Contents lists available at ScienceDirect

Education for Chemical Engineers

journal homepage: www.elsevier.com/locate/ece

Revamping of teaching–learning methodologies in laboratory subjects of the Chemical Engineering undergraduate degree of the University of Barcelona for their adjustment to the Bologna process

Montserrat Iborra, Eliana Ramírez, Javier Tejero, Roger Bringué, Carles Fité, Fidel Cunill*

Department of Chemical Engineering, Faculty of Chemistry, University of Barcelona, Martí i Franquès 1, 08028 Barcelona, Spain

ABSTRACT

Laboratory work is conventionally addressed to the demonstration of theoretical principles. Traditionally, students pass through several experimental setups and perform a set of tasks following the provided laboratory hand-out. With this procedure, student-oriented approaches, as well as transversal key competences, are poorly developed. To adapt practical subjects of the Chemical Engineering undergraduate degree of the University of Barcelona (Spain) to the European Higher Education Area, teaching–learning methodologies have been progressively revamped during the three academic courses (2009–2012). The main changes were mainly applied on the use of continuous formative assessment methodologies, to increase feedback, to promote collaborative learning and to engage students in ethical commitment. In accordance with the analysis of subject evaluation inquiries and academic marks obtained by students, it can be considered that the teaching–learning process in laboratory subjects has been improved especially in the acquisition/development of transferrable competences as teamwork, professional ethics, oral and written communication, and personal autonomy and self-regulation, which are necessary for personal fulfillment and employability of the chemical engineer in a knowledge-based society.

Keywords: Bologna process adaptation; Laboratory subject revamping; Transferrable competences development

1. Introduction

During the last two decades, the working environment and the job market for chemical engineers has evolved continuously as a consequence of the globalization of the world economy (Molzahn and Wittstock, 2002). In many countries, less than 25% of the recent graduates are employed in the conventional chemical and petroleum industries. Most of the graduates are recruited in a broad array of industries, not essentially chemical, that have discovered very recently the suitability of hiring chemical engineers (Prausnitz, 2001; Shallcross, 2006).

Chemical Engineering (ChE) must change as the world is changing, stimulated by developments in such as technology, politics, social institutions, i.e. by changes in the way that people think, feel and choose to live their lives, by their ethics and beliefs, by their attitudes and expectations (Prausnitz, 2001). Therefore, the engineering education has to face enormous challenges in order to provide the students with relevant engineering knowledge and skills, as well as those aspects of their education that are relevant for the ever more flexible, interdisciplinary and intercultural nature of ChE work (Gillett, 2001; Molzahn, 2004; Grant and Dickson, 2006; EFCE, 2010).

* Corresponding author. Tel.: +34 93 4021308; fax: +34 93 4021291.
E-mail address: miborra@ub.edu (M. Iborra).
Received 25 July 2013; Received in revised form 10 April 2014; Accepted 14 April 2014
http://dx.doi.org/10.1016/j.ece.2014.04.002
1749-7728/

Table 1 – Levels of experimental work (Atkins and Brown, 2002).

	Level	Aim	Materials	Method	Answer
Demonstration	0	Given	Given	Given	Given
Exercise	1	Given	Given	Given	Open
Structure enquired	2	Given	Given part or whole	Open or part given	Open
Open enquired	3	Given	Open	Open	Open
Project	4	Open	Open	Open	Open

The harmonized European Higher Education Area (EHEA), proposed in the so-called Bologna process, involves sweeping modifications in the structure of university studies, as well as in teaching–learning methodologies. Higher education is structured in two cycles (undergraduate-master degree) and the original staff-centered approach is redirected to a student-oriented approach. According to the recommendations of the European Federation of Chemical Engineering (EFCE) for Chemical Engineering education in a Bologna degree system (EFCE, 2010), the learning outcomes, in terms of knowledge and general chemical engineering and transferable skills, and the curricula are defined in a way that there is a common understanding of what graduates are expected to know and be able to do. An important objective in the education of chemical engineers is to acquire the ability to engage in life-long learning and in interdisciplinary cooperation.

Laboratory subjects have an important place in the chemical engineer core curriculum (Molzahn, 2006). To increase the efficiency and effectiveness of practical work in laboratory courses, the major goals to be achieved are: (1) to teach manual and observational skills relevant to the subject; (2) to improve understanding of methods of scientific enquiry; (3) to develop problem-solving skills; and (4) to nurture professional attitudes. Among them, the latter one is most subtle and is probably the most important long-term goal, because practical work should provide to the students the knowledge, understanding and skills necessary for their future professional career.

According to Atkins and Brown (2002), the most common methods in laboratory teaching are demonstrations, exercises, enquiries and projects. The proportion on each aspect vary in the degree of the openness of the task and in the time spent on the task, as it can be seen in Table 1. Laboratory work in the ChE undergraduate degree of University of Barcelona (Spain) has been traditionally addressed to illustrate theoretical principles, previously outlined in lectures, by means of a basic performance described as a level 0 to 1 of experimental work (see Table 1). Under the supervision of the academic staff, the students perform lab scale experiments following a preordered set of tasks as indicated in the laboratory manual or hand-out. The main deficiency of this traditional approach is that students become skilled only in following the 'recipes' (hand-outs) and in getting a narrow range of expected results, sometimes taken from student reports from previous years. In this way, student-oriented approaches, as well as general and transferable skills, are poorly developed.

In order to adapt the practical subjects of the ChE undergraduate programme of the University of Barcelona to the EHEA philosophy, teaching–learning methodologies have been gradually revamped during the three academic courses (2009–2012). In this paper, the development and implementation of this new learning-teaching process is presented. The obtained results are discussed and evaluated.

2. Methodology

Practical work in ChE undergraduate programme of the University of Barcelona was classically structured in a series of 4 laboratory subjects called Chemical Engineering Experimentation (ChEE), each consisting of 60 lab hours (15 sessions of 4 h) with 30 students per shift. Laboratory work was developed in groups of 5–6 students per experimental setup. During a laboratory subject, each student groups operated five different experimental setups.

The ChE undergraduate programme of the University of Barcelona adapted to the Bologna two-cycle degree system last 4 academic years (8 semesters), with 60 ECTS each (total 240 ECTS). After completing the first cycle, students can continue their study with a second cycle (master) programme of 90 ECTS (1 1/2 academic years).

With the aim of fitting laboratory courses to the Bologna system requirements (see Fig. 1), practical work has been confined to two subjects. The former corresponds to practical work related to theoretical principles outlined in Introduction to ChE, Fluid Mechanics and Heat Transfer lectures, the later to Chemical Reaction Engineering and Unit Operations lectures. Each of them consisted of 80 lab hours (20 sessions of 4 h assessed by a senior teacher supported by a junior one), and the experimental level has been changed from demonstration/exercises (levels 0 and 1 in Table 1) to structured and open enquiries (levels 2 and 3) where students have to identify a problem, to formulate it clearly, to develop their own experimental procedures and to provide their own interpretation of the obtained results. Because teaching periodicity, session length and the number of students have been reduced, the teaching–learning methodologies have been completely modified to improve students understanding and knowledge acquirement, and to develop general and transferrable skills. The change in total subject hours (from 60 to 80 lab hours) has been done during the academic year 2011–2012.

One of the first tasks was to adapt the old subject programme by introducing a new extended and detailed one, which included all information about contents, specific goals and developed skills, activities or tasks list, and how continuous assessment and evaluation would be carried out.

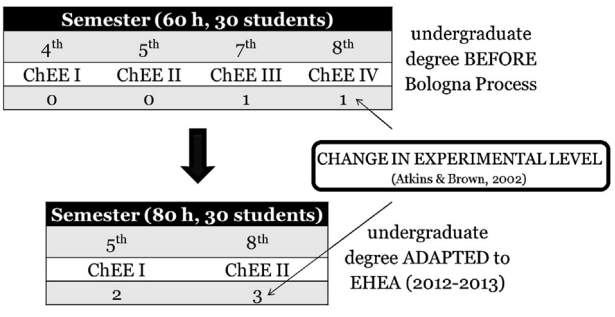

Fig. 1 – Laboratory subjects in ChE undergraduate programme of the University of Barcelona.