 up to now.

First, some small universities were combined with bigger ones. Two national universities were established in Hanoi and in Ho Chi Minh City. Hanoi National University was established through the merging of Hanoi University, the Teacher Training University and the Teacher Training University of Foreign Languages. Ho Chi Minh City University combines all 9 universities in the city, except the Medicine and Art Universities. Three regional universities were established in the 3 cities of Thai Nguyen, Hue and Da Nang. Each university combines all the previous universities in the city.

The second renovation is the diversification of types of universities. Nowadays, in Vietnam, there are public universities, semi-public universities and private universities. Among private universities, there is one technical engineering university in Ho Chi Minh City, but it is very young. It is being considered to establish the next one in Hanoi.

The 3 rd renovation is the supplementation of a 2-phased process of training in all of the universities. The 1^{st} phase is 1.5 years. The 2^{nd}, 3.5 years. In the 1^{st} phase, students in all technical universities study the same subjects with the same program. This mode of training allows the universities to organize the training process in the same way, to exchange qualified teachers. It also allows students to transfer from one university to another.

The fourth renovation is the implementation of a credit system instead of the semester system, as in the past.

In implementing the next renovation, the system of scholarship and tuition fees was revised and reformed.

Next, improved learning and living conditions for students was made and a sense of responsibility was raised among them.

Lastly, international relations between Vietnamese universities and universities of other countries and many international organizations were developed and expanded. Relations with 19 countries, 34 non-government organizations, 10 international organizations and more than 60 foreign universities have been established.

Although renovation has been carried out and some aims have been achieved, there are still weaknesses and some difficulties. They are:

1. Aspects of the structure, network, goals and objectives, contents and methodologies are defective and irrational. For instance, almost all technical universities in Hanoi are small and specialized in narrow fields.
2. Manpower to maintain and develop universities remains fragile. For example, a serious shortage of well- qualified teaching staff-only 20% have a Ph.D. degree. In addition, facilities in the universities are very limited and seriously outdated.
3. Socio-economic conditions remain limited. The budget for education is small. The state budget for a student is 500 US$ a year. In comparison with economic fields, for instance, oil and gas or electricity, there is almost no foreign investment.

III STRATEGY ORIENTATIONS FOR HIGHER EDUCATION DEVELOPMENT FOR THE 21ST CENTURY

The strategy for socio-economic development up to the year 2000 in Vietnam defines the education and training objectives as: development of human resources, raising the intellectual level of the people, training of talented people, building of contingents of intellectuals, business people, managers, technical experts and highly skilled workers able to pave the way for the country to enter the twenty-first century.

Some strategic orientations for higher education are as follows

1. Crucial Role of the Higher Education System

In order to respond to the great demands for producing a well-educated and efficient labour force, which can work at a much higher and newer level to satisfy all that is needed in the use of modern scientific and technological advances in all fields of socio-economic activities, the higher education system must ensure the initial quality of the work force of all branches in the national economy and in the cultural development of the country. This point concerns first of all the engineering higher schools. The new engineering generations should have creative capabilities to find new directions and effective solutions for economic development. The higher education system has also to provide retraining and regular additional training for people to acquire better knowledge. The higher schools should play an essential role in quality training for all the levels of education. How can the higher education system undertake well its tasks in the condition of a market economy ? It is very important to mobilize not only the state investment but many sources of capital from society (a system of tuition fees).

2. Research, Development and Society-serving Functions of the Higher Education System

Universities must constitute a potentially powerful force to do research, develop and cooperate with other researchers in the whole country in the service of social and community development. They must become centres to create scientific and technological developments.

In the open-door trend to integration with the international community, the higher education system must promote its external relations and international communications to absorb modern scientific and technological progress.

The higher education system of Vietnam should attach great importance to its research function so as to cope with emerging problems created by the realities of the country renovation and development, by making applied research or development research or basis research, depending on the problems ; and in the basic training, contents and methods have to be very close to the reality of Vietnam.

3. Renovating and Rationalizing the Networking of Universities and Colleges

Rearranging and reorganizing the universities network evenly distributed across the country and linking training to research will increase the efficiency of the training and retraining process.

New networking should be able to use all the capacities of the teaching staff and pedagogical facilities, equipment as well.

It is necessary to focus on building some centres of excellence with the higher level of training in the region. These will be piloting centres, which are the first to approach the ultimate scientific development, creating favorable conditions to further develop the whole network in the future.

4. Upgrading the Contingent of Teaching Staff, Redesigning Methodologies of Training

In order to suit new requirements, the teaching staff must achieve certain academic qualifications and standards by continuing training and retraining.

Universities should take the initiative to quickly redesign the contents of training programs in the spirit of both linking them closely to the demands for national development and adapting them to the progressive trend of our times. It would mean more autonomy for universities and responsibility as well.

Special attention should be paid to renovating methodologies with respect to train student capabilities in creative thinking and problem-solving abilities and involving students in scientific research programs to serve society. The learning process evaluation must basically be reformed and upgraded.

5. Developing and Extending International Cooperation

It is indispensable to expand cooperative relations among the universities of Vietnam and of other countries, and international organizations ,in order to cultivate teaching staff and students, to exchange information and documentation ,and to make close cooperation and coordination in training and scientific research.

IV SOME CONCRETE PROPOSALS FOR COOPERATION BETWEEN THE ENGINEERING INSTITUTIONS IN THE REGION

With ever increasing advances in science and technology, the countries in the region will face a lot of difficulties in improving engineering training quality, if they do it separately. Joint collaboration will strengthen the engineer training system, and desired results will be achieved. In this respect the following suggestions are made:

1. Facilitate the exchange of the professors and researchers with other educational institutions of the region. Many Vietnamese universities have a great desire to establish relations with neighboring countries' universities. Individual contacts should also be encouraged.

2. Reinforce the formulation of engineer training curriculum by specific aid programs responding to a high-quality requirement.
3. Establish a regional engineering higher school network for more efficient cooperation between each other.
4. Intensify the linkage between engineer training and vocational training in order to make them more responsive.

In addition, Vietnam is always ready to use overseas investment to set up foreign engineer training institutions to answer the needs of socio-economic development.

Section Four: Recommendations

Recommendations

Following the paper presentations and the country reports, the participants held discussions in small groups. The focus areas for discussion included :

1. Curriculum
2. University-Industry Linkages
3. Continuing Education/Regional Cooperation

Each group then reported their findings. In summary, the following general observations were made :

1. CURRICULUM

Management skills must be integrated into the curriculum. These skills include the ability to communicate, problem solving skills, ethics, environmental consciousness, foreign language ability, sensitivity to multiculture, team working. In order to achieve this ; planning by the top management is required to incorporate management skills into the curriculum.

2. UNIVERSITY-INDUSTRY LINKAGES

A National Commission on University-Industry Linkage should be organized, comprised of members from the industry and academe who could ensure that the curriculum fulfills its requirements.

Linkages can be strengthened among universities within their own country and between countries simultaneously, laying a solid foundation for the development of university-industry linkages.

3. CONTINUING EDUCATION/REGIONAL COOPERATION

The introduction of an international course, for example, "Current Issues in Engineering Education" could be introduced into all countries in the region.

Short course should be arranged periodically to facilitate the exchange of information with regard to new technologies.

Key Recomendations

As a result of these discussions and proposals the following key recommendations were made :

1. University-Industry Linkages (UIL) are the focal point for Continuing Education and as such RIHED shall cooperate with AUAP again to organize another colloquium for early 1998 ; the theme being University-Industry Linkage and the venue shall be in Vietnam.
2. SUT and AUAP will cooperate to provide short training courses for professional engineers in the use of new technology.
3. The French Government and RIHED will jointly arrange a Regional School on Mathematics for Applications in Science and Technology. The participants will be from SEAMEO Member Countries, with the Ministry of University Affairs giving support to the Thai participants.
4. The proposal to establish APCEEN (Asia-Pacific Continuing Engineering Education Network) was fully supported, and once approved by the AUAP Governing Board, the implementation of a Construction Management Course will be the first priority.

Annex One : Programme

Programme

Monday 10, February 1997

	Arrival of Participants

Tuesday 11, February 1997

08:00 - 08:30	Registration
08:30 - 09:00	Opening
09:00 - 10:00	Keynote Address : "Reflections on the Education of Engineers" by Prof. Roger Downer, President of AIT
10:00 - 10:30	*Break*
10:30 - 12:00	Panel Discussion I : Engineering and Technology Education in France *Moderator :* Prof. Dr. Georges Camy Permanent Representative of France to SEAMEO *Panelists:* 1. Ms. Monique Le May, CESI, Paris, France 2. Prof. Jean Francois Me'la President of University of Paris 13 3. Prof. Dr. Christian Rumelhard, Chaire de Physique des Composants Electronique
12:00 - 13:30	*Lunch*
13:30 - 15:00	Panel Discussion II : Collaboration in Engineering Education *Moderator:* Prof. Dr. Ruben C. Umaly, Director of Centre of International Affairs, Suranaree University of Technology

	Panelists: 1. Dr. S.A. Boctor, Ryerson Polytechnic University 2. Dr. F. Hamdullahpur, Technical University of Nova Scotia 3. Dr. G. Schneider, University of Waterloo 4. Dr. L. Otten, University of Guelph
15:00 - 15:30	*Break*
15:30 - 17:00	Panel Discussion III : Engineering and Technology Education in SEAMEO Member Countries *Moderator:* Dr. Tong-In Wongsothorn, Director of SEAMEO RIHED *Panelists:* 1. Assoc. Prof. Dr. Hasanan Md. Nor, Head of Department, Faculty of Civil Engineering, Universiti Teknologi Malaysia 2. Assoc. Prof. Er Meng Hwa, Dean , School of Electrical and Electronic Engineering, Nanyang Technological University 3. Dr. Bandit Fungtammasan, Dean of Faculty of Engneering, King Mongkut's Institute of Technology, North Bangkok

Wednesday 12, February 1997

08:30 - 10:00	Country Reports : Cambodia China Lao PDR
10:00 - 10:30	*Break*

10:30 - 12:00	Country Reports : Malaysia Singapore Thailand Vietnam
12:30 - 13:30	*Lunch*
13:30 - 15:00	Group Discussion 1 *Groups* Group 1 Asia and Pacific Continuing Education Network (APCEEN) Group 2 Mekong University Network (MUNETEE) *Topics* 1. Collaboration on Undergraduate Education 2. Collaboration on Continuing Education 3. Collaboration on University - Industry Education
15:00 - 15:30	*Break*
15:30 - 17:00	Group Discussion 2

Thursday 13, February 1997

08:30 - 10:00	Group Report and Discussion
10:00 - 10:30	*Break*
10:30 - 12:00	- Adoption of the Report and Recommendations - Closing
12:00 - 13:30	*Lunch*
13:30 - 15:00	Visit Suranaree University of Technology Technopolis
15:30	Leave for Bangkok by Bus
18:00	Arrive at the Hotel in Bangkok

Friday 14, February 1997

09:00 - 12:00	Visit King Mongkut's Institute of Technology, North Bangkok and The Thai - French Innovation Centre (TFIC)
Afternoon	Departure of Participants

Annex Two: List of Participants

List of Participants

Cambodia

1. Mr. Chan Choeun ,
   Deputy Director of Higher Education Department,
   Department of Higher Education,
   Ministry of Education, Youth and Sport,
   Phnom Penh,
   Cambodia
   Tel : (855-15) 831-481

2. Mrs. Phoeurng Sackona,
   Dean of Faculty of Food Chemistry,
   Institute Technology of Cambodia,
   Phnom Penh,
   Cambodia
   Tel : (855-23) 426-913
   Fax : (855-23) 362-110

China

3. Prof. Yang Sizhong,
   President of Yunnan Polytechnic University,
   President Office,
   Yunnan Polytechnic University,
   Kunming, Yunnan 650051
   People's Republic of China
   Tel : (86-871) 331-4031 - 4235
   Fax : (86-871) 331-4459

Lao PDR

4. Mr. Vixay Chansavang,
   Head of Department of Communication and Transport,
   School of Communication and Transport,
   Km. 3, Sokpaluang,
   Vientiane,
   Lao PDR
   Tel : (856-21) 312-058
   Fax : (856-21) 312-058

5. Mr. Viravouth Sengsohphone ,
   Vice Dean of Faculty of Engineering,
   NPI Project Director,
   Faculty of Engineering,
   National University of Laos,
   Sok Paluang Road, Vientiane
   Lao PDR
   Tel : (856-21) 313-332
   Fax : (856-21) 314-382

Thailand

6. Dr. Bundit Fungtammasan,
Dean of Faculty of Engineering,
King Mongkut's Institute of Technology North Bangkok,
1518 Pibulsongkram Road, Bangsue,
Bangkok 10800
Tel : (66-2) 587-4351
Fax : (66-2) 585-6149

7. Mr. Panarit Sethakul,
Director,
The Thai-French Innovation Centre,
King Mongkut's Institute of Technology North Bangkok,
1518 Pibulsongkram Road,
Bangsue, Bangkok 10800
Tel : (66-2) 587-4346-7
Fax : (66-2) 585-6149

8. Mr. Arnauld de Nadaillac,
Deputy Director,
The Thai-French Innovation Centre,
King Mongkut's Institute of Technology North Bangkok,
1518 Pibulsongkram Road,
Bangsue, Bangkok 10800
Tel : (66-2) 587-4346-7
Fax : (66-2) 585-6149

9. Dr. Prakob Wirojanagud,
Associate Professor and Dean,
Faculty of Engineering,
Ubon Ratchathani University,
Ubon Ratchathani 34190
Tel : (66-45) 288-376-7
Fax : (66-45) 288-378

10. Assoc. Prof. Rachavarn Kanjanapayakom ,
Assistant Dean for International Affairs and
Special Projects,
Faculty of Engineering, Kasetsart University,
50 Paholyothin Road, Chatuchak,
Bangkok 10900
Tel : (66-2) 579-2200
Fax : (66-2) 579-6804

11. Dr. Mathanee Sriart ,
Acting Head of Department of Mechanical Engineering,
Department of Mechanical Engineering,
Faculty of Engineering, Naresuan University,
Phitsanalok 65000
Tel : (66-55) 261-061
Fax : (66-55) 261-062

12. Representative of AIT

13. Dr. Sanguan Vongchavalitkul,
Dean,
Vongchavalitkul University,
Midtapab Road, Muang
Nakorn Ratchasima 30000
Tel : (66-44) 255-523-4
Fax : (66-44) 256-833

14. Mr. Chalerm Mutigo,
Faculty of Engineering,
Rajamangala Institute of Technology
Rangsit - Nakorn Nayok Road, Klong 6
Thanyaburi, Pathumthani 12110
Tel : (66-2) 549-3401
Fax : (66-2) 577-5026

Vietnam

15. Dr. Ha Duyen Tu ,
Vice-Director,
International Relations Office,
Hanoi University of Technology,
221 - c1, Dai Co Viet 1 Road,
Hanoi, Vietnam
Tel : (84-48) 692-005
Fax : (84-48) 692-006

16. Prof. Dr. Tran Kim Lan ,
Vice-Director of International Relations Department,
Ministry of Education and Training,
49 Dai Co Viet Street,
Hanoi, Vietnam
Tel : (84-4) 869-4961
Fax : (84-4) 869-3243

France

17. Mr. J C Terrac,
Cultural Counselor,
French Embassy,
29 Sathorn Tai Road,
Bangkok 10120
Tel : (66-2) 287-1592-8
Fax : (66-2) 287-1019

18. Prof. Dr. Georges Camy,
    Permanent Representative of France to SEAMEO
    Office of the Cultural Counselor,
    French Embassy,
    29 Sathorn Tai Road,
    Bangkok 10120
    Tel : (66-2) 287-1592-8
    Fax : (66-2) 287-1019

19. Ms. Monique Le May,
    cesi,
    83 Rue Desnouettes,
    75015 Paris,
    France
    Tel : (01) 45 33 31 28

20. Prof. Jean Francois Méla,
    President of University of Paris 13,
    Paris, France

21. Prof. Dr. Christian Rumelhard,
    Chaire de Physique des Composants Electronique,
    Conservatoire National Des Arts et Métiers,
    292 rue Saint-Martin,
    75141 Paris Cedex 03,
    France
    Tel : (33-1) 40 27 21 79
    Fax : (33-1) 40 27 24 81

Private Sector (Invited by SUT)

22. Representative from the Industrial Council of Thailand

23. Representative from the Industrial Council of Nakorn Ratchasima

24. Representative from Ministry of Industrial of Nakorn Ratchasima

Resource Persons (Invited by RIHED)

25. Assoc. Prof. Dr. Hasanan Md. Nor,
    Head of Department, Faculty of Civil Engineering,
    Universiti Teknologi Malaysia,
    Karung Berkunci 791, 80990 Johor Bahru,
    Negeri Johor Darul Tazim,
    Malaysia
    Tel : (097) 557-6160
    Fax : (097) 556-6157

26. Assoc. Prof. Er Meng Hwa,
Dean, School of Electrical and Electronic Engineering,
Nanyang Technological University ,
Nanyang Avenue, Singapore 639798
Republic of Singapore
Tel : (65) 791-1744
Fax : (65) 791-9340

AUAP Members

Indonesia

27. Mr. Erwin Siahaan ,
Vice Dean, School of Engineering,
Tarumanagara University,
Jln. S. Parman No. 1, Jlct. 11440
Indonesia
Tel : 507-2548
Fax : 566-3277

28. Mr. Eduard Tjahjadi Dioling ,
Lecturer, School of Engineering,
Tarumanagara University,
Jln. S. Parman No. 1, Jlct. 11440
Indonesia
Tel : 507-2548
Fax : 566-3277

29. Sutan Assin ,
Vice Rector, University Trisakti,
Jl. Kya Taya, Jakarta 11440
Indonesia
Tel : (62-21) 567-1356
Fax : (62-21) 567-1356

Philippines

30. Dr. Rebecca Cajilog ,
Dean, College of Engineering,
University of Baguio,
Gen. Luna Road, Baguio City 2600
Philippines
Tel : (63-74) 442-4195
Fax : (63-74) 442-2357

31. Prof. Rosalinda C. Balacuit,
Dean, College of Engineering,
MSU-Iligan Institute of Technology,
Iligan City,
Philippines
Tel : (63-2) 221-5309
Fax : (63-2) 221-4056

Thailand

32. Dr. Norkun Sittiphong,
Dean, Faculty of Engineering,
Chiang Mai University,
239 Huay Kaew Road,
Suthep Sub-District
Muang, Chiang Mai 50200
Tel : (66-53) 944-101
Fax : (66-53) 217-287

33. Dr. Montip Chamchong,
Lecturer, Food Engineering Department,
Faculty of Engineering,
Kasetsart University, Kamphaengsan Campus,
179 Phondamri Road, Kamphaengsan,
Nakorn Pathom 73140
Tel : (66-34) 351-897
Fax : (66-34) 351-404

34. Mr. Suchat Leungprasert,
Lecturer, Department of Environmental Engineering,
Faculty of Engineering, Kasetsart University,
50 Paholyothin Road, Chatuchak,
Bangkok 10900
Tel : (66-2) 561-4621 ext. 368
Fax : (66-2) 579-0730

35. Dr. Pornchai Mongkhonvanit,
President, Siam University,
235 Phetkasem Road,
Phasi-Chareon District,
Bangkok 10163
Tel : (66-2) 457-0061
Fax : (66-2) 457-3982

36. Prof. Dr. Smith Kamperpool,
Dean, Faculty of Engineering,
Siam University,
235 Phetkasem Road,
Phasi-Chareon District,
Bangkok 10163
Tel : (66-2) 457-0068, 457-0478-9
Fax : (66-2) 457-3982

37. Ekachai Prommas,
Kasem Bandit University,
99/101 Patanakarn Road,
Suan Luang,
Bangkok 10250
Tel : (66-2) 321-6930-9
Fax : (66-2) 321-4444

AUAP Representative

38. Prof. Dr. Wichit Srisa-an,
President , AUAP,
President, Suranaree University of Technology,
111 University Avenue, Suranaree Sub-District
Muang, Nakorn Ratchasima 30000
Tel : (66-44) 216-130
Fax : (66-44) 216-127

39. Prof. Dr. Ruben C. Umaly,
Secretary-General, AUAP,
Director, Center for International Affairs,
Suranaree University of Technology,
111 University Avenue, Suranaree Sub-District
Muang, Nakorn Ratchasima 30000
Tel : (66-44) 216-191-8 ext. 1154
Fax : (66-44) 216-122

CUTC (Canada)

40. Dr. S. Boctor,
Ryerson Polytechnic University,
Ontario
Canada

41. Dr. F. Hamdullahpur,
Technical University of Nova Scotia,
Halifax, Nova Scotia,
Canada

42. Dr. G. Schneider,
University of Waterloo,
Ontario,
Canada

43. Dr. L. Otten,
University of Guelph,
Ontario,
Canada

44. Ms. Carol Conor,
Continuing Education Center,
Technical University of Nova Scotia,
Halifax, Nova Scotia,
Canada

Suranaree University of Technology

45. Assoc. Prof. Dr. Terd Charoenwattana,
Dean, Institute of Agricultural Technology

46. Asst. Prof. Dr. Tawee Lertpanyavit,
Dean, Institute of Industrial Technology

47. Assoc. Prof. Dr. Kasem Prabriputaloong,
Dean, Institute of Resources Technology

48. Assoc. Prof. Dr. Krich Suebsonthi,
Dean, Institute of Social Technology

49. Assoc. Prof. Dr. Vutthi Bhanthumnavin,
Dean, Institute of Science

50. Prof. Dr. Vitoon Osathanondh,
Dean, Institute of Medicine

51. Asst. Prof. Vitawas Yomchinda,
Chair, School of Agricultural Engineering

52. Assoc. Prof. Grpt. Capt. Dr. Vorapot Khompis,
Chair, School of Mechanical Engineering

53. Asst. Prof. Wng. Cmdr. Dr. Sarawut Sujitjorn,
Chair, School of Electrical Engineering

54. Asst. Prof. Dr. Weerapun Sriboonlue,
Chair, School of Civil Engineering

55. Dr. Veerachai Manopichetwattana,
Chair, School of Industrial Engineering

56. Mr. Sart Sukprasert,
Chair, School of Transportation Engineering

57. Assoc. Prof. Dr. Chaiyot Tangsathitkulchai,
Chair, School of Chemical Engineering

58. Dr. Chongchin Polprasert,
Chair, School of Environmental Engineering

59. Prof. Manas Sathirachinda,
Chair, School of Metallurgical Engineering

SEAMEO RIHED

60. Dr. Tong-In Wongsothorn,
Director, RIHED,
5th Floor, Ministry of University Affairs Building,
Sri Ayutthaya Road,
Rajathevee, Bangkok 10400
Tel : (66-2) 644-5418
Fax : (66-2) 644-5421

61. Mr. Kevin Charles Kettle,
Publications Officer, RIHED,
5th Floor, Ministry of University Affairs Building,
Sri Ayutthaya Road,
Rajathevee, Bangkok 10400
Tel : (66-2) 644-5591
Fax : (66-2) 644-5421

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ACRONYMS AND ABBREVIATIONS

ADB	-	Asian Development Bank
AFTA	-	ASEAN Free Trade Area
APDC	-	Asia and Pacific Development Center
APEC	-	Asia Pacific Economic Cooperation
ASEAN	-	Association of South East Asian Nations
BIMP-EAGA	-	Brunei Indonesia Malaysia Philippines-East ASEAN Growth Area
BIOTROP	-	Southeast Asian Regional Centre for Tropical Biology
BSP	-	Brunei Shell Petroleum
CHED	-	Commission on Higher Education
CSI	-	Civil Service Institute
ESCAP	-	United Nations Economic and Social Commission for Asia and the Pacific
FDI	-	Foreign Direct Investment
GATT/TWO	-	General Agreement on Tariffs and Trade/ World Trade Organization
GDP	-	Gross Domestic Product
GTBC	-	Growth Triangle Business Council
HEIs	-	Higher Education Institutions
HRD	-	Human Resource Development
IMT-GT	-	Indonesia Malaysia Thailand Growth Triangle
IMTGT-UNINET	-	Indonesia-Malaysia-Thailand Growth Triangle University Network
IT	-	Information Technology
ITB	-	Institute Teknologi Brunei
LMI	-	Labor Market Information
MEDCO	-	Mindanao Economic and Development Council
MIB	-	Melayu Islam Beraja
MNLF	-	Moro National Liberation Front
MSU	-	Mindanao State University
MOU	-	Memorandum of Understanding
NIE	-	Newly Industrialized Economies
PMHRD	-	Public Management and Human Resource Development
RIHED	-	Southeast Asian Regional Centre for Higher Education and Development
R & D	-	Research and Development
SEARCA	-	Southeast Asian Regional Centre for Graduate Study and Research in Agriculture

SEAMEO	-	Southeast Asian Ministers of Education Organization
SEAMES	-	Southeast Asian Ministers of Education Secretariat
SIJORI	-	Singapore Johor Riau
SOM	-	Senior Officials Meeting
UNIMAS	-	Universiti Malaysia Sarawak
UBD	-	Universiti Brunei Darussalam
UMS	-	Universiti Malaysia Sabah
UP	-	University of the Philippines
UPM	-	University of the Philippines Mindanao
VOCTECH	-	Southeast Asian Regional Centre for Vocational and Technical Education

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Signature: K C Kettle

Printed Name/Position/Title: KEVIN CHARLES KETTLE PUBLICATIONS OFFICER

Organization/Address: SEAMEO RIHED 328, SRI AYUTTHAYA ROAD BANGKOK 10400 THAILAND

Telephone: 2461106-14 x526

FAX: 6445421

E-Mail Address: Kevin@mua.go.th

Date: 10 Jan 98

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