

CURRICULUM DESIGN IN CHANGING TIMES

by

J.S. Townsend

Engineering educators are concerned not only with HOW to teach but with WHAT to teach. In an era of changing social values and rapidly expanding technology there must be constant review and revision of teaching methods and curriculum content.

Modern engineering has been defined in many different ways. Some educators see engineering as the application of science to meet the recognized needs of society in an effective manner as judged by the current values of society. A more concise definition states that engineering is decision making.

Facts and concepts are only the raw materials for improving society. The ability to apply these facts and concepts is the tool for improving society. Students can never learn in their undergraduate engineering education all the knowledge that they will need for a whole lifetime. Thus, it makes sense to teach students how to search for knowledge, where to search for knowledge and how to use the knowledge once found.

Courses should be presented to give the student the pleasure and the frustration of behaving as an engineer. The student should experience the satisfaction of solving complex practical problems for the best answer possible with the limited time and resources available.

Students need experience in logical thinking, gathering information, communicating ideas and using methods of analysis, synthesis and evaluation. Courses should not simply demand regurgitation of facts. The ability to recognize and define problems must be developed. Engineering students must be aware of and appreciate the impact of engineering work on society.

Today's students are ambitious, concerned about the future of society and anxious to contribute to the improvement of society. An engineering education is good preparation not only for those graduates who enter the narrow field of engineering practice, but for many other socially important activities. The proportion of engineers employed of strictly engineering jobs is expected to increase almost 50 percent in the next decade.

In the past engineers who moved into non-engineering, non-technological jobs have in general proved extremely capable. More recently employers of engineers have tended to be more concerned about the individual than about his specialized discipline. Thus engineers are increasingly found in government agencies, public administration, wholesale and retail trades, banks, hospitals, insurance, real estate and service industries in general.

Traditional engineering curricula contained a large technological content with exposure to laboratory techniques. There was a minimum amount of mathematics and basic science and little or no humanities and social sciences. The great expansion of technology since the end of World War II and the even greater acceleration in new technology since the

start of aerospace exploration in 1958 has required changes in the traditional engineering curriculum.

In some countries engineering education responded to these rapid changes by increasing the number of specialties available in the curriculum, especially at the graduate level. In the United States the number of specifically named curricula increased by 400 percent since 1958 but not all engineering colleges offered all such programs. Many of these new curricula were offered only at the graduate level. In Canada and the United States the most general response of engineering schools to rapidly changing and developing technology has been to offer a more fundamental and general engineering education at the undergraduate level.

Since first year engineering students vary as to knowledge, background, needs and desires it is not possible to offer a common curriculum for all. The engineering student must acquire an understanding of the state of science as it exists at the time of his education. But he must be able to understand and apply new technology as it occurs.

There are changes taking place in society and in its values as well as in science and technology. Society's needs must be served and the engineer must understand such needs and their relative importance. Besides developing technological skills and scientific competence the modern engineer must have an appreciation of the humanities and the social sciences.

The foundation of any engineering education should of course be mathematics and science. There have been some experimental curricula where of the total credit hours, 50 percent have been in the liberal arts area and 50 percent in the area of technology. A more reasonable allocation of the credit hours would seem to be 25 percent for mathematics and basic sciences. The humanities and social sciences should make up approximately 25 percent of the total required credit hours.

Basic engineering sciences covering the areas of mechanics, thermodynamics, computer science, electrical science, etc. should also make up about 25 percent of the total credit hours. These courses should be application oriented. Up to this point, or 75 percent of the total credit hours, the ideal curriculum consists of courses that have a general use beyond that of a narrow field of specialization. The final 25 percent of the credit hours should be in the area of engineering and technological specialties. Examples of courses in this area are applied mathematics, applied specialized sciences, laboratories, experimental techniques and specialized analysis, design or synthesis.

It is interesting to examine several existing curricula with reference to the above general plan for curriculum design. Table summarizes the allocation of credit hours into the above four areas for six different engineering educational institutions.

TABLE 1. Percent of total credit hours allocated to the areas of mathematics and basic sciences (MBS), humanities and social sciences (HSS), basic engineering sciences (BES) and engineering and technological specialties (ETS) for six different Universities

University and Department	Percent of total credit hours in areas of			
	MBS	HSS	BES	ETS
1. Khon Kaen				
Agr. Engineering	23	12	37	28
Civ. Engineering	23	12	43	22
2. Chulalongkorn				
Mech. Engineering	32	17	33	18
3. UC Davis (US)				
Agr. Engineering	30	22	26	22
Mech. Engineering	31	22	29	18
4. Arizona (US)				
Agr. Engineering	22	20	28	29
Mech. Engineering	29	17	29	25
5. Manitoba (Canada)				
Agr. Engineering	20	9	35	36
Mech. Engineering	21	7	37	35
6. Canterbury (NZ)				
Agr. Engineering	30	0	26	44
Mech. Engineering	34	3	39	24

From Table 1 it can be concluded that all of the listed curricula need strengthening in the humanities and social sciences in order to achieve curriculum balance as outlined above. The above allocations seem ideal in light of existing social and technological conditions but are subject to

change once these existing conditions change. Curriculum planners must be responsive to these changing conditions and keep existing curricula under constant review and revision.

The above allocation of credit hours between the four areas can be used effectively in designing new curricula. For example, Khon Kaen University anticipates offering instruction in Mechanical Engineering in the near future. Assuming that competent instructors are available the general course outline could be approximately as follows (based on 160 total credit hours):

1. Mathematics and Basic Sciences	Proposed Credit Hours
Mathematics (geometry, trig., calculus through differential equations)	18
Chemistry	6
Physics	6
Biological Science	6
Statistics	4
2. Humanities and social Sciences	
Philosophy, psychology, etc.	9
Communication Arts and Language	24
Management	3
Economics	4
3. Basic Engineering Sciences	
Mechanics (statics, dynamics, kinematics, etc)	12
Materials Science I	4
Engineering Drawing and Machine Design	6
Thermodynamics I	6
Electrical Science	6
Computer Science	6

4. Engineering and Technological Specialties

Applied Mathematics	6
Machine Design	6
Automatic Control	4
Instrumentation	3
Mechanical Vibrations	3
Design Project	3
Thermodynamics II	6
Manufacturing Processes	3
Machine Shop	3
Materials Science II	3

Engineering educators must plan curricula around program goals and objectives that they consider to be the most useful to their students. This involves careful selection of course content material usually from vast quantities available. The reward for this care in selection will be increased numbers of engineering students who will find the relevance that they are seeking in an engineering education.

ACKNOWLEDGMENTS

Many of the ideas expressed in this article have been gleaned from past issues of Engineering Education published by the American Society for Engineering Education. In particular, Schultz, A. 1973. Basic Engineering-Basic Education for the Professions. Engineering Education, 63 (5):338-340.