CHEMICAL ENGINEER FOR TODAY AND TOMORROW THROUGH CURRICULAR REFORM

Álvaro Ramírez García
Ch E school, Universidad Industrial de Santander
Bucaramanga, Colombia

Introduction

This paper presents some major questions raised in the process of curricular reform of the Chemical Engineering school at Universidad industrial de Santander (UIS), in Bucaramanga, Colombia.

UIS was founded in 1948 and began institutional life offering three engineering programs: mechanical, electrical and chemical. Today is a very well recognized public university, with 22000 students in 50 undergraduate programs in engineering, natural science and mathematics, human science and health science. There are about 1400 students in graduate programs; 40 in three doctoral programs: physics, chemistry and chemical engineering. Total alumni are 48.000. The Ch E school offers programs in undergraduate, master and doctoral levels: 1.200 undergraduate, 17 master and 11 doctoral.

The former curriculum of Ch E at UIS (this is the program up to year 2005) had a strong industrial chemistry influence of the Spaniard school. German teachers who came to UIS in the fifties reinforced this tendency. The North-American influence began to be strong since the seventies. Consequently, curricular changes have gone in the direction of increasing unit operations, transport phenomena, reactor and process design for which it is also observable a decreasing tendency on chemistry and chemical process description. The chemical engineers from UIS have very good recognition in national industry and have been successful in graduate schools abroad.

The curricular reform process took more than a decade and involved students, teachers, alumni and foreign university visitors. The output could be considered as a changeable compromise between several tendencies. Actual program changes began in 2006. Some major questions to begin with are: being a leader and successful chemical engineering program, why should it be reformed? What to reform? In what directions?

The need for curricular reform

The former curriculum of Ch E program at UIS was successful in a social environment characterized by a closed national economy in which big chemical industry companies, many of them state owned, offered stable employment with high salaries and good social benefits and were confronted with scarce competitors in a protected market. Advances in chemical engineering as a discipline came in the direction of transport phenomena, use of computer calculations and materials science and engineering. Those advances were introduced to reinforce the core of the former, traditional curriculum.

The present and near future appear to be quite different. The local Chemical Engineering is faced to an environment in which employment is temporal, unstable and scarce; competition occurs in a global market for a country that is not in the main stream of the economy. Also relevant is the factor that the local established chemical process industry is not growing fast enough to accommodate the total offering of new chemical engineers coming out of the eleven ChE programs in the nation. But, there are plenty of technological challenges and potential raw materials to generate chemical process industries.

There are new frontiers in the first world Chemical Engineering science and technology, namely, bio, computational and nano engineering.

The former program of chemical engineering, of course, was not intended for these new frontiers neither for the emerging social conditions.

There are also internal or university requirements to be satisfied: a 5 years program with 50 courses at most; students should come to take Ch E. courses since the first semester when most of their courses are in science and general studies. Another important condition is that there is a growing demand of young people to study Chemical Engineering.

Since the former curriculum was fitted for an environment that does not exist any more, there is a need for curriculum reform to prepare a Chemical Engineer for today and tomorrow; one able to cope with both traditional and new frontiers of Chemical Engineering, because young Chemical Engineers will probably find a closed traditional environment as well as an open challenge to build a new Ch E career as discipline and profession.

<u>General purpose and characteristics</u>

The new curriculum is intended for the student to build strengths for generating, developing and managing traditional and non-traditional chemical process industries and technological services.

The new directions of the curriculum embraces new scopes: from atomistic to macro scale; steady and unsteady states; traditional and new frontiers of Chemical Engineering science and technology, business vision and a worldwide perspective of chemical process industry and technology.

Consequently, in the normal set of characteristics of a good chemical engineer should be included competitiveness, enterprise orientation and flexibility (universality). These three characteristics are intervolved and call for productivity, quality culture and environment care. A chemical engineer has to contribute to society in an interdisciplinary work environment from a technological perspective, that is, to do on the bases of knowledge.

The curricular reform

Accepted that a curriculum reform should be performed and given the above purposes and characteristics, a question arises on what to reform. The curriculum involves at least course program, pedagogy, assessment, environment and rules.

The traditional and the new chemical engineering program are supported on strong and modern formation in math and natural sciences including chemistry, modern physics and biology. The math component is rather strong: six courses on superior algebra, descriptive geometry and calculus and three courses on informatics and numerical analysis. The number of chemistry courses was diminished leaving only three; in physics the number of courses, three, remain the same, but contents in the third course were changed to include modern, twentieth century, physics fundamentals. Two new biology related courses appear, microbiology and bioprocesses.

The core of traditional chemical engineering has to be preserved because it contains the fundamentals for running and even developing the traditional chemical process industry still existing in the world and locally and also because it is the basis for developing new frontiers in the discipline and the profession. It includes stoichiometry, thermodynamics, transport phenomena, unit operations, reactor design, control and design of processes. According to trends in the market, there seems to be an increasing industrial interest in batch processes, which should be reflected in the academic program, including also, of course, continuous processes. The core of traditional chemical engineering is expanded to include nanotechnology and computational engineering.

To give attention to the social conditions already described, the program offers opportunity for formation on enterprise based on knowledge. Two courses are devoted to this purpose.

The proposed curriculum brings together contradictory tendencies: new subjects keeping the traditional ones and also giving time to the student to develop a worldwide vision, all of that in the same 5 years program; on the other hand the students are going to be taught about subjects that teachers never took at school; and also students are being formed in subjects that, currently, are not being applied in the local chemical process industry.

To cope with these different trends some strategies were adopted in regard to pedagogy, assessment, environment and rules:

In the course contents and assessment emphasis should be made on basic concepts rather than in detailed completeness; to develop a general and holistic view in contrast with an exhaustive purpose.

Repetitions of topics in different courses should be avoided. The student should be aware of the academic requisites for undertaking a given course. To help in previous preparation for a course, review material in the form of by computer interactive learning programs should be available for students. These programs are prepared for senior students as final graduate work under the direction of a teacher. Of course, this material is also valuable for students taking the respective course.

New courses are added to the program; some traditional courses are withdrawn and some others are readjusted. In this case, 22 courses were withdrawn and 13 new were added. Some of the withdrawn were lab curses that in fact were included in the basic courses, example, the basic chemistry lab now makes part of Chemistry I.

As a laboratory course there is only one that occupies half of the credits of one semester. This course is devoted to process design and control. The idea is that the student have a practice on a complete process, in such a way that the student faces a complex interdisciplinary situation instead of doing specific measurements in a, for example, transport phenomena lab course. However, those specific measurements should make part of the transport phenomena course that includes lab practices.

As indicated above, each core course includes laboratory practices designed by the teacher to emphasize basic concepts. It is advisable to familiarize the student with modern equipments such as differential calorimetry, gravimetric thermal analysis, rheology, microscopy or any other piece of equipment available in the school. This is the least implemented part of the curricular reform. Equipments are available, a new building facility is available, designed practices are not, yet. A necessary and still incomplete effort should be done to make available hardware and software to support core courses.

The introduction of teachers and students into new frontiers of chemical engineering has been done through research and academic mobility. Through supported research programs some thesis have been devoted to topics on computational engineering in collaboration with universities abroad. Also, final works of senior undergraduate students have been devoted to exploring topics on computational engineering and nano basic knowledge and technology.

Another important strategy is to take advantage of international collaboration agreements to establish some kind of a two-way exchange. UIS undergraduate students have gone as interns to Universities like Texas A&M (USA) and Campinas (Brazil) to make a lab and research practice that is valid in UIS as a final graduate work. Those students present in public his findings and experiences in both traditional and non-traditional fields of chemical engineering. This has given support to the underlining ideas of the curriculum reform. Some of these students, after graduation at UIS, went back to continue graduate studies and some of them probably will contribute to make a difference in the Colombian chemical engineering in years to come. Also these collaboration agreements have made possible the visit of Professors from Texas A&M and Campinas to UIS to give constructive criticism and very valuable ideas to make a better curricular reform. Some visiting professors have given short courses on fundamentals of computational engineering, nanotechnology, update thermodynamics and material science.

Discussion and conclusion

The proposed curricular reform has an inherent risk for new generation of chemical engineers who will meet a chemical process industry for which they are, at best, over prepared.

At first glance it seems to be a waste of time and of scare resources and a potential cause of frustration.

The confronting view is that engineers for today chemical process industry should have been formed yesterday and that today formation should be intended to support traditional chemical process industry, but also, to build a new Ch E career and profession.

That is why new frontiers of chemical engineering (bio, nano, computational), complete scale reference (nano and macro), complete process regime (steady and unsteady) and enterprise capacity are key points in the proposed curriculum reform.

References

C. Retamoso, A. Ramírez . Estado de desarrollo e inserción social de la Ingeniería Química en Colombia. La conformación de comunidades científicas en Colombia. Vol 3, Tomo II, Fonade, Misión de Ciencia y Tecnología. Bogotá, 1990

A Ramírez , C. Retamoso. A study on Chemical Engineering development state and social insertion in Colombia, Proceedings "The 1993 Centennial Conference of American Society for Engineering Education", Urbana, USA, 1993

K.R. Hall, Seeing the future: How to do it! Memorias XXIII Congreso Colombiano de Ingeniería Química, Manizales, 2005

Visión Colombia. Segundo centenario: 2019. Departamento de Planeación Nacional, Bogotá, 2005

Frontiers in Chemical Engineering Education, http://web.mit.edu/che-curriculum/