Chemical Engineering Education: The Interaction of Professional Institutions & Academic Education

by

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ABSTRACT

In this paper a very concise survey of the cultural history of Chemical Engineering from both the professional and the educational viewpoints, has been made keeping in view the global arena in general and the Indian picture in particular. The present situation with respect to interaction between the Chemical Engineering curricula and the professional institutions has been outlined. Relevant areas of evolution have been identified in terms of would-be professional needs. In conclusion a synthesis with suitable recommendations for future trends is presented.

INTRODUCTION

"The objectives of technical education with respect to its obligations to society are more clearly recognised and its contributions have more direct social impact and long-range influence "—so remarked W. R. Marshall, ex-president of the American Institute of Chemical Engineers Hence engineering education must change in content, form and method of implementation from time to time, keeping pace with the changing needs of the profession and the society. A glance into the evolution of chemical engineering education reveals that it has been quite rapid throughout its history in response to an equally fast evolution of the professional requirements which the job market has imposed on graduates from time to time.

CULTURAL HISTORY—GLOBAL SCENE

Chemical Engineering originated,developed and flourished in U.S.A. long before it was imitated and adopted in other countries. Chemical engineering education was offered in several engineering institutions already at the end of the 19th century. However, significant developments were achieved in the 20th century. Prof. O. A. Hougen traced the historical development of chemical engineering education and has divided the same into three overlapping eras as follows :

(a) An era of industrial chemistry extending up to 1940.
(b) An era of the development of chemical engineering unit operations from 1920-1950.
(c) The present era of chemical engineering . sciences, which began around 1950.

Upto about 1920, chemical engineering curricula consisted of general engineering subjects, supplemented by instruction in Chemistry and descriptive courses in Chemical Technology. This was the time when there was total intermixing of engineering and chemistry. However, such an instruction became obsolete during the next few years when the chemical industry diversified its production to an increasingly greater variety of chemicals and more and' more new technologies came into being.

The professional requirements at the time were for a chemical engineer who, rather than knowing in detail a few well-established technologies, would understand the scientific principles underlying any chemical technology and thus be prepared to develop new ones as soon as the need would arise. The academic world met the challenge by introduction of unit operations through the classical text book "Principles of Chemical Engineering" by Walker, Lewis, Gilliland and McAdams in 1923. With the introduction of the unit operations concept, chemical engineerirg ceased to be a mixture of chemistry and engineering and became instead **a** discipline with a definite cultural identity of its own. The work of cultural revolution did not take place at the same time all over the world, the difference being related to the potential growth of local chemical industry. With the progress of time, growth of chemical industry which suffered a depression in 1930 resumed and the process of diversification continued thereby resulting in the development of new types of unit operations. It was then recognized that a unified approach to the basic principles of unit operations would go a long way towards making the chemical engineering graduate understand chemical engineering in a more scientific manner- The academic world was again ready for the challenge and in the fifties the concept of transport phenomena became the cultural core of chemical engineering. The book of transport phenomena by Bird-Stewart—Lightfoot appeared in 1960

The cultural evolution of the nucleus of chemical engineering was reflected in the ancillary subjects; a typical example is that of chemical reactor technology, which was considerably influenced by the deeper scientific understanding which developed during the years 1920-1950 and which gave rise to the discipline of chemical reaction engineering. Similar other disciplines which originated and developed around the nucleus during the above-mentioned era are biochemical engineering, environmental engineering etc.

INDIAN PICTURE

Compared to its inception in Europe and U.S.A., chemical engineering education for India is fairly young. Though the first course in Chemical Engineering was introduced in our country some fifty years ago, the progress in the field of chemical engineering education in the last three decades has been phenomenal. In the last twenty years alone the progress has been quite spectacular, having kept pace with the fast rate of growth of chemical industries in the country. This is evident today from the establishment of more than thirty institutions in the country (India stands second in the world next to U.S.A. in terms of number of institutions offering the first degree) with a total annual intake of about 1500 at the undergraduate level, compared *to* barely ten institutions established by I948with a total intake of 200 students. This speaks of the quantitative advancement of chemical engineering education.

A glimpse into the curricula of chemical engineering followed in the country reveals the qualitative reformations adopted in conformity with the professional requirements at different times. Chemical and Process industries being the major customers for qualified chemical engineers, it is natural to expect that the academic training of chemical engineers is oriented towards meeting the requirements of these primary customers. For example, prior to the fifties chemical engineering education existed mainly in the form of courses in industrial chemistry or chemical technology supplementet) by courses in general engineering. Such an education was acceptable as long as the chemical industry was concentrated on a few processes, the technology of which had been optimized through the years by an empirical trial and error procedure. But in subsequent years, when Indian chemical industry diversified its production and new technologies came into being, the technology-oriented course of chemical engineering could no more satisfy the professional requirements. An all India board of technical education in chemical engineering and technology took up this professional challenge and a uniform five-year integrated undergraduate course leading to the first degree in chemical engineering was implemented in many institutions in 1959. The main features of the five-year integrated course are illustrated in Table.

Table 1

A.I.B.T.E. Curriculum for the first degree course in Chemical Engineering

No.	Subjects	% time distribution in curriculum
1.	Humanities and Social Sciences	5.1
2.	Basic Sciences	31.3
3.	Other Engineering Sciences	24.7
4.	Chemical Engineering	38.9
5.	Elective	—

PRESENT SITUATION

Chemical engineering curricula in the world to-day vary in length from three years (eg. U.K.)to five years (typical of India, Italy), the difference being related to the background in mathematics, physics and chemistry that the incoming students possess. An analysis of the curricula from Universities of various countries reveals that about one-fourth to one-third of the total instruction in chemical engineering is dedicated to the same subjects all over the world. These are referred to as core subjects and they characterize what is the essential cultural background of a chemical engineer. The core subjects include industrial chemical kinetics and reaction engineering, unit operations, process dynamics and control, plant design including economy and management.

The other sections of the instruction in chemical engineering are dedicated to widely different subject material. These include instruction in basic sciences, humanities and social sciences, engineering sciences and specialized subjects generally referred to as electives. The percentage time distribution for various subjects in the curricula of a few different countries has been compared in Table 2.

The existing differences in various curricula are to some extent related to historical grounds i-e-they are the consequence of a previous tradition but in some degree they also reflect evolutionary trends, and in this sense they may be indicative of future possibilities, particularly if viewed in the light of present trends of evolution of the professional requirements-

Instruction in basic engineering sciences has been quite heavy in the European curricula (except that of U. K.) which is perhaps the typical example of the strength of the previous tradition. In countries like West Germany and Italy chemical engineering is very often only a section of engineering. In Italy especially the profession of chemical engineering does not exist as such ; professional status is still granted to "engineering " with no internal distinction. It is therefore not surprising that instruction in basic engineering subjects is still heavy in such countries. On the other hand, in U.S. and Canada where autonomous chemical engineering departments have been in existence over several years and where chemical engineering has enjoyed an autonomous professional status for an almost equally long period, instruction in general engineering subjects has been of minor importance.

There has been a tendency to restrict engineering instruction to courses in mathematics and basic sciences in the chemical engineering curricula of the universities of U.S. and Canada. This has aroused serious criticism, especially from industry. As W. R. Marshall who has raised serious objections to this in this address "Science Ain't Everything " has rightly put it, " The science syndrome among some of our engineering faculty his resulted in engineering graduates being unprepared and unmotivated to participate in the real world of engineering practice."

A look into our own curriculum reveals that the science context is comparatively less with respect to those of U.S. and Canada, but the value is in agreement with that of the curricula followed in U.K. and Germany. Further it is evident that increased weightage to basic sciences in the curricula of U.S. and Canada has been given at the cost of basic engineering sciences. But it is not possible to do so in the Indian curriculum while a substantial knowledge of other engineering sciences will be essential for chemical engineers engaged in small scale industry and for those self-employed. This point requires critical review because the future of many chemical engineering graduates seems to be linked up with small scale industries and self-employment.

RELEVANT AREAS OF EVOLUTION

" In a scientific age in a society profoundly indebted to engineering and a country hopefully dependent on engineering for much

Table 2

Comparison of the suggested curriculum with that in other countries

No.	Subjects	% time distribution in curriculum					
		India (C.E.E.D.C.)	U.S.	U.K.	W. Germany	Canada	Switzerland
1.	Humanities and Social Sciences	7.3	20.0	13.0	—	3.3	3.0
2.	Basic Sciences	32.9	41.0	29–35	35.0	53.5	30.0
3.	Other Engineering Sciences	22.0	10.0	3–8	33.0	10.7	22.0
4.	Chemical Engineering Science	32.8	28.0	49–50	23.0	29.2	45.0
5.	Electives	5.0	—	—	9.0	3.3	—

of its future, the engineer's education of others is paramount. In the 20th century, the engineer has a great deal to say to the modern world. Indeed no engineer who conceives his education as self-contained, limited to a single perspective and uncommunicative to non-engineers can meet his obligation to the world of his lifetime "— so spoke Chancellor H.S. Ransom of Texas University in an Annual Award meeting of the American Institute of Chemical Engineers. A critical examination of most of the graduate and undergraduate programmes in chemical engineering would reveal that the scope of those programmes has been restricted to mere basic educational exercises. On the other hand, the evolution of professional requirements for Indian chemical engineers in the recent past is related to important evolutions in industrial reality in general and social reality in particular. Attention may be focused on the following issues-

Ecological awareness has created the vast problem area of pollution abatement and control, which can not of course be neglected by one of the important pollution sources i.e.the chemical industry-

Another professional challenge to the chemical engineer has been on the energy front in view of the devastating effect of its crisis due to the continuous price-hike in petroleum crude. Chemical engineers can meet the challenge by exploiting suitable alternate energy sources or by conserving energy in chemical plants by an efficient energy management.

Food engineering is another important area of evolution for the chemical engineers of the third world. It is unfortunate that the present courses in food technology offered by a few universities generally do not provide sufficient training in the chemical engineering sciences to make them effective in the practices of food engineering'

Fermentation processes, the pharmaceutical industry and enzyme reaction processes have reached a state where technology cannot simply rely on empiricism and engineering science needs to support the design and operation of these industries.

CONCLUSION

In view of the changed situation, the professional requirements for chemical engineers are evolving towards those of an individual who, in addition to the classical cultural background of a chemical engineer, has also specific scientific competence in one of the broad problem areas such as biochemical engineering, food engineering, energy management, environmental engineering and the like, It is not possible to educate a chemical engineer in all such problem areas, because the usefulness of such an education would be dubious. Therefore, it will be appropriate to include a co-ordinated programme of instruction in one of the above-mentioned problem areas in addition to the core subjects in modern chemical engineering curriculum. This aspect has been taken care of in the recently proposed curriculum of the eight-semester course in chemical engineering proposed by the Chemical Engineering Education Development Centre, Madras under the name 'electives'. This comprises around 6% of the curriculum. (Table-3). Different departments of the country may offer curricula with emphasis on one of the areas of evolution.

Table 3

C.E.E.D.C. Curriculum for eight-semester first degree course in Chemical Engineering

No.	Subjects	% time distribution in curriculum
1.	Humanities, Social Sciences and Management	7.5
2.	Basic Sciences	22.5
3.	Basic Engineering	24.2
4.	Chemical Engineering	39.6
5.	Electives	6.2

The choice of a specific problem area to be incorporated in the curricula will depend primarily on the scientific competence of the faculty members and the research activity of the department. As a result, large departments may develop co-ordinated research programmes in several problem areas keeping in view the national interest at large, whereas the medium-size and small departments would need to concentrate their efforts in one of the problem areas relating to the professional requirements of the local region. No doubt, this policy will introduce some restraint to complete freedom of research, but it is necessary if the research programme is to be the necessary cultural support for a programme of undergraduate education adequate to contemporary professional requirements.

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