Evolution of Programme Structures and Teaching Methodologies for Chemical Engineers?

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Abstract

Ecological emergency, consequence of greenhouse gases emissions, is of major concern for society. We now talk about socio-ecological transition. New sources of energies have to be developed, and the existing ones have to be optimized, to improve their efficiencies and to prevent increase of the already observed global warning. Industries and transportations need also to reduce their impact of the greenhouse gases emissions.

Chemical engineers, trained with a systemic approach, based on mass and energy balances, integration of different subjects, and the ability to optimize and innovate processes should be able to contribute, not alone, and to provide some elements of solution.

The future Chemical Engineer needs deal with interdisciplinarity (and the ability to identify new chemical paths, new domains), energetic transition (and the capacity to find new processes, including biomaterials or resourced products for a carbon free industry, to develop thermal integration or new sources of energy storage) and digital transformation (for an on-demand production, of intensified processes, using artificial intelligence and neural networks)

The future Chemical Engineers will also have to deal with information inflation, internationalization of markets and supplies, social and environmental responsibilities, decision making (with frequently limited or incomplete information), critical thinking and creativity, and the ability to anticipate.

What a challenge! To bring some elements of solution, the Chemical Engineering programme structures might need to be adapted?

The importance of basic knowledge and understanding is not questionable! It is regularly highlighted by both industrialists and academics. But this should also include new trends, such as sustainability, biochemistry and products, digital competencies, dynamics… Engineering skill should either not be reduced, and professional skills are of increasing importance!

The programme structure, as defined by the European Federation of Chemical Engineering, can bring some elements. It is composed of 8 skills, all described in competencies, according to the Bloom Taxonomy (knowledge, understanding, application, analysis, synthesis and evaluation), dealing with Cognitive skills, Engineering skills and professional skills.

Such a programme structure includes:

- Basic knowledge and understanding of core chemical engineering topics (balances, thermodynamics, transport, separations, reactions, unit operations, including also fundamentals in mathematics, physics, chemistry, biology, informatics and digitalization.
- Engineering skill, and the ability to analyse & design complex processes, systems and products, to develop investigations and to practice. Industrial internships are intended to contribute to the engineering practice, to illustrate the applications and limitations of theory, to set the courses in a wider context, to understand the nature and approach of applied industrial projects and to provide social and management skills.
- Transferable skill should include economic dimension, ethics and professional responsibilities, the ability to act for the transition of companies and society. These include also management, innovation, in intercultural context, as well as the capacity to make personal and professional choices.

Skills assessments also need to use suitable methods to evaluate their acquisition, corresponding to a task carried out in a professional context. Such authentical situations are based on case studies, project and problem solving, internships in research laboratories or industry, practical works…

For a limited training period, integration of such new and different subjects in a 5 years programme might need to make some choices, to propose some specializations, or to develop lifelong learning.

Fortunately, some innovative teaching methodologies have been developed and might also be used. The contributions of neurosciences and cognitive sciences highlighted the importance of mutual attention, of active engagement, of feedback, and of distribution of the learning phases. This is of great interest when teaching to students of the Z (like zapping) generation, characterized by their ability to do several things at once, that grew up with YouTube tutorials and MOOCs, that prefers to learn by doing, and whose attention span might be limited.

Such active teaching methodologies include flipped classrooms, problem and project based learning, online courses, and are based on active engagement, on collaborative learning and on co-construction of knowledge. This implies a change in the teachers' posture, who guides the students in their learnings. These active teaching methodologies are also complemented by numeric tools (tutorials, learning analytics, virtual or augmented reality devices) adapted learning spaces, allowing authentic situations, and assessment of skills.

Chemical engineering concepts seem then necessary to address the socio-ecological transition. Some new emphases are needed on sustainability, digitalization & professional skills, that might be defined in concertation with industrialists. Active teaching and tools ensure better involvement of the learners, and are known to improve training, favoring acquisition of knowledge and development of skills.

Institutions should continue to involve industrialist in steering committees, promote teachers' training and encourage the use of active methodologies, tools & learning spaces. Industrialists should also contribute to the reflexions on teaching contents and be involved in acquisition of engineering and transferable skills. Teachers are encouraged to use and develop reflexive teaching, to continue to train on innovative technologies and teaching methods and might develop & promote lifelong learning activities.

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