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Engineering Education and Training in a Changing Philippine Society*

by

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Introduction

The establishment of the Philippine "New Society" started a new era in Philippine history and new goals and plans have been adopted to respond to the country's changing needs. Thus, there is always a continuing need to relate the basic premises and curricula of engineering education to the changing needs of a changing society.

It has always been my position that for the University to effectively carry out its responsibilities, it needs the cooperation of government, industry and professional societies. It is therefore necessary to discuss the following issues and problems related to engineering education and training:

1. Responsibilities of Engineering Education
2. Premises of Engineering Education
3. Dynamic Influences Affecting Engineering Education
4. Flexibility/Rigidity of the Engineering Curriculum
5. Increasing Need for Continuing Education
6. University/Government/Industry Interaction.

Responsibilities of Engineering Education

The American Society for Engineering Education had adopted the following responsibilities of engineering education:

1. **To the individual.** The primary responsibility is to enable the indi-

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vidual to develop such natural talents as he may have and to provide him the knowledge, skills, understanding, and appreciation that will encourage him to pursue a personally rewarding career of work and study in engineering during his working years.

2. **To Society.** There is the responsibility to guide the total education of a group of able young people during an impressionable and formative period so that as professional persons, publicly or privately employed, they will conscientiously, wisely, and competently supply valuable engineering services to society.

3. **To the Engineering Profession.** There is the responsibility to supply the engineering profession with a group of embryonic engineers able at graduation to perform satisfactorily the simpler tasks of an engineering organization under guidance, capable and eager to develop into engineers able to handle assignments of progressively greater difficulty and responsibility, under diminishing supervision.

At this point, we may ask the following appraisal questions:

1. To what extent does engineering education and training in the Philippines perform these responsibilities to the individual, society and the engineering profession?
2. What innovations can we introduce to effectively carry out these responsibilities?

The discussion on the succeeding problems and issues could provide some mechanism in assessing the situation and lead to answers to the above questions.

Premises of Engineering Education

In carrying out the responsibilities of engineering education, the following premises have to be recognized:

1. Knowledge of engineering and natural sciences, essential to doing engineering, is not the whole of engineering education. Curriculum content should include the professional behaviors and skills of engineering practice. To do engineering, it is equally important that a person be reliable, thorough, pragmatic, efficient and socially concerned, and that he be skilled in learning, planning, communication, analysis, computation, experimentation, human relations and innovation.

2. In addition to a mastery of the basic principles, engineering science is best learned in the manner that is similar to the way it is practiced: in

interdisciplinary whole problem-oriented fashion.

3. An advanced degree does not necessarily qualify engineering faculty to know the preparation needed by the students for the engineering profession. Relevant involvement in engineering practice can provide the means through which faculty can continually improve the educational process.

4. The engineer has a dual role: as applied scientist and as manager of industrial and public works.

If we accept these premises, then we can make an assessment of the engineering education and training programs and see how we can relate these basic premises and curricula of engineering education to realistic appraisals of changing times and needs. For example, the energy crisis, the increasing concern for a better environment, the thrust for more labor-intensive projects, the thrust for rural development and other similar national efforts have important ramifications to engineering education.

Dynamic Influences Affecting Engineering Education

Engineering is applied science. Any advance in science creates new potentialities of application which sooner or later must be reflected as an addition to engineering education. Furthermore, engineering is applied economics, applied sociology, and sometimes applied politics. For the engineer to design and operate an engineering work in the best interest of society, he must have knowledge of its economic and social effects.

In recognition of these changing needs, new efforts must be directed towards:

- making instruction at all levels more responsive to the needs, abilities and aspirations of individual students
- educating engineers about the economic and social consequences of their work
- providing students with a rich assortment of authentic engineering experiences to bring them to a high level of professional responsibility and accomplishment
- preparing engineers to accept the new responsibilities placed on them by society and to discharge these duties in a competent and professional manner.

One development which has tremendous impact on engineering education is the computer. You must have noted that in the last 20 years we have experienced a computer revolution. The 80's will be the decade of the computer. New developments in computer technology will enable us to do things which were previously not possible. It will be recalled that the computer revolution of the 1960's has focused on hardware and software developments which resulted in several generations of larger and faster computer systems that could store more information – with each succeeding generation being able to process the work more efficiently and less expensively. However, the computer revolution of the 70's has first centered on the design and production of smaller minisystems and more recently on the development of microsystems. These developments have to be reflected as an addition to engineering education.

Flexibility/Rigidity of the Engineering Curriculum

In carrying out the responsibilities of engineering education, the curriculum is the machinery by which we implement the philosophy of engineering education. However, it is equally recognized that a good curriculum must be adequately supported by a competent faculty, adequate facilities and student guidance.

Some of the criticisms against our undergraduate engineering education are:

1. in general it is conventional, compartmentalized, static, and unimaginative
2. it does not reflect adequately the dual role of the professional engineer as applied scientist and as manager of industrial and public works
3. it does not produce specialists who can be immediately useful to their employer if there is a particular specialist job available
4. the men directing it do not have professional experience.

I am sure that if we are going to ask people in government and industry as to what they wish, we will get variable replies. An executive of an industry, for example, may wish to have graduates who are to succeed in managing his enterprises, to write well, to speak well, and to be broadly grounded in both the science and techniques of the engineering profession. Scientific and specialized knowledge may be less required by this executive. However, employment officers in the same company may require graduates to have the latest specialty in their curriculum, say in electronics. Some government employers on the other hand, would like the engineering education to strongly emphasize social and economic consciousness, participation in public affairs, responsibilities of the engineer as a citizen, etc.

It would be ideal if we could satisfy all these attributes required by the employers. But we cannot put everything in the curriculum. I therefore suggest that a re-examination of the engineering curricula be made and some innovations be introduced to achieve greater flexibility so that engineering education's responsibilities to the individual, society and the engineering profession can be effectively carried out. This flexibility can be achieved through the following means:

1. increasing the number of electives in fundamental science and specialized courses in design, planning and management.

2. developing interdisciplinary programs wherein students from the various fields of engineering and other disciplines such as architecture, law, biology, geology, sociology, political science, etc., are brought together to discuss problems and form teams to devise solutions in an interdisciplinary whole problem-oriented fashion.

3. requiring students to participate in seminar courses where guest lecturers who appreciate the larger problems of society can address them.

However, I wish to emphasize that in our efforts to make engineering education more responsive to these various needs, the engineering graduate must have a sound base. In other words, engineering education must first provide greater fundamental background and wider breadth of outlook and a better foundation for graduate study if we wish our graduates to have greater versatility after graduation. The question then is: Can undergraduate engineering education provide this fundamental background and at the same time allow specialization?

Let me consider,as an illustrative example, the civil engineering curriculum at the University of the Philippines. The present C.E. curriculum as well as some possible changes are given in Table 1. It will be noted that if the 15 units of legislated courses can be removed, these can be replaced by electives in fundamental science and specialized courses in design, planning and management. As a matter of fact, together with the other indicated possible changes, we can increase the total electives by 22 additional units. Comparing these additional 22 units to the 30 units presently required for the Masters degree, we will then be moving towards the present Masters degree as the requirement for entry to the engineering profession. These changes will provide the flexibility that will allow individual students to specialize without sacrificing the sound base that he needs as a versatile professional engineer.

The criticism that in general our undergraduate engineering education is conventional, compartmentalized, static, and unimaginative also requires a re-examination. Some innovations in teaching methods and changes in course content have to be seriously considered if we wish to make engineering education more responsive to the needs of our society and to enable our graduates to play their increasing role in the solution of complex social problems. In other words, engineering education must not only be concerned with the attainment of a high level of technical competence but must also impart a thorough knowledge of the many non-technical aspects of modern life which interact significantly with the technical problems. For example, development is more and more a compromise between that which is technically possible, that which is considered economically attractive, and that which is acceptable in environmental grounds. As a major instrument of development and change, the engineer must be the advocate of this essential compromise. This important aspect must be emphasized in his education and training. An interdisciplinary approach to a multidisciplinary problem will lead to a better understanding of the interaction of the various factors involved.

Table 1

U.P. CURRICULUM IN CIVIL ENGINEERING

	Present	Future
General Education		
Communications		
English/Pilipino	9	12 (plus 3)
Speech	3	– (minus 3)
Mathematics, including (CE 21 & ES 21)	24	19 (minus 5)
Physics	12	12
Chemistry	5	5
Engineering Science		
Computer Science	3	3
Mechanics of Solids and Fluids	16	16
Electrical Science	3	3
Thermodynamics (Mechanical)	3	3
Materials Science	3	3
Engineering Graphics	2	2
Geology	3	3
Humanities	3	3
Social Science	6	6
Natural Science	3	3
History (Philippines, Asia)	6	6
	104	99

Departmental Engineering Courses		
Synthesis, Analysis, Design of Systems and their Components		
Structural Engineering	14	11 (minus 3)
Transportation Engineering	6	6
Sanitary Engineering	4	6 (plus 2)
Hydraulic Engineering	7	6 (minus 1)
Soils/Foundation	3	3
Construction Management	3	3
Engineering Economy	3	3
Surveying	7	7
Engineering Ethics/Human Relations	2	2
Electives/Special Problems	5	27 (plus 22)
	54	74
Legislated Courses		
Spanish	12	0
Rizal Course	3	0
Total for 5-year Program	173	173

Note:

1. Enclosed in parenthesis are the changes as compared to the present.
2. Reduction of 5 units in Math is based on the assumption that Math 17 (algebra) may be removed. Philippine Science High School graduates generally satisfy this. Another alternative is to retain but upgrade it.
3. If the legislated courses can be removed, a total of 22 units can be made available as elective and thus allow greater flexibility.

This brings us to the complaints that teachers tend to confine their teaching to compartments and little or no attempt is made to relate the lectures to other subjects in the curriculum. Let us consider, for purposes of discussion, the teaching of service courses in the engineering curricula. Some instructors in civil engineering, for example, feel that the exposure that students get in mechanics or engineering sciences does not satisfy what they need. Mechanics instructors on the other hand complain that students come to them inadequately prepared in mathematics and physics. Mathematics and Physics people blame the high school.

There are gaps but there is no serious attempt to bridge these gaps. There is no communication between the instructors in civil engineering, mechanics, mathematics and physics. This situation holds true in the teaching of courses in the humanities and social sciences. Is there an attempt, for example, on the part of the social science instructors to discuss the social impact of technological change, engineering works such as multi-purpose dams (e.g., Pantabangan, Magat), alternative sources of energy, appropriate technology for rural development and the like? Is there an attempt on the part of physics teachers to illustrate applications of fundamental principles to interesting physical phenomena in mechanics, electricity, sound and light that would serve two purposes of giving interest to the subject as well as developing interest and curiosity in the engineering situation where these phenomena are applied? It has been said that one of the secrets of good teaching is to make the student enthusiastic. Arousing the student's interest makes him enthusiastic. Relating the subject matter and showing how it fits into other engineering subjects help in arousing this interest. This can be achieved through exchange of instructors among departments, interaction between instructors from various departments concerned and/or team teaching.

I had the opportunity to participate in the "Regional Seminar for Teachers in Engineering Schools on the Training of Personnel for Rural Development" which was held at Chulalongkorn University, Bangkok, Thailand, on December 15-19, 1980. I wish to share with you some of the recommendations as they are relevant to engineering education and training. Among the recommendations were:

1. Special courses in Social Science subjects should be designed for engineering students, with emphasis on rural societies. The lectures given to them should contain material on technology. Of particular interest will be topics of technology impact type subjects on socio-cultural, economic and environmental factors.

2. Social scientists should be requested to formulate research projects on the application of technology to rural development and the impact of technology on rural societies.

3. A study on forms of effective communication between schools of engineering and rural communities should be undertaken.

4. The practical training of engineering students should be reviewed. The possibility of placing them for training in rural areas should be considered.

5. Aspects of Appropriate Technology and Indigenous Technology and

its history should be incorporated into some of the subjects in the engineering curriculum. Some textbooks should also be amended to incorporate the above.

6. University, government and inter-governmental agencies and the private sector should work closely to determine rural problems and needs and training of engineering staff involved in rural development.

7. A multidisciplinary study should be undertaken to determine the appropriate methods for introducing industries into rural areas.

8. A study of the impact of modernization through technology transfer should be made.

Increasing Need for Continuing Education

The rapid advance of scientific knowledge as well as the rapid growth in complexity of technological problems have had consequences in the education and training of engineers. It will not be uncommon for an engineer to find out that the technology he is familiar with will be obsolete in a few years time. A young graduate, for example, may find out that the technology he was taught in college is obsolete after he graduates. Students of twenty-five years ago used the slide rule in their computations. The students and engineers of today have programmable calculators and microcomputers available for their use. There is therefore an increasing need for continuing education and this is one of the responsibilities of engineering education to the engineering profession.

In Table 2 are some suggested areas for continuing education. Educational institutions are universally recognized as the credentialing agent within our society. Such a credentialing responsibility extends beyond the traditional bachelor's, master's and Ph.D. degrees. Thus, any credentials to be awarded as a result of the accumulation of educational experience in the classrooms of academic programs, in-plant courses, short courses, or correspondence courses should be from an educational institution.

University/Government/Industry Interaction

The issue of cooperation between the University on one hand and the government and industrial sectors on the other hand has always been the subject of discussion. There is no doubt that there is need for such cooperation. But the present level of cooperation between the University and industry is generally low. Perhaps this can be attributed to the fact that industry does not fully appre-

Table 2

AREAS FOR CONTINUING EDUCATION

Areas	Sponsor(s)	Form(s)	Participants
1. Current industrial practice generally not covered satisfactorily in present university programs	Industry in cooperation with the university or the university in cooperation with industry	Short Courses/ Seminars/In-Plant Courses	Young graduates in industry in particular or young members of the profession in general
2. Research and development into new areas of interest to the profession	University in cooperation with both industry and professional societies	Short Courses/ Seminars	People from a specific industry in particular or members of the profession in general
3. Career Development and Project Management	University in cooperation with industry and professional societies	Seminars/Short Courses	People from specific industries in particular or members of the profession in general
4. Multidisciplinary areas such as energy conservation, environmental quality management, etc.	University in cooperation with professional societies and industry	Seminars/Work-Shops/Short Courses/In-Plant Courses	People from industry or the profession in general
5. New tools in engineering practice such as systems analysis, computer usage, etc.	University in cooperation with professional societies and industry	Seminars/Work-shops/Short Courses	People from industry or the profession in general

ciate the capability of the University to provide solutions to some of its problems. It is therefore desirable to understand the prime motivations of both sides in order to promote a better climate for productive cooperation.

From the point of view of the academe, the following forms of assistance will be welcomed:

1. teaching assistance when industry has special knowledge
2. industrial guidance in curriculum design and development
3. industrial guidance in developing technologies for the future
4. financial support for faculty research programs and student industry-oriented projects
5. financial assistance in the form of scholarships, professorial chairs, laboratory equipment
6. assistance by providing opportunities for young faculty members to round out their careers with actual experience in industry.

Industry, on the other hand, has to understand that the University can reciprocate through the following:

1. curriculum responsive to industrial needs
2. continuing education for people in industry with emphasis on industry's needs
3. preferential help in recruiting qualified graduates
4. assignment of university key researchers to specific projects which are of interest to industry
5. access to the academic institution's research results
6. access to the academic institution's library and laboratory facilities.

A continuing dialogue between the University and industry will lead to a better understanding and appreciation of the mutual benefits that could be derived from such a cooperation. On one hand, the academe will be more aware of the problems and challenges of industrial activity and research. On the other hand, industry will be more aware of the values of university curricular and research programs to their own objectives.

Summary of Issues and Recommendations

1. The three responsibilities of engineering education are (i) to the individual, (ii) to society and (iii) to the engineering profession. An assessment of engineering education must be made against this background.

2. The philosophy of engineering education must be well defined. A clear understanding of the role of the engineer in society to which he aspires will be necessary for an objective reappraisal of the philosophy and of the means by which we implement that philosophy.

3. There are dynamic influences which affect engineering education. This means that engineering education must change to cope with changing times.

4. The engineering curriculum is the machinery by which we implement the philosophy of engineering education. It must be able to provide greater flexibility so that engineering education's responsibilities to the individual, society and the engineering profession can be effectively carried out.

5. Increasing the number of electives in fundamental science and specialized courses in design, planning and management will provide greater flexibility. The repeal of the Spanish Law and the removal from the present curriculum of other legislated and unnecessary courses will permit this change.

6. The need for a sound base in the undergraduate engineering curriculum must always be maintained. While moving towards specialization is desirable, this should not be done at the expense of greater fundamental background and wider breadth of outlook which are necessary for the engineer to have greater versatility after graduation.

7. In addition to a good curriculum, it is equally important to have a competent faculty, adequate facilities and proper student guidance.

8. Innovative teaching has to be adopted. Teachers should not confine their teaching to compartments and try to relate the subject matter to other subjects in the curriculum.

9. Engineering is best learned in the manner that is similar to the way it is practiced, in interdisciplinary whole problem-oriented fashion.

10. The engineer has basically a dual role: as applied scientist and manager of industry and of public works. For him to design and operate an engineering work in the best interest of society, he must have knowledge of its economic and social implication. The education and training of the engineer must therefore reflect these needs.

11. Relevant course topics should be added whenever needed and appropriate. For example, environmental issues, energy-related topics, appropriate technology for industrial and rural development, etc. are issues that are now relevant to the education and training of engineers.

12. The rapid advance of scientific knowledge and the rapid growth in complexity of technological problems make continuing education a must for the engineer. Otherwise, he will be by-passed by progress in his own field and will be incapable of responding to his role and obligations.

13. The credentialing responsibility of the University extends beyond the traditional bachelor's, master's and Ph.D. degrees. It includes nonformal education.

14. For the University to effectively perform the responsibilities of engineering education, it needs the cooperation of government, industry and professional societies. A continuing dialogue is necessary to this end.